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Wm C. Davis,
2d Lt. 5th Arty

JOURNAL

OF THE

UNITED STATES ARTILLERY

PUBLISHED BY AUTHORITY OF THE

STAFF OF THE ARTILLERY SCHOOL.

VOLUME II.

1893.

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ANNOUNCEMENT TO VOL. II.

The establishment of the *Journal of the United States Artillery* in 1892, was felt by its projectors to be largely an experiment. While the idea of an artillery review for our service was not new, yet the idea itself had for various, and doubtless good reasons never been carried out. The benefit that would follow from a professional journal was acknowledged, but remained unreaped. Seed however had not been sowed in vain. The reasons advanced for the establishment of an artillery review increased in weight as years came and went, and as the importance of coast-defense and all related questions passed from the domain of theory to that of condition. The origin therefore of our present *Journal* is to be sought in the attempt made long since to set on foot a review devoted to the interests of our arm of the service. And if efforts to-day have met with success where before they encountered defeat, the reason lies ultimately in the changed environment of the artillery question. For that there is an artillery question, no clear-thinking man will to-day deny.

It is scarcely necessary here to review the results of the past year. In brief, a working plan submitted through the commanding officer of the Artillery School to its Staff, met with the approbation not only of the Staff, but of the artillery at large. Previous investigation had shown that for financial reasons alone, all others being disregarded, a review could not be maintained at any place other than Fort Monroe. But it is equally true that, however great the facilities at the school, these alone would not have sufficed. A professional review became a possibility only by combining the generous support of the artillery with the "wise liberality" of the School. The outcome of this combination is the *Journal* as it exists to-day. We shall leave the results accomplished to speak for themselves.

It may not be amiss, however, at the outset of a new year, to dwell for a moment upon the changes made necessary by the natural development of affairs. The original organization of the

Journal was avowedly temporary. The reasons for this consisted mainly in the exigencies of the service, and in the proper desire to acquire experience before proceeding to lay a permanent foundation. Difficulties had to be overcome and obstacles removed; many problems arose, the solution of which called for serious effort on the part of the projectors. To all the questions that came up, the temporary organization was found adequate. But it became at the same time increasingly evident that continuous results could be expected only from continuous effort, and that this in turn meant a permanent organization. The *Journal* will therefore in future be under the management of an editor, aided by a committee of general direction and publication. This committee will consist of the following officers who, having consented to act in this capacity, are designated by the Staff of the U. S. Artillery School:

Colonel Henry W. Closson, 4th U. S. Artillery,
Captain James M. Ingalls, 1st U. S. Artillery,
Captain E. L. Zalinski, 5th U. S. Artillery,
Lieutenant E. M. Weaver, 2nd U. S. Artillery,
Lieutenant George O. Squier, 3rd U. S. Artillery.

The editor is Lieutenant John W. Ruckman, 1st Artillery.

It is believed that this organization will receive the cordial approval and loyal support of all artillery officers. While it secures on the one hand, permanency and continuity of effort, on the other, it lends itself by its elasticity to the requirements of growing experience.

Having thus a strong and simple organization, the *Journal* renews with increased confidence, the assurances held out in the initial number. It feels that the experimental stage is passed, and relies for this feeling upon the intelligent interest of the arm of the service that it seeks to represent.

In relinquishing its charge, the temporary committee of 1892, desires here to make its appreciation of the encouragment with which its labors have been received. To say that under the new management this encouragement will grow in strength and purpose, is to say that the future of the *Journal* is assured.

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JOURNAL

OF THE

UNITED STATES ARTILLERY.

VOL. II. NO. 1. JANUARY 1893. WHOLE NO. 6.

OUR ARTILLERY ORGANIZATION.

BY COLONEL JOHN HAMILTON, U. S. ARMY.

Whether it is that artillery being the latest arm of service or from the great differentiation of its duties, uniformity of opinion as to its proper organization appears to be impossible of attainment.

Of late our best writers on what field artillery wants, agree pretty well (Tidball, Birkhimer and Parkhurst) as to its needs in field organization. Whether this should constitute a separate arm from siege, or sea-coast artillery, may justify a good deal of thought.

Because all officers of our arm are not equally suited for all the duties of the arm, as actually organized, it should not necessarily require a re-organization to suit the personnel. Admitted that every captain of an artillery regiment be not fitted for a horse battery, still, under the present organization, enough are, and should extension be required plenty of senior first lieutenants are to be found for the places.

This, however, is merely saying that our condition is not lamentable, and does not bind the writer to an expression that our present system is the best fitted for nor the best to prepare us for war.

In fact all organizations, laws, and regulations made in time of peace are trimmed to suit actual necessities: the exigencies of war being in the dim distance are scarcely thought of in administration. What is best to be done now to insure safety, economy, and a mere existence, is the aim of popular government.

As to our arm, it is believed that had the old blood of the service done its duty in the past we would have been in a greatly advanced state of organization and status. But the old are conservative and inert, hence the young have been the only workers. These on the other hand have generally been too ambitious and have wished to reorganize by great leaps, which legislators have feared to take, seeing that the strongest part of the supporting arguments for the new order of affairs was the well arranged promotion which would result. Even these changes might have been good, but most of them excited antagonism from those of whom the scheme did not make field officers.

One point we believe is agreed on by all artillerists, that no change in the way of increase in regiments nor change of units can be of any permanent benefit to the arm without a Chief.

This is a question entirely independent of our numbers, or of bureau, corps, or "*department*" proclivities. We are a weak arm in numbers and in warlike prestige, owing to our duties, as translated and applied by infantry and cavalry generals, being considered as subsidiary to those of their battalions or squadrons. We are not considered in the same breath with those arms. *Vide* Hunt and Barry's claims for a brigadiership. Brilliant men, brainy men, but having no chance of recognition, though their practical infantry experience, as well as artillery and staff, had much antedated that of their successful rivals.

We all know the history of detachments of mixed commands. No artillery officer is ever sent in command of such. However true or untrue it may be, the artilleryman always complains that the infantry or cavalry commander gets into camp first, selects the best ground, wood, and water and the artillery is left to "hustle." Marches are fixed quite regardless of his comfort, and guard duties added to him for which his arm is not fitted and which become an extra onus on his men.

We remember an instance of mixed service worthy of note. Previous to the indian scare of 1868 on *the Republican*, Uncle Sam had made a worthy but unsustained effort to start a school of field artillery at Fort Riley. There were men in uniform and there were government horses, hence public clamor required that these should be sent to protect the settlers against the wild man. Had it not been for the serious injury it was doing to the arm and to the command, it would have caused a smile to see these men set forth on their 1200-pound horses to catch indians. Of course only captains could be sent out and on arriving at the field of operations they found a cavalry major there to direct them, and he did. His horses needed rest so the artillerymen were dispatched to all points of the compass to sight the indians, but on no account to engage them. The artillery "scout" was to hurry in to camp headquarters and report, so that the cavalry should go out and kill the savages. It never was known whether this order was given in the interests of the artillery men or of their horses. The major may not have wanted to lose the artillery men to the service, or he may have thought that the scouting was sufficiently hard on the horses without exposing them additionally to the enemy's bullets. On their return the horses were healthy enough, had lost a good deal of adipose, but were in no way bettered for artillery work.

In ye olden time when red-legged infantry was common on the plains and in the everglades and where its record does not place it second to any, a mixed detachment was ordered out in Texas. After the detail was made the detaching officer's attention was called to the fact that the artillery captain ranked. This would never do, so he was placed on some home special duty, and the command set out; the red-legged company commanded by an old lieutenant of the Florida wars. At the first camp the infantry captain selected his camp and directed the artillery lieutenant to fix himself in a certain position. The lieutenant replied that, No, he proposed to command this detachment on an old brevet that he had won in past indian battles, showed his commission and took command as regulations then stood, much to the dismay of the infantryman; but history does not record whether to the failure or success of the enterprise.

Though we cannot expect any well organized course of improvement either in organization or instruction in time of peace without a Chief, his existence in war is of still greater importance. We know how hard it was in the rebellion to break down the feeling of the cavalry and infantry generals that artillery's use was simply as a tail to a battalion's or at most to the brigade kite. This had arisen not from a study of European organizations but from our own wars, where, either through smallness of the numbers engaged, or at a more remote time, from the little development of the arm, masses of artillery were useless, or the field such that grand operations were out of the question.

Had a Chief existed at the beginning of our late struggle his dictum would never have been questioned, but when the generals had to have it argued into them by artillery majors, and where the brigadiers thought they saw in an artillery reserve a possible loss of strength to their brigade, or a loss of prestige to their commands they were found to be in active hostility to it.

The opposition to such an official (that of a major-, or even brigadier-general) from the Washington authorities was very natural. It would, did the office once obtain, not be broken up by a cessation of the war and then the existing departments would have a new problem of accommodation which they shrank from solving. 'Twere better to let the arm take its chances for good or evil rather than create another *Department*, that might rival the existing ones in its claims on congress, or intrude on the prerogatives of some, or have its duties that should conflict with old current geographical deparment routine to be adjudicated.

Whatever changes on present organization are made they should grow out of the experience of a Chief of Artillery. The idea of preparing for him his arm, completely organized by others, would strike one as an unnatural course of procedure. The great problem will be how he may fully and to the best advantage cultivate the artillery knowledge of his arm, and at the same time avoid any essential interference with the local administration of the generals commanding geographical departments. It is not believed that in the present feeling of the people, any important number of troops could be set aside as a body not liable to duty with the musket. And it is probably not desirable that there should be. Always, odd portions of time can be utilized in garrison to make fair infantry out of our artillerists and nothing will add more to their smartness of appearance than this training. Observe the few evenings per month that our national guardsman is exercised. The guard is composed of hard worked business and laboring men, yet they make a very effective infantry. Furthermore, could one work his men continuously at artillery labors it is undeniable that it would be done at great cost; for ropes, timber, ammunition, and all artillery supplies needed for exercise and instruction are very costly and are rapidly worn out. Our men should be supplied with the very best infantry arm. The carbine and musquetoon have had their advocates for artillery guard-duty service, but, arm a man with an inferior weapon and he loses his self-respect. The artilleryman has not the excuse of the cavalry soldier for carrying the carbine and it is doubted by many if the carbine be the best weapon for the horseman. Now, however, that the three-tenths rifle is coming to the front all troops will likely be armed with the same weapon.

We are so used to getting all our supplies from other departments, from the ordnance or quartermaster's, that few of us think how much this trammels our development. We should remember that in making his estimates for the action of congress, the Chief of Ordnance must look out for his own plants and the demands for his constructions and investigations. He is necessarily ignorant of what the demands of a manned artillery fort will or should be for the coming year and is in no condition to battle for increase of allowance. The artillery commander of a fort may be a very energetic officer or may have no interest in the specialties of his arm. He may prefer to spend all his force on a neat garrison, projecting improvements in gardening, painting, white-washing, and pipe-claying. The Chief of Ordnance cannot tell if he will mount, dismount, or fire a gun in the year. It is not known in any case where a Chief of Ordnance has urged an artillery commander to practice his specialty with the material that the Chief might be able to supply, nor is it known where the Chief has recommended activity in this direction to a department commander.

We do not bring this as a charge against this office of Chief of Ordnance but simply to show that said officer can have no interest in our improvement as an arm and that his own department is quite exacting enough to demand the exclusive energies of the most gifted man. Hence, all our estimates for material and for appropriations must be made by our own Chief based on work that he knows his own arm will have to perform, and which work he can exact from them. And above all to be able to go before congress with the right to say, Give me this and I will do that. No Chief of Ordnance can do this for us. More than that, no promise of this kind can be made by any existing authority which will bear uniformly on all the artillery. No two department commanders will take the same interest in our work, and it is human nature to direct us more for present convenience to those immediately concerned, than for prospective good to the arm.

There is another crying necessity for a Chief to our arm. To determine our armament. At the present time there is nobody to say what shall be our gun or equipment. We will be answered, Yes, the ordnance makes them and hands them over to you when ready. Just so, and here is the difficulty, that it is the ordnance that determines the necessity for the arm and equipment. An artillerist who doesn't know what he needs and how to demand it, is not an agressive nor even progressive soldier. Had we had a Chief of Artillery it is well recognized that the Ordnance Department would have seen the necessity for a 3″.2 (or 3″.25) field gun sooner. A Chief of Artillery would have been a stimulus in the production of many of the modern guns, a Chief of Artillery might even have procured modern ordnance for West Point, where now the practical instruction is limited to accustoming the ears of the cadets to a big noise. The Chief of Artillery might save the ordnance the responsibility of experimenting on unpractical improvements in harness, carriages, etc. If the service needed a mountain howitzer the Chief of Artillery should give the conditions it was to fulfil and have the officers and men ready to man it. This would not prevent, as in the Mexican war, the ordnance from running a side game of their own, but it would have been a stigma on a Chief of Artillery had he not foreseen a necessity for such an arm. If constructionists desire to ply a free lance as combatants they should not be obstructed. But should they keep back a proper armament from combatants that they themselves might use it, would it not be a *casus belli?*

Another matter in which there is no question the artillerist should be entirely free is that of selecting his ammunition and equipments. The Chief should be as free in such selection as the appropriations of congress will permit him to be. This would in no way conflict with the progress, experiments, investigations, and convictions of our most conscientious and talented construction departments.

The only difficulties that may arise for solution in the introduction of the new functionary, Chief of Artillery, would be those due to a conflict of claims on the artillerist for his specific professional duties, and those of his more general ones as required by his department commander. But the way to settle these is to settle them. Resumption they say was accomplished by resuming. By looking at difficulties from a distance they are magnified by their haziness; give us the Chief and let him "fix" things: there are plenty of us ready to grapple with the question. Of one thing however we may be sure as before referred to, whatever may be our unit of organization the public will require of such a large body of men fitness for general service, and immediate obedience to the department commmander. Many arguments could be well raised to continue the old regimental organization. 1. It is not so likely to be tampered with by legislation. 2. Till lately its legal organization preserved the officer from the chance of invidious selections against him; he was more entitled to the good luck of his promotions, to the changes of posts falling to him, &c. 3. It saved him from one man power idignities, thus giving him a higher bearing, and nobler motives for duty. As law stands now, however, we may properly look to a Chief as a protector, as an intermediate, to oppose against unfair selection, or a favoritism that even the highest human nature may be influenced by.

Few arguments can be adduced against a corps organization, other than the facility with which it can be legislated down. It is not seen how any change of minor units, either in their localities or in their instruction need infringe on their general routine duties outside of their specific armal pursuits. A reduction of corps in our country, to put it mildly, is not imminent. Our greater commercial complications with the world, our wealth, our weaknesses, the speed which is lending itself to modern war, all court aggression on our coasts. We have more to fear from having our cadres filled by overtopping rank from other arms being reduced than from danger of our own reduction.

Another minor point of improvement should be had in our arm. Though we deprecate turning the artillerist into a constructionist, still there are found men in our arm suited to mechanical investigation who when they have found "a good thing," should, on the approval of our Chief, have the best opportunities to investigate it to a practical conclusion. These opportunities should be reached through our ordnance or quartermaster's department or through the naval shops or even through such private *chantiers* as might liberally open their plants to such service; and there should in this be full reciprocity with the navy. Wherever the best opportunities offer let the aspirant be sent.

To render them more expert in the field and that they may learn all the most modern appliances of their profession, every young artillerist should spend a year in these shops before joining his regiment. The knowledge acquired by the officers of the line at Willet's Point will be of incalculable benefit to the service in case of war.

Esprit de Corps has been greatly used as an argument for regimental organization, but it doesn't appear to be very logical. There may be some adventitious courage or enterprise gained from the feeling of responsibility to one's immediate intimates, or in the support of a reputation for the organization, gained by past sacrifices; but other than regimental organizations have shown all this. It is probable that a man will fight and work as well for his arm as for a sub-division of it. In any case, had we a corps organization there would be plenty of prestige to stimulate us and plenty of reprehension to be feared for shortcomings. As we are, if *esprit de corps* had ever had any claims the regimental family should have always remained intact from cadet to colonel. But it was only cultivated through the company grades, and thrown to the winds with the field officers; there, individual claims were considered of more importance than *esprit de corps:* we are to be congratulated that justice has reached the young at length. It is believed that the enfranchisement of the subaltern, opening his whole arm to him, will in no way detract from his enthusiasm or pluck.

But what we need first, last, and middle, is a Chief.

1. If our arm needs development in instruction, organization, or unanimity of purpose, it can only be done through him.
2. If we want to be held to an immediate responsibility of advancement, he must be the exactor.
3. If we want to have the best appliances for effective work a Chief free from all other dependencies than the General of the Army and congress is necessary.
4. If we need a professional study of the harbors of our country, he alone can make it systematic and can equalize it through his arm.
5. A stable force should, like a stable government, grow into existence under its daily necessities: to direct this growth healthfully, we need a man at our head, whose whole heart is in his work. One who, however much he may be forced to "trim" to surrounding conflicting interests, will keep the good of the arm as the main object before his eye: at the same time it would be unjust to that man, to complicate his problem by previous hasty legislation.
6. Every *corps d'armée* in the field will need its chief of field, siege, or *pièce de place* artillery, and a Chief of the Arm is the only one that can secure this to the corps, protecting it against

the disintegrating process of frittering away in detachments to brigades, battalions, and pickets.

In selecting our Chief there should be no restriction. It would probably be safest to bet on his coming from the cavalry or infantry. He should not be an old man, out of whom all the work has been driven, or whose brain has been atrophied through disuse in other than attention to old fashioned elegant routine. He should not be too young, for if a mistake in selection be made death or retirement will be the only available remedy. Let not our artillery pride be an obstruction in the selection. Maybe it would be better to have him from the engineers or even the ordnance. Once placed at the head of our arm he would be loyal enough to it, and would not restrict himself in its enlargement. At the same time we have minds and energy in our own arm if petty jealousies might not mar the whole by opposition excited by individual claims.

In the worst case (like the old maid's selection of a poor husband, "He is much better than none"), we will have an excellent safeguard in our Chief's staff. The young, bright administrative staff he will gather around him will be a guarantee of work and progress.

Some things present themselves as lost to us up to the present for want of a Chief. Had General Hunt been made such during or after the war, we would have had a practice ground of from four to six miles in length along the Chattanooga where the artillery of the southern coast would have been gathered for summer work. Guns of every class could there have been practised with, and for winter work, the healthy season, the arm could have worked at everything involving the hydrography at their proper forts.

A study, in regular course, of theoretical armament of our sea-coast forts would have been instituted, involving, of course, an exhaustive instruction in their defense.

Let us have a Chief and organization will follow.

THE ARTILLERY OF SIEGE WARFARE.

By Second Lieutenant L. G. BERRY, Fourth Artillery, U. S. A.

A GLANCE AT THE MATERIEL.

The day has long since passed when a siege was the principal operation of a campaign. And, especially in our own service, there has been a tendency to conclude from the disastrous results of the sieges of Paris and Metz and want of results from the prolonged resistance at Plevna, that a force which allows itself to be besieged is beaten from the beginning. Hence it is not surprising that we find that there are in the artillery arm of the service many officers who are skilled in the use of field artillery, but comparatively few who have devoted serious attention to the subject of siege warfare.

Yet if we may judge from the contents of foreign periodicals it is a subject which is receiving great attention abroad, and it remains to be seen whether our situation is such that it would be profitable for us to follow this example.

If we assume the offensive as we we would be forced to do in case of a war with our next door neighbor and hereditary enemy, England, "Quebec is the most important objective; for its possession by us would prevent the naval or military reinforcement of the British armies or fleets above that point, and history proves that it is the key to the conquest of Canada." "The capture of Montreal is a necessary stepping stone to the reduction of Quebec." "At the first sound of war they (the garrisons of Forts Porter and Niagara) should be thrown across the frontier, seizing and holding the International R. R. bridge between Fort Erie and Buffalo, and the Roebling, Keefer and Cantilever bridges below the falls of Niagara. Pushing on with the utmost celerity, they could then seize the Welland canal and blow up its locks."[*]

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[*] The Military Geography of Canada, by Captain *Arthur L. Wagner*, 6th U. S. Infantry, Journal of the Military Service Institution, May, 1892.

In the case of offensive operations by sea against us, "The same reason (to secure a base of supplise) would doubtless lead any nation intending serious operations against our sea-board, to seize points remote from the great centres and susceptible of defense, like Gardiner's Bay or Port Royal, which in an inefficient condition of our navy they might hold with and for their fleets." *

It would then be the duty of our own army to capture these places. If the country should be invaded either from the sea-board or from Canada owing to a temporary superiority on the part of the enemy, a delay would be of the greatest value to us. Captain Mahan very pertinently remarks: "How would a delay like that of Plevna have affected the fortune of war, had Turkey had any reserve of national power upon which to call?" †

It would seem that in case of hostile operations, either offensive or defensive, we would be compelled to undertake siege operations at the outset. The question then of the artillery of siege warfare should not be without interest to the artillery arm of the service.

A siege is "The placing of an army round or before a fortified place for the purpose of attacking it, and compelling a surrender, or the operation of attacking a fortified place under cover of earth thrown up from trenches."

The fortified places which will be besieged or defended by our armies may be divided into two general classes: 1st. Strategic fortifications, 2nd. Tactical fortifications; but without any distinct line of separation between the two classes.

Under the first class are included: (*a*) The fortifications of important strategic points erected in time of peace, sometimes called permanent fortifications, such as those of Paris. These will probably be made of granite, concrete, iron or steel, together with a certain amount of earth, or of earth alone.

(*b*) Similar fortifications erected on the outbreak of war, such as were the fortifications of Washington, and such as will probably be erected covering the locks of the Canadian canals. These consist of earthworks of strong profile and include block

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* Influence of Sea Power on History. *Mahan*, page 212.

† Influence of Sea Power on History, *Mahan*, page 16.

houses and similar constructions.

Under the second class are the earthworks of more or less strong profile, forming pivots for tactical wheels, protection for flanks, and generally defensive points on the field of battle, either constructed in advance or improvised.

As to the artillery for siege purposes, abroad "there appears to be a tendency to classify the artillery—so far as it is possible to draw a hard and fast line in this matter—into that required to deal with personnel and that to attack materiél."* The same idea was developed in our service during the war of secession.

General Abbot says in his report: "Without questioning the wisdom of composing each field battery of a single caliber and class of guns, as was always done after a little experience in Virginia, we found great advantage in placing a few smaller rifled guns in heavy batteries, where barbette carriages are required. Thus Battery Spofford, on James river, was composed of two 100-pounder and three 30-pounder Parrotts. It was subjected to a heavy fire of 7-inch and 8-inch Brooke rifles and 10-inch Columbiads, at a range of about 2700 yards. The enemy were so annoyed by the rapid practice of the 30-pounders at their embrasures as to make interrupted and wild firing, thus enabling the practice of the 100-pounders to be deliberate and effective. The 30-pounders played the part of sharpshooters, who can often destroy precision of fire in a field battery." †

We may then take it for granted that the artillery is to be considered under the aspects (1st) against materiél and (2nd) against personnel. Mortars are useful for both these purposes, but as they deserve separate consideration from direct and curved fire guns, we may form a third class: mortars.

"It is a mere truism to assert that, nowadays, events in war proceed with unexampled rapidity, but this assertion lies at the root of the matter. It is pointed out that the interval that must elapse between the investment of a fortress, and the arrival of the siege train requisite for its attack, according to the approved formal method, is very considerable, and is, in fact, so great as

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* Foreign views upon Siege and Fortress Warfare—Major *J. Wolfe Murray*, R. A. Proceedings Royal Artillery Institution, June, 1897.

† Professional Papers of the Corps of Engineers, No. 14, page 125.

to be inconsistent with the rapid march of events in modern warfare. Thus it is pointed out that, in order to satisfy the text-book conditions, which require the provision by the besiegers of an artillery at least equal in number to that of the besieged on the front attacked, probably at least a month would have passed before fire could be opened from the batteries of the first artillery position. Various suggestions have been made to curtail this period.

"Practical attempts at a solution of this problem have already been made by several European powers; they may be classified as follows:—

"(*a*) Partial equipment of the field artillery with mobile mortars, of large caliber, possessing great shell effect. *e. g.*, Russia.

"(*b*) Organization of the siege park in such a manner that certain units are armed with medium caliber guns, which can be readily brought to the front, *e. g.*, Russia, Germany.

"(*c*) Equipment of specially organized artillery units with guns of medium caliber possessing sufficient mobility to act in the field.

"Thus, it is clear that a tendency exists to attach to the army in the field an artillery of position capable of playing a twofold part, namely, either to act as a heavy field artillery in the attack of hastily entrenched positions, which will probably be met with more frequently in future wars, or to form an advanced light siege train in case works of a more permanent character are to be dealt with. The conditions to be met by this new development of artillery preclude the use of guns, and necessitate the employment of mortars or howitzers using curved fire." *

As to the heavier guns, the same reasons impose the condition of the utmost mobility consistent with a proper performance of their appropriate functions.

DIRECT AND CURVED FIRE GUNS FOR USE AGAINST MATERIEL.

Against works constructed of steel or iron.—This class of work resembles in its protection the armor clad ship and the same classes

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* Foreign views upon Siege and Fortress Warfare—Major *J. Wolfe Murray*, R. A. Proceedings Royal Artillery Institution, June, 1891.

of guns, *i. e.*, battering, will be used against each. For this class work naval guns or guns constructed for coast-defense would answer. The existence of works of this kind abroad forms the reason for the long guns still retained in the siege trains.

Against works made of concrete or granite, or earthworks of strong profile.—The experiments carried on abroad in recent years have demonstrated what the Germans knew and practiced in 1870, that against this class of works shell effect was immensely superior to the impact of projectiles. In the siege of Strasbourg the breaching was done by short 15-cm. guns firing, with a curved trajectory, special elongated shells. In the bombardment of Alexandria the English used only common shell, which is a shell of comparatively small capacity and they produced a correspondingly small effect. General Abbott says: "Earthen parapets of proper thickness cannot be seriously injured by the explosions of rifled shells of any caliber less than 6.4 inches; and not by these if the garrison is active in repairing damages."* Of course we must bear in mind that he refers to the shell of that day (1866). Experiments recently carried on at Fort Monroe show that firing at a parapet with shells from the 3″.2 gun does not injure the parapet. These examples show that for breaching, shell of large interior capacity will be required.

Abroad nearly every service has guns of 12 cm. (4.8 in.). 15 cm. (5.9 in.) or 6 in. and short guns 18 cm. (7.1 in.), Austria; 21 or 22 cm. (8.3 in.–8.7 in.), Austria, France and Spain. We have as yet no guns corresponding to the greatest caliber. Our 7-in. howitzer, with proper shell, will probably prove to be very efficient of its type. We have no gun representing the 15-cm. class, either short or long. The 12-cm. class is represented in our service by the 5-inch siege gun. This gun is very long, 30 calibers, it has a high initial velocity (1829 f. s.) and weighs 3660 lbs. It is the successor to the 4.5-inch siege gun of cast-iron, having a length of bore 26.5 calibers, initial velocity 1280 f. s., weight 3570 lbs. The 4.5-inch gun was the successor to the 24-pounder smooth-bore. The use for which the latter was constructed is shown in General Roberts's Hand-book of Artillery:

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* Professional Papers of the Corps of Engineers, No. 14.

"*Q.* In what manner should the fire of siege guns be conducted in order to form a breach?

"*A.* 1st. Make a horizontal section the length of the desired breach along the scarp, at one-third its height from the bottom of the ditch, and to a depth equal to the thickness of the wall.

"2nd. Make vertical cuts through the wall, not further than ten yards apart, and not exceeding one to each piece of ordnance, beginning at the horizontal section and ascending gradually to the top of the wall.

"3rd. Fire at the most prominent parts of the masonry left standing, beginning always at the bottom and gradually approaching the top.

"4th. Fire into the broken mass with howitzers until the breach is practicable."

Passing down the line of legitimate descent to the 5-inch siege gun we find that it is eminently fitted to perform the duties above described. But inasmuch as no walls are being built to-day for the purpose of being breached by direct fire, this gun will have to find some other sphere of usefulness in our next war. Its want of shell capacity would restrict it to the destruction of earthworks of light profile, while its lack of mobility would interfere with its successful use against these works. Perhaps the method sometimes adopted with the unserviceable personnel of the U. S. Artillery might be followed, viz.: transfer it to the foot artillery, then it could be mounted in a sea-coast fort as a rapid-fire gun for the defense of mine fields, &c.

It would seem advisable to reduce the length, weight and initial velocity of this type and thereby so increase its mobility as to make it a useful gun to an army in the field.

As an example of a gun approximating to the required conditions, we have the 12-cm. short Canet gun; weight, 1874 ℔s.; weight of shell, 39.7 ℔s.; initial velocity, 1312 f. s.

Against tactical fortifications.—It is prescribed in the Infantry Drill Regulations, that infantry on the defensive will always fortify, and even the offensive tacticians of the German school have recognized the value of entrenchments more or less hastily constructed. We may take it for granted then that on the battle fields of the future many entrenchments will be found. This would be especially the case with Canada, whose rôle would be to seek a sufficient delay to enable help to arrive from the other parts of the British Empire. These fortifications would then call for siege operations more or less extended, for their destruction.

We must then have with an army in the field guns such that no field works but those of a very strong profile can stand before them. General Tidball says: "It has been found from actual experience that the 4.5-inch siege gun is capable of accompanying an army in the field with almost the same facility as the 12-pounder. Its great range, power and accuracy endow it with many advantages when used as a heavy field piece, and it should form a portion of the artillery of every army organized for campaign purposes." This piece, carriage, limber and implements, together, weighed 7400 lbs.; which is about the weight of the 7-inch howitzer and carriage. As the country is well supplied with heavy draft horses, there should be no trouble in taking this piece into the field; where its large caliber and consequently great shell effect would make it very formidable. It seems doubtful whether there would be any advantage in constructing guns of 6-inch caliber, if we are to have the 5-inch and 7-inch, even though most European services have this caliber.

DIRECT OR CURVED FIRE GUNS FOR USE AGAINST THE PERSONNEL.

Abroad it is proposed to use shrapnel from the siege guns of smaller caliber and from field guns, against the personnel. It has also been proposed to use rapid-fire guns for this purpose. A 6-pounder 40–45 calibers long, with an initial velocity exceeding 2000 f. s., caliber 2.24 inches, shrapnel fragments 100, would be quite effective. On account of its great accuracy, quick aiming qualities and controllable recoil, it would compel the enemy to hug their cover very closely and would seriously interfere with the accuracy of the enemy's fire. It has still another advantage, the velocity of the projectile is greater than that of sound, so that the burst would come without warning.

HIGH ANGLE FIRE GUNS.

These guns are somewhat inappropriately styled mortars in this country. They are used both against materiél and personnel consequently they are supplied with shells and shrapnel.

The latest additions to the European armaments have been made in this direction, all of the countries adopting under the lead of Russia and Switzerland, for service in the field, mortars mounted on field carriages. The calibers adopted are 9 cm. (3″.54), 12 cm. (4″.7), 15 cm. (5″.9), 6″, 8,″, 21 cm. (8″.27), up to 27 cm. (10″.3). Of this series we have now only the 3″.6 mortar, which is intended to take the place of the Coehorn mortar. Like its prototype, this mortar bears the same relation to siege operations that a mountain gun does to field operations. Unfortunately it has been decided to follow the example of the Coehorn in the style of mounting. General Abbott says in his report: "Contrary to the usual theory it was found necessary to use a platform with the Coehorn mortar whenever any accuracy was desired." The smaller mortars used abroad are mounted wholly or partially like a field gun, thus saving the time that would otherwise be expended in building platforms. One great advantage of a mortar is its superior mobility for a given caliber. Lieutenant General von Sauer says: "Shells and shrapnel fired from guns, too, are effective by their burst and splinters, but this effect is different from the effect of burst of shells in vertical fire." "In vertical fire it is otherwise. Here the velocities are small and the shot themselves—and, therefore their internal contents, and bursting charges—larger."* In the old days when the principal siege operation was sapping, small mobile mortars were of great value. At the present time their value seems to be not definitely known. Our field mortar should have the caliber of the light position gun, 5 inches. We should have, to complete the series, a class of 8.5-inch and a class of 10.5-inch.

PROJECTILES.

A very capacious shell even six calibers long has been or is about to be adopted abroad by all of the great powers. The bursting charge is a high explosive. The cast-iron common shell is, except as a range-finder, a thing of the past. This shell

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* "Tactics and Vertical Fire." Journal Royal United Service Institution, January, 1891.

is as a rule to be used against earthworks, &c., but occasionally against animate objects, as the bursting charge gives a high velocity to the fragments. Against animate objects shrapnel is used. The destructive effect of the torpedo shell is so great that it seems to be generally considered abroad that sapping will no longer be necessary.

SIGHTS AND SIGHTING.

This is a most important matter to the artillerist and that we are now in our present deplorable condition is simply owing to the unfortunate quality of our people of refusing or neglecting to learn by experience. In this respect General Abbot's remarks, true in 1866, are worthy of careful attention to-day: "For a sharpshooter's rifle which is not expected to fire more than five or six hundred yards, we supply accurate globe sights and a really fine telescope. For a rifled gun, which is to fire three thousand or four thousand yards, we give sights far coarser than those of any old smooth-bore musket. * * * It may be objected that these sights would be expensive and too delicate for the field. The reply is that they should be as strongly made as possible, and that care corresponding to their value must be used in handling them. They are absolutely essential to accurate firing at long or even ordinary rifle ranges. We place telescopes on surveying instruments and on the rifles of sharpshooters; why not on the rifled siege gun, the ammunition of which is too expensive, too heavy, and of too much importance in the campaign to be wasted? Rifled artillery of the larger calibers can never accomplish what it ought until this matter receives attention."

As siege operations must necessarily be conducted at night an electric lighting plant has been generally supplied to the siege train abroad. The question is now entirely beyond the experimental stage and as one electric light can be fought only by another, their adoption into our service is now necessary.

Some theories have been advanced as to the materiél which will be necessary for the proper conduct of sapping. Of course the sap roller of wood is a thing of the past. The general idea seems to be that works can be made untenable and parapets breached without resorting to the operation of sapping. On account of the accuracy of the curved fire employed and the great angle of fall it is possible to continue the fire at the besieged until the assaulting party are about to enter the breaches.

We see that our next war will involve siege warfare at the outset. We know that the materiél of siege warfare is complicated in its construction and management; that in firing it is necessary to measure or find the range; to calculate the charge for a given angle of fall; to have a system for observing the fire and transmitting the results; to have a system of aiming at an unseen object such that corrections can be made; to have such a knowledge of the atmospheric effects and of the probable error of the gun under service conditions, as to enable the effect to be properly judged; and finally to have that intimate knowledge of the trajectory of the gun which can only be gained by practical experience. We know that the command must be able to construct entrenchments and shelters, must understand the care of horses and of materiél. All these requisites can only be obtained by the equipment and mounting of some of our present foot batteries as siege batteries, and their proper training in time of peace. One to a regiment would not be too many.

As to our materiél, neglecting that which is obsolete, we see that certain parts of it are excellently planned. As to the siege gun the general statement is justified that, in our country, there is no good reason for making a siege gun longer than 18 calibers.

As a proposed system of siege guns we should have (the numbers are approximate):

Cal.	Kind.	Wt. of gun. tbs.	Wt. of shell. tbs.	I. V.
2″.24	R. F.	800	6	2000
5″	Short	1900	45	1300
7″	"	3710	105	1085
8″.5	"	9000	200	1200

The 8.5-inch gun is quite heavy but it has an enormous shell effect which would make itself felt in a siege.

MORTARS.

3″.6	250	20	650
5″	1400	45	850
8″.5	6500	200	850
10″.5	12500	375	850

The light mortars of 3.6 inch caliber are for mountain service and light siege work.

Without discussing the subject of organization, these guns would be distributed as follows:

5″ mortars.—These would be with and form a part of the field artillery.

5″ guns.—These would be the light position guns. Some of them would be near the heads of columns to clear away obstacles.

7″ guns and 8″.5 mortars.—These would form the heavy position guns, or the first échelon of the siege train. They would march immediately in rear of the field army. They would participate in the great battles as well as siege operations of the army.

8″.5 guns and 10″.5 mortars.—These form the second échelon of the siege train and are directed as nearly as may be by rail on the besieged place. The rapid-fire guns form parts of the batteries of the two échelons of the siege train.

A FEW THOUGHTS ON PRACTICAL ARTILLERY.

By First Lieutenant G. N. WHISTLER, Fifth Artillery, U. S. A.

The question which should most interest the officers of artillery is how to obtain the most efficient service from a given gun.

Remember this question does not rely for its solution upon any particular class or grade of guns, but refers as well to the antiquated smooth-bore as to the modern high power rifle.

It is of course natural that we should desire a modern armament, and a more perfect weapon than the old Rodman smooth-bore. The lack of such an armament, and the apparent indifference of our legislators for years past, may explain but cannot excuse the lack of interest shown by many officers of artillery in this all important question.

The true soldier is one who always tries to obtain the best results possible with the means at hand. It is true that our guns are antiquated, our powder old and deteriorated, our projectiles poor, our sighting devices crude and inaccurate; nevertheless there must be a maximum of efficiency obtainable from a given gun, even under these adverse conditions. What reason have we to assume that an officer who can obtain but 60 per cent. of this maximum efficiency, from our present armament, will be able to reach a higher percentage with the modern armament. It is true that 60 per cent. of the maximum efficiency of the modern high power 8″ B. L. rifle may far exceed in practical value 100 per cent. of the efficiency of the present 8″ M. L. rifle. And, therefore, the practical efficiency of the entire service will be increased by a mere improvement in the weapon; but is this enough, will this satisfy our Corps? Are we contented to rest our reputation for accurate artillery work upon the mere improvement in our armament? I think not—and therefore maintain that the question: *How to obtain the most efficient service from a given gun*, is the most important artillery question of to-day. I further maintain that the officer who is unable to obtain over 50 per cent. of efficiency from the old 10-inch Rodman with mammoth powder, will not be likely to obtain more than 50 per cent. of efficiency from any modern high power B. L. rifle with brown prismatic or smokeless powder. Inefficient service, and by this I mean a low percentage of the maximum obtainable from any given gun, is due in the first place to *inattention to details*, secondly to crude instruments and careless and inaccurate use of them; and thirdly, to a lack of knowledge of the fundamental principles of ballistics.

There is undoubtedly another influence tending to induce careless work—Captain Ingalls and other experts have elaborated careful scientific theories, and calculated valuable ballistic tables. And by means of these principles, enthusiastic young officers debarred from practical work, have calculated important practical range tables. Practical artillerists relying upon the ability and accuracy of these experts, with perfect confidence in their calculated tables; go to the firing point all cocked and primed with elevations, allowances, etc., load, aim and fire, and do not strike within 300 yards of the target.

Then they abuse the gun, the powder, the Ordnance Department, and "all others in authority," and are loud in their protestations, at the outrage of expecting an officer to do good work with a weapon that will not work to within 300 yards of what it should do in theory.

Let us note the difference between the theoretical and practical artillerist.

The former, using a theoretical gun, giving a theoretical muzzle velocity, firing a theoretical projectile, into a theoretical atmosphere, with theoretical hygrometric, barometric and thermometric conditions, finds no difficulty in obtaining a theoretical range and hitting a theoretical target.

The latter, using a gun in which the sight seat may be out of place, platform sunk, jump unknown, with pintle loose, top carriage guides not fitting; using a powder the initial velocity of which he does not know; using projectiles no two of which weigh the same; is required to fire into an atmosphere, which never is at the standard, and rarely constant for the entire range, often without barometer, thermometer and hygrometer (and if he has them is unable to apply them); and is disheartened because he does not obtain theoretical results; or more properly (as he does not know what the theoretical should be), because he does not obtain in the actual conditions the result which he should obtain under theoretical conditions.

Do my brother officers consider this far-fetched or offensive? Certainly no offense is intended; let me bring it home to you, by a few questions.

Take the 8″ converted rifle—with ordnance sight.

1. How many of you have adjusted the position of sight seats before beginning practice?

2. How many of you have tested to ascertain whether the line of sight was parallel to the axis of the bore before firing?

3. How many know how to make this latter test?

4. How many have tested level, to see whether either trunnion has sunk before firing?

5. How many have tested the spirit level on breech-sight, and adjusted it before firing?

6. How many know how to make this adjustment?

7. How many have adjusted spirit level on quadrant before firing?

8. How many can tell me exactly how much the particular quadrant used was out in its readings?

9. How many are certain that the same quadrant was used at the same gun, on two successive days?

10. How many have examined pintle key and top carriage guides, to insure as far as practicable the same jump for the same elevation?

11. How many are absolutely sure that the density of loading was the same for each shot?

12. How many have measured length of cartridges to insure that the powder was compressed about the same, each shot?

I could go on and give you question after question, all upon small minor details, but all important; in fact absolutely essential if the maximum efficiency is to be obtained from a given gun.

Circumstances having given me the opportunity to study and experiment with the 8″ converted rifle more than most of my brother officers, I have often thought of preparing a paper setting forth the results of such experience. In this paper I shall use the 8″ M. L. rifle as a model, but my remarks will apply equally well to any other gun, and I shall endeavor to show the principal details which must always be carefully noted, in order to obtain the "*maximum efficiency from any given gun.*"

In order that accurate work may be done, officers will often find it necessary to contrive apparatus which should be, but are not furnished by the Ordnance Department. In this respect the Ordnance Department is not to blame, it cannot be expected to furnish apparatus for the artillery until they know what is needed, and this can only be determined by experiment, *and these experiments must be made by the artillery.*

All the apparatus mentioned in this paper will be such as can readily be constructed at any post. I assume that there will be found at every permanent work, a screw cutting lathe, run by foot or water power, upright blacksmith drill, large breast-drill and an ordinary set of machinist's hand tools. I also assume that each post is now furnished with the articles lately issued for artillery work.

INSPECTION OF GUN AND CARRIAGE.

One of the requirements of existing orders, is the careful inspection of and report upon the condition of gun and carriage, before and after firing, and as the Inspector of Artillery at least in the Department of the East is very particular that such reports shall be rendered, I presume that the inspections are always made. The question is, how intelligently are these inspections made? What is inspected? And what points are important to notice? Presumably the usual inspection is simply to ascertain whether everything is all right. Now there is nothing more essential to accurate work, than these inspections. One of the main difficulties that we have to contend with is the *jump of the gun.* And while it is not known exactly what causes the jump, it is certain that it is a function of the form, construction and general condition of the carriage. While we cannot prevent jump, we should do all in our power to keep it constant. The first point to note is the pintle. The chassis invariably rises and lifts on the pintle, but does not always return to the same position and often the washer or transom jams so that the amount of lift will vary each shot. This should be carefully noted, and if necessary, the transom or washer should be freed by a blow with a handspike; always before the gun is run in battery, as it cannot be done afterwards.

The amount of oil in the cylinder is a matter of great importance; more or less oil is continually leaking out. In practice I invariably directed that the cylinder should be emptied, and the oil measured and be refilled before beginning practice. Of course with the few rounds usually fired in our target practice, once is sufficient, but never rely upon what was done by the battery which preceded you in practice. While the cylinder is empty you have a good opportunity to run the piece in and out of battery and note whether the piston works freely. It often happens that the nut on the head of the piston is jammed too tight, which prevents the piston rod from playing in the transom, and consequently puts a bending stress upon the rod, during recoil;* this should be carefully noted.

Note carefully the front guides on the top carriage, they should not be tight, but must be equally distant from the rail. If one be looser or farther from the rail than the other, the gun is liable to tip toward the tighter guide and thus derange the fire. In a rifled gun there is always a tendency to tip to the left. Examine carefully the left trunnion bed. With an 8" M. L. rifle always drive the key in the sleeve well home, when any tendency to loosen is observed.

Examine carefully the elevating gear, it is almost impossible to put the arc on to the gun so that it will work absolutely true. The result is that the teeth become worn in certain places, the gear jams and will undoubtedly affect the "jump of the gun."

Assembling bolts of transom and guides often work loose, they should always be tightened before beginning practice.

These are some of the points which I have noted in practice. I am confident that there are others which have escaped my attention; but a careful and systematic inspection and examina-

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* [The piston rod of a 15" S. B. gun was broken at Fort Monroe, Va., last summer apparently due to this cause.—ED. JOURNAL.]

tion carried on from year to year, will develop all these points, and not only teach us where to look for trouble, but also enable us to improve the construction of our carriages.

ADJUSTING SIGHTS, SIGHT-SEATS, ETC.

All our sight-seats are fitted by templates and it is mechanically impossible to fit them absolutely accurate; they are often taken off and put on by an ordnance sergeant with but little care to get them in true adjustment. Our sights readily get out of adjustment, and the more perfect the instrument, the easier it is to disarrange and the more important it is to insure accurate adjustment in order to obtain accurate work.

I wish primarily to place myself on record as maintaining the "*sine qua non*" of accurate artillery practice, to be that *each sight should belong to, be adjusted for a particular gun, and never be used on any other.*

No two guns have exactly the same inclination of the trunnion; no two platforms are exactly at the same level or out of level; no two sight-seats are in exactly the same position; and therefore no sight can be adjusted for use on more than one gun.

Each sight should be adjusted for a particular gun, be marked as belonging to that gun and be used on no other.

The first desideratum is a good *leveling bench,* upon which all levels may be adjusted.

The Ordnance Department should furnish one for each permanent work. It should consist of a solid casting, having sockets and seats attached for all service sights, fitted with ordinary leveling screws and sensitive levels, like transits. This should be permanently attached to the solid masonry of the work and be used for adjusting sights, levels, quadrants, etc.

In the absence of such instruments, a good plane table may be used, if it is provided with leveling device. A rough one can be constructed as follows:

Upon some part of the masonry fit a strong wooden frame; into this frame insert sockets and round headed screws, three in number, so arranged that they may easily be raised or lowered. These can be made on any screw-cutting lathe. Upon these screws place a slab of slate or stone. By means of a good level which can always be obtained at the post, this slab may be adjusted to the true level at any time, of course using ordinary precaution of reversing the level to insure accuracy. On such a slab, most, although not all of the levels, used in artillery work can be adjusted. The remainder must be adjusted on the gun itself using a pre-adjusted level, to level the gun.

TO LEVEL THE GUN.

This may at first appear to be a simple operation, but it is one of great difficulty to perform accurately.

The bore of a rifled gun cannot be used with accuracy, and the face of the muzzle is inaccurate, as in order to insure success, the level placed against it must be absolutely vertical.

Every gun should be, but is not, fitted with a flat surface, parallel to the axis of the bore, for this purpose.

The best device I know of is constructed as follows:

Have two disks turned a little larger than the caliber of the gun. Through the center points drill a hole in each disk about 1¼ inches in diameter. Shrink the disks over a central shaft, which will extend six inches beyond one of the disks, distance between disks about two feet. Place the whole device in the lathe, and turn the disks to the exact diameter of the bore, and turn the shaft absolutely concentric with the disks. Take off the levels from two old fashioned quadrants, and fit them to this device (they can readily be replaced upon the quadrants). One of these levels which we will call the *shaft level* is fitted on the shaft, on the end which projects beyond the disk. This can be accurately done in the lathe. The other level is fitted on the disk nearest to the end of the shaft which projects and at exact right angles to the *shaft level*, this also can be accurately done in the lathe. The instrument is now complete.

Take this instrument to the levelling bed and adjust both levels. Insert it in the muzzle of the gun, the end having the two levels to the front.

Turn the instrument until the cross-level has the bubble in the center, and then level the gun by the shaft level. It may then be found that the cross-level is out, if so turn the instrument until it is "true" and level again. Remember the gun is not level until both levels are "true"; if this condition cannot be obtained, it is evident that your instrument is not in adjustment, take it back to the bench and adjust it. As all sight adjustments depend upon exact leveling of the gun, one cannot be too particular about this adjustment.

TO ADJUST THE ORDNANCE SIGHT.

The only adjustment for the sight proper is the level. Were properly constructed level-benches furnished, it would merely be necessary to insert the sight in the proper socket, level the bench and then adjust the sight level.

In absence of any such instrument the following method is suggested. Set up a light gin in front of the gun, and from it suspend a shot by a strong wire as a plumb-bob. Set your sight in its socket running the sight piece up to the top of the sight: level the gun and aim on the wire of the plumb-bob; be sure the gun is level; and also the sight; now drop the sight piece to the bottom, being careful to maintain the sight level; note whether in this position the gun is still sighted on the wire; if it is not, the sight piece has not dropped vertically, therefore your sight is not vertical and your level needs adjustment. If the aim has passed to the left of the wire, the left side of the level needs raising and *vice versa*. Adjust your level until the sight piece may be moved up and down the sight, without the aim passing off the wire. In other words so adjust your level that the center line of the rear sight shall lie wholly in the vertical plane, passing through the front sight and plumb-bob.

To adjust the line of sight.—Establish a line of metal, after having carefully leveled the gun. Using this line of metal, aim on some distant point, preferably one at a distance three times the range of the gun, now look through the sight and tap the front sight with a mallet to the right or left until the line of sight is on the same point.

It is manifest that at the maximum range of the gun, the line of sight will be out only ⅓ of the distance from the sight-seat to the axis of the bore, which is but a few inches. This is sufficiently accurate for all practical purpose. In practice I have found sights put on by the ordnance templates to be out sufficiently to make a difference of 15 or 20 yards for every 1000 yards of range.

To determine the error due to the axis of the trunnions not being in a horizontal plane:

Level the gun and sight on a distant object; elevate the gun 2°, raise the sight piece and note how many points it is necessary to move the sight to the right or left, in order to bring the line of sight upon the object. Perform the same operation for 5°, 7°, 9°, etc. Having several points, a curve can readily be constructed which will give the error of the gun for any elevation. This information is of *no value* when the rear sight is used, but it is *absolutely essential* when firing is done at squares. For practice at squares or any other system when the gun is pointed by the azimuth angle, this error must always be allowed for.

TO ADJUST THE ZALINSKI SIGHT AND SEAT.

Clean the left trunnion face as clean as possible, using acids to remove all paint, etc. Bore the holes as true as possible by templates; screw on the seat; leveling as accurately as you can. Level the gun, aim on some distant object by the ordnance sight; now place the Zalinski sight in position and looking through the search tube ascertain whether the cross hairs are also on the distant object. If not adjust the seat by inserting pieces of tin foil, between the seat and the trunnion, until the correct alignment is obtained. After removing the sight, pour strong acid between the seat and the face of the trunnion, to clean the surface, and then fill in with soft solder; repaint the face of the trunnion immediately, to prevent rust. Adjust the longitudinal level of the Zalinski sight at the leveling bench. Place the sight on the seat, level the gun and, if necessary, file the seat until the bubble of the longitudinal level is in the center. The seat is now in adjustment.

To bring the axis of the telescope parallel with the axis of the seat.

Place the sight in position, level the gun and also the instrument, traverse the gun until the cross hairs of the search tube are on some distant object, or preferably the long plumb-bob, now note whether the cross hairs of the telescope are on the same object; if not adjust until they are. This of course is only approximate, unless the cross level of the instrument is in adjustment, and must be repeated after the latter is adjusted.

To adjust the cross level.—Level the gun and the sight, aim upon distant object by the ordnance sight, be sure that gun and Zalinski sight are level. Note whether the cross hairs of the sight are upon the same object, if not take points to the left or right until they are; note this reading as it is a constant correction which must always be used with this gun. Now elevate the gun 7°; then by the ordnance sight bring the gun back upon the distant object. Note whether the cross hairs of the sight are on the object, if not adjust cross level, and re-level until they are. Repeat the operation until with a given constant lateral deviation the cross hairs of the telescope will be on the distant object; when the gun is pointed thereon, whatever may be the elevation of the piece.

This constant lateral deviation is the measure of the inclination of the sight-seat and trunnions, and as it will always be a constant which must be allowed for, should be marked on the gun. It is manifestly better to allow for this error, rather than to attempt to correct it, as your means of correction will always be crude as compared with the facility with which it may be allowed for on the sight.

We thus have two important corrections: 1st. The correction for inclination of the trunnions or sight-seats. This correction must always be made when the sight is used; but is not required to be considered when firing at squares. 2nd. The correction for axis of trunnions not being horizontal. This correction need not be made when the sight is used but must always be made when firing at squares. The gun should be tested frequently and the curve of allowance for this error accurately determined.

AMMUNITION.

The next important question is the preparation of ammunition. Every officer should be familiar with the proper grade of powder to be used in each gun. I have prepared a table which is appended to this paper; which, together with the remarks attached, gives the necessary information for the 8″ M. L. rifle.

Let us now consider the subject as applicable to this particular gun. I fear that the majority of our officers, while they know that a hexagonal or sphero-hexagonal powder is used in the gun, are not informed as to what particular grades of these powders are suited to the gun.

The ordnance sergeant reports that he has several grades of hexagonal and sphero-hexagonal on hand, and wishes to know which to use.

An examination shows the following grades in the magazine:

K.H.C.	Hexagonal,	Granulation	123.	Sp. Grav.	1.775
E.V.N.	"	"	72.	"	1.750
E.V.F.	"	"	72.	"	1.750
O.B.	"	"	123.	"	1.725
O.C.	"	"	123.	"	1.750
F.P.B.	"	"	67.	"	1.750
M.W.	"	"	123.	"	1.725
I.T.	"	"	30.	"	1.728
O.V.	Sphero-Hex.	"	100.	"	1.750
O.X.	"	"	100.	"	1.795

With a charge of 35 lbs. and 90 per cent. density of loading, the following results would be obtained with these different powders, all being new:

K.H.C.	M. Velocity	1367	ft. sec.	Pressure	30666	lbs.	per sq. in.
E.V.N.	"	1366	"	"	30480	"	"
E.V.F.	"	1367	"	"	30600	"	"
O.B.	"	1380	"	"	33000	"	"
O.C.	"	1325	"	"	25700	"	"
F.P.B.	"	1130	"	"	18000	"	"
I.T.	"	1000	"	"	17000	"	"
O.V.	"	1383	"	"	33500	"	"
O.X.	"	1330	"	"	27000	"	"
M.W.	"	1391	"	"	35800	"	"

The proper conditions for the gun are muzzle velocity from 1370 to 1400 ft. sec., pressure not to exceed 34000 lbs. per sq. inch.

The following grades are suitable in the order here given:—O.V.—O.B.—K.H.C.—E.V.F.—E.V.N.

It would be useless to use F.P.W. or I.T. as the shot would not take the grooves.

O.C. and O.X. might be used but the velocity would be low. The proper charge for these powders is about 39 lbs.

M.W. gives entirely too high pressure for the gun.

For the 8″ M. L. rifle the granulation should lie between 72 and 123. With sp. gravities from 1.750 to 1.775.

A granulation of 72 should go with a sp. gravity of 1.750 and 123 with 1.775.

Thus M.W. has a granulation of 72, but as the sp. gravity is 1.725, it is too quick for the gun, but may be used with lower density of loading.

F.P.W. has a granulation 67 to the pound and is therefore too slow, although the sp. gravity is 1.750.

O.X. has a granulation of 100, but its sp. gravity of 1.795 makes it too slow for the gun.

A granulation of 100 to the pound and a sp. gravity of 1.750 will give the best results.

There is however another difficulty to be met with which tends to discourage officers, and that is the deterioration of gun powder, which is often so great that the results obtained are simply ridiculous.

I will give an example from my own experience. We had at Fort Wadsworth some E.V.N. powder manufactured in 1881 which we were to use in the 8″ M. L. rifle.

Considering myself quite an artillery sharp, I determined to show my brother officers how to do it, scientifically. So I carefully searched the Ordnance Reports until I found the test of this powder in 1881, it was then 1888. I found they had obtained a velocity of 1367 ft. sec. with a pressure of 30500 lbs. per square inch—I carefully worked out a range table by Ingalls's method, allowed for barometer, thermometer, etc., and at my first shot at 2000 yd. range I gave the elevation for a velocity of 1367 ft. sec., making all scientific allowances. You can imagine my sensation when the shot fell 325 yds. short. *Scientific artillery practice was below par.*

Some of this powder was sent to Sandy Hook and tested, and they obtained a velocity of 1221 ft. sec. and a pressure of but 19000 lbs. per sq. in.

The deterioration in seven years had been so great, that the velocity had been reduced from 1367 to 1221 ft. sec. and the pressure from 30500 to 19000 lbs. per sq. inch.

Nevertheless since that time I have made magnificent shooting with that same powder. Battery "K," 2nd Artillery, with this same powder struck the target five times out of the six shots allowed.

An analysis of the above results gives the following:

In 1881—the characteristics were as follows:

Pressure characteristic	1.5175
Velocity characteristic	0.7676
Force	1.0089
Time of burning	1.3144

In 1888 they were as follows:

Pressure characteristic	1.1994
Velocity characteristic	0.4795
Force	0.9691
Time of burning	2.0210

The principal change is the time of burning, due probably to absorption of moisture.

The variation in force was not necessarily due to any chemical change in the powder; the amount of fixed gas was probably the same in both cases, but the amount of heat developed by the deteriorated powder was probably much less than when the powder was new.

The chief difficulty to contend with is the lack of uniformity in old powder, we have no certainty that any two barrels will give the same results or even approximately the same.

I would therefore suggest the following plan. At all of our permanent works, there should be a large leather mixing barrel mounted on a wooden axle. This barrel should be large enough to hold eight or ten barrels of powder. Once every year all the powder of any particular grade should be emptied into this mixer and be thoroughly mixed and repacked in the original barrels. After which a test should be made, of at least two charges from each lot; and the barrels should be marked with the gun for which it was intended; muzzle velocity obtained therein with regulation charge; and its characteristic. The object of marking characteristic on the barrel is, that in case the powder is to be used in a gun of different caliber from the one in which it was tried, the probable pressure and velocity which it will give will readily be ascertained.

I would use a single characteristic. Thus for all hexagonal and sphero-hexagonal black powders, we may consider the force as equal to unity, and the coefficients depending upon form of grain are 3 and 1. Therefore Sarrau's formula for this grade of powder becomes:

$$\beta = \frac{a^2}{3}$$

We may therefore substitute this value for β in all the formulæ and consequently (a) will be our *sole characteristic.* This will materially simplify all the practical formulæ of interior ballistics. Thus for the 8″ M. L. rifle with regulation charge powder 35 lbs. and shot 183 lbs., reduces to the following:

Max. pressure $= Q a^2$ In which $\log Q = 4.12264$

Muzzle velocity $= Ma - Na^3$ In which $\log M = 3.08419$
and $\log N = 2.13372$

In both cases the density of loading is taken at 0.90, which corresponds to seating the base of the shot $22\frac{1}{4}$ inches from the bottom of the bore.

When the shot is seated 24 inches from the bottom of the bore, the density of loading is is 0.853.

When $\log Q = 4.09906$
$\log M = 3.07526$
$\log N = 2.12073$

For any other weight of shot Q varies directly as the $\frac{3}{4}$ power of the weight of the projectile, and M as the $\frac{1}{4}$ power of the weight of the projectile. The value of N is not affected by weight of shot.

Appended will be found a table which gives first the approximate muzzle velocity and maximum pressure, that will be obtained in an 8″ M. L. rifle with the regulation charge, for powders varying from one in which log $a = 0.22000$ to one in which log $a = 0.07500$. This is given for a shot seated 22¼ inches from the bottom of the bore, and for a shot seated 24 inches from the bottom of the bore. In the last column is given the charge of powder necessary to produce the standard muzzle velocity of 1370 ft. sec. See remarks following table.

EXAMPLE.

All the powder for the 8″ M. L. rifle is used up—there is in the magazine however a haxagonal powder for which log $a = 0.14549$. What initial velocity will be obtained in the 8″ M. L. rifle if we use a charge of 35 lbs. of this powder and 90 per cent. density of loading, and what is the proper charge in order to obtain the standard velocity? From the table we find that log $a = 0.14500$ will give a pressure of 25861 lbs. per sq. in. and 1326 ft. sec. muzzle velocity. The dif. for pressure is 602 and for velocity 6. $602 \times \frac{49}{500} = 60$
$25861 + 60 = 25921$ lbs. per sq. inch. $6 \times \frac{49}{500} = 0.6$
$1326 + 0.6 = 1326.6$ ft. sec.

This powder will therefore give a velocity of 1327 ft. sec. and a maximum pressure of 25921 lbs. per sq. inch. The proper charge to use in order to obtain 1370 ft. sec. velocity would be 38 lbs. 5 oz.

The E.V.N. powder which had deteriorated so much, had for a characteristic log $a = 0.07895$, the proper charge therefore would have been about 47 lbs.

DENSITY OF LOADING.

The density of loading plays a very important part in obtaining accurate results from our guns, particularly from muzzle-loading guns. An examination of Sarrau's formulæ will show that the velocity is an increasing function both of the density of loading and of the travel of the shot. Now in a muzzle-loading gun, any variation in the position of the shot alters both the density of loading and the travel of the shot, and materially varies the muzzle velocity. An examination of the table will show that a variation of less than two inches in the position of the shot makes a difference of 40 ft. per second in the velocity. At a range of 3000 yds. this means a difference in range of 100 yds. or thereabouts.

As our cartridges when loaded are about 24 inches long, the most convenient condition of loading is with the base of the shot 24 inches from the bottom of the bore. A slight alteration in the width of the cartridge bag would admit of seating the shot 22¼ inches from the bottom of the bore, which would be a considerable advantage. The table shows, that with 22¼-inch loading a velocity of 1385 ft. sec. is obtainable with a pressure of 34091 ℔s. per sq. inch; with 24-inch loading the same, or nearly the same pressure gives only 1368 ft. sec. velocity.

It is true that the shot with our present cartridges can be forced back to 22¼ inches, but it will not stay there. The spring of the bag will send it forward and uniform results cannot be obtained; in addition to this the pressure on the bag will vary the ignition.

Great lack of uniformity was found to result from the following conditions: the cartridge bags are all cut to the same size, but in sewing them up, the seam is sometimes a quarter and sometimes a half inch from the edge, the result is a cartridge is sometimes over 24 inches long, which prevents obtaining uniform density of loading.

It was also found that in our muzzle loading rifles, the position of the shot would be changed by elevating the piece. In order therefore to insure uniformity, the shot was seated at about 30 inches; the piece was then elevated and aimed, and then the shot sent carefully home. A very simple device can be constructed for insuring a uniform density of loading. It consists merely of a rammer-rest of wrought-iron, constructed somewhat like a strap hinge. One part is attached to the side of the gun near the muzzle by screws, the other part, which is a long bar, swings in front of and across the muzzle and is held in position by a latch attached to the side of the gun, on the side opposite to the hinge. This bar is swung in front of the muzzle while ramming the shot; is swung back out of the way, when inserting cartridges or shot. and is swung entirely back against the side of the piece when firing, where it is held by a catch. In the center of the rest, there is cut away a semicircular notch to receive the rammer, the center of notch being in the center of the bore. Through the rammer staff is a pin, which permits the rammer to go only so far in, when the rest is in position.

The notch insures the centering of the rammer and the pin insures uniform density of loading. When ramming the cartridge the rest is swung out of the way, so as to allow the rammer to go well home.

This is a far better device than the one furnished by the Ordnance Department, of a long pin through the rammer staff, which strikes against the face of the muzzle. In the first place this does not insure a uniform density of loading unless the rammer is always maintained in the center of the bore, and secondly these long pins always become bent. This muzzle rest is about the same thing as the muzzle rest for the star guage.

In conclusion I will give a few examples of the uniformity in range obtained when these details are carefully observed:

8″ M. L. RIFLE.

Angle of Elevation 5° 00′.

1st shot:	Range,	2860	yds.
2nd "	"	2882	"
3rd "	"	2864	"
4th "	"	2861	"
5th "	"	2862	"
6th "	"	2850	"
	Mean Range:	2862	"

Fired at Fort Wadsworth, N. Y. H.

IMPORTANCE OF ATMOSPHERIC VARIATIONS.

In order to insure accurate work it is exceedingly important to note carefully the atmospheric conditions.

I can best show this by a simple case.

We are firing at 3000 yd. range in the morning, barometer 29″, thermometer 80°; it cools off to 70° thermometer, and the barometer rises to 30″ while at dinner and before the afternoon firing. Now this is an ordinary change and which would simply be perceptible to the senses. Nevertheless this change in atmospheric condition would vary the range 35 yds. A head wind of

10 miles per hour, which is a very light breeze will shorten the range 20 yds. Therefore if with the above atmospheric conditions we had a rear wind in the morning and a head wind in the afternoon, of only ten miles per hour, the entire variation in range due to these conditions would be 75 yds.

Thus a battery stops firing at recall having just *hit the target*, returning in the afternoon find but slight apparent change in condition except that the light breeze is now blowing from the tront instead of from in rear. The same elevation is taken and the shot falls 75 yds. shot. "*Of course it is all the fault of the powder*," or the gun is not worth a "continental."

In this connection I would call attention to my Graphic Method, of Tables of Fire, by which all these allowances may readily be made, and which has lately been published by the War Department.

My purpose in this paper is to bring these practical ideas to the attention of my brother officers, recognizing them to be incomplete; but hoping that a discussion of the subject may lead to a more careful system of observation and study, looking to the improvement of Practical Artillery.

TABLE.

Approximate muzzle velocity and maximum powder pressures that will be obtained in the 8″ M. L. Rifle with regulation charge. *Powder 35 lbs. Shot 183 lbs.*; for various grades of powder. Also maximum charge of powder which can be used with safety in the gun, in order to obtain 1370 ft. sec. velocity. Maximum safe pressure, 34000 lbs. per sq. inch.

REMARKS ON TABLE.

The values of log *a* for American powders suitable for use in this gun lie between 0.22000 and 0.14000, when the powders are new. The muzzle velocities will therefore lie between 1400 and 1300 ft. sec. The average result with good powder is about 1370 ft. sec. The best about 1404 ft. sec.

Tidball's Manual gives a muzzle velocity of 1430 ft. sec. with a maximum pressure of 33000 lbs. per sq. inch. I can find no American powders which theoretically should give any such results, nor can I find any records in Ordnance Reports which justify any such expectations.

In the experiments with 8″ rifle No. 1, the best results obtained were 1407 ft. sec. with a pressure of 34081 lbs, per sq. inch, and the mean of all their tests gave a velocity of 1370 ft. sec. There were but two shots which in any way approximated to the statement in the Manual. I therefore consider that 1404 ft. sec. velocity and 34000 lbs. per sq. in. may be considered the maximum, and 1370 ft. sec. as the ordinary standard velocity for this gun.

Characteristic of powder, log *a*.	Base of shot 22¾ inches from bottom of bore. Density of Loading .90.				Base of shot 24 inches from bottom of bore. Density of Loading .853.				Maximum Charge.	
	Pressure lbs. per sq. in.	Diff.	Velocity ft. sec.	Diff.	Pressure lbs. per sq. in.	Diff.	Velocity ft. sec.	Diff.	lbs.	ozs.
0.22000	Pressure	too	high.		34599		1370		35	0
0.21500	"	"	"		33811	788	1368	2	35	0
0.21000	"	"	"		33042	769	1365	3	35	1
0.20500	34091		1385		32290	752	1362	3	35	2
0.20000	33315	776	1382	3	31555	735	1359	3	35	3
0.19500	32557	758	1379	3	30836	719	1355	4	35	4
0.19000	31816	741	1375	4	30134	702	1351	4	35	8
0.18500	31092	724	1370	5	29448	686	1347	4	35	12
0.18000	30384	718	1365	5	28778	670	1342	5	36	0
0.17500	29692	692	1360	5	28123	655	1337	5	36	4
0.17000	29016	676	1355	5	27483	640	1332	5	30	8
0.16500	28356	660	1350	5	26875	608	1326	6	36	12
0.16000	27710	646	1344	6	26246	629	1320	6	37	0
0.15500	27080	630	1338	6	25649	597	1314	6	37	5
0.15000	26463	617	1332	6	25065	584	1308	6	37	13
0.14500	25861	602	1326	6	24484	581	1301	7	38	5
0.14000	25272	589	1320	6	23937	547	1294	7	38	13
0.13500	24690	576	1313	7	23392	545	1287	7	39	5
0.13000	24135	561	1306	7	22859	533	1280	7	39	13
0.12500	23585	550	1298	8	22339	520	1273	7	40	6
0.12000	23049	536	1290	8	21831	508	1265	8	41	0
0.11500	22524	525	1282	8	21334	497	1257	8	41	11
0.11000	22011	513	1274	8	20848	486	1249	8	42	6
0.10500	21510	501	1266	8	20373	475	1241	8	43	1
0.10000	21021	489	1258	8	19910	463	1233	8	43	14
0.09500	20542	479	1250	8	19457	453	1225	8	44	9
0.09000	20074	468	1242	8	19014	443	1217	8	45	8
0.08500	19618	456	1234	8	18581	433	1209	8	46	5
0.08000	19171	447	1225	9	18158	423	1200	9	47	3
0.07500	18735	436	1216	9	17745	413	1191	9	48	2

I have taken 34000 lbs. per sq. inch as the maximum pressure which should be used in this gun, and have given values for log *a* down to 0.07500, which allows for great deterioration; powder below this should not be used, at least not with the service charge, as it is useless to fire this gun with less than 1200 ft. sec. muzzle velocity.

It is manifest that for powders the characteristic of which exceeds 0.18000, 22-inch density of loading should not be used, as the pressure would be too high.

It is preferable to set the shot home only to 24 inches from the bottom of the bore, this gives a density of 85.3 per cent., and is readily attainable, with uniformity; if the shot is set further home the cartridge is compressed and uniformity is difficult to obtain.

The following list of powders may be serviceable:

Best Grades.

Du Pont's	E.V.N.	Hex.	Gran.	72	log	$a = 0.18113$
"	E.V.F.	"	"	72	"	0.19530
"	O.B.	"	"	123	"	0.19747
"	P.G.	Sphero. Hex.	"	100	"	0.19038
"	P.T.	" "	"	100	"	0.17962

Inferior Grades.

Du Pont's	O.C.	Hex.	Gran.	123	log	$a = 0.14412$
"	O.X.	Sphero. Hex.	"	100	"	0.14820

Powders which give extreme pressures:

Du Pont's	O.V.	Sphero. Hex.	Gran.	100	log	$a = 0.20172$
"	O.V$_1$	" "	"	100	"	0.20958
"	O.V$_2$	" "	"	100	"	0.21579

While it might not be wise to use the O.V. powders in target practice, they may safely be used in action, as the gun is well able to stand the pressure.

TARGET PRACTICE.

By First Lieutenant HENRY C. DAVIS, Third Artillery, U. S. A.

"If we do not attain more than 75 per cent. efficiency with the old material, we shall not attain so great a degree with the new."*

This seems a rather startling announcement when made with reference to the handling of our war material, but sober thought will make the truth of this apparent. Any avoidable variation in loading and laying a gun, due to carelessness, oversight or ignorance, which gives a shot an absolute deviation at a given range, of say one yard, is evidently of far less importance when the probable error of the gun is fifteen yards, than when such error is but two yards. In the first case, the error, due to carelessness, &c., is but seven per cent., while in the latter it is fifty per cent. of the probable error. The former is the case of the old and the latter that of the new material. In short, the new guns, having inherently a greater accuracy than the old, respond all the more readily to any change in the conditions of firing, whether made intentionally or through inadvertance and lack of skill. By trusting to luck, instead of to painstaking and intelligent care, that the conditions for successive shots remain the same, the resulting errors, possibly relatively small for the old, become very important for the new guns, with the result that the efficiency attained in handling our tools decreases in proportion as the inherent efficiency of the tools increases. When viewed in this light the truth of the above proposition is evident.

How many officers have heard the statement: "Why fritter away time on the old material, which is worthless; why not wait till we get the new?" This is human, and, at first, seems excusable. The artillerist knows, that with all care possible in handling

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* Lieutenant Whistler's lecture at Fort Monroe, Va.

the old 8" converted rifle, he cannot approach the accuracy which will be attained in firing the corresponding new one, even though he handle it with relative carelessness. He will think rather of the gain in accuracy than of the actual loss of efficiency in handling; he will think rather of his getting nearer the target, than of the fact that he is, relatively, shooting worse. On the other hand, if there is an accurate knowledge of the maximum efficiency of the guns now in use, and of the degree of proficiency attainable in handling them, the artillerist will readily perceive when he tries the new, whether he is really getting better or worse results than he did with the old—whether he has advanced with the improvement in the material or whether he has really gone backward. Some of this necessary information is attainable from theoretical considerations, but a great deal must be gotten at the gun. And here let us note that, in studying the gun, the great desideratum is not *how many shots may be fired in an afternoon, but how much intelligence may be exercised in the few that are fired.*

"This makes target practice too tiresome," some one says, The writer knows from experience that there are many more pleasant occupations than that of spending an afternoon at the end of a base-line, but if any officer finds his necessary professional duty too irksome there is a sure remedy. It is generally known that a *soldier* never grumbles at hard work or privations when he feels that something is being gained thereby; otherewise he yields his time and labor grudgingly and hence less efficiently.

When the writer first entered the service, the artillery was in the depths; it was practically red-legged infantry and his first experience of army life was gained in attendance from morning till night on the small arms target range. Although somewhat out of the line of artillery work, this was an experience, and every experience should teach a lesson. Look at the infantry of to-day and compare it with that of a dozen years ago. Compare its efficiency in handling its weapon to-day with that it attained to in the days when the old guard fired its volley into the clay bank. Ask the infantry officer, or the older artillery officer for that matter, how many times he has spent the whole day on the small arms range or in the gallery; ask him if he considered this work thrown away so far as the general results are concerned.

Now for our own arm. Are we striving as patiently and as persistently for improvement as did our friends the infantry? Are we utilizing to the *best advantage* all the opportunities afforded under the newer conditions? Are we advancing as rapidly as we should, and, finally, are we ready for the new guns for which we are clamoring?

At present the artillery is more concentrated than it has been for many years, but already there are rumors of a scattering anew. The larger the garrisons, the denser is the professional atmosphere, and the greater is the tendency to absorb knowledge even for those not naturally addicted to work and study. To-day is our school time for practical work, the time to get started on new lines, the time for laying together of heads to learn how to shoot and hit, not for theoretical work alone, which is of great importance, but for practically learning that which we should know. Now is the time to learn how to apply our theory and how to correct it in the light of practical experience. We have all heard, doubtless to satiety of Prince Kraft's three rules, but for all that they are gospel truths.

To attain the desired proficiency, it is necessary that we engage in gun practice, and this should be divided into three distinct parts;—*ballistic firing*, *target firing*, and *tactical firing*.

Ballistic firing.—The object of this is to give the artillerist an opportunity to thoroughly study his gun, to learn *how* to study it, to know what to expect of it under similar conditions and also to know the nature and extent of the corrections necessary when different conditions are imposed. In the firing it is *better to miss the target and learn why, than to hit it accidentally*. Who of us has not, on the small arms range, stood over a man who skilfully alternated his bull's-eyes with zeros, or twos, and feeling the hopelessness of the case, turned with relief to observe and encourage his companion who rarely made a bull's-eye and just as seldom made less than centers? Was there any doubt as to which was the better marksman? So with gun practice; that artillerist, who, knowing the error of his gun, keeps within it, is far ahead of him who does not know his gun, but occasionally destroys a target. Every artillery officer has Captain Ingalls's hand-book and feels that he has the results of the latest study on ballistics, also that he is prepared to solve any ordinary problem in gunnery, provided he has the necessary data. Lieutenant Whistler has made, from his own and Captain Ingalls's formulas, a chart for the 8″ converted rifle which makes the solution of problems for that gun very simple, provided the necessary data is given. The principal quantities which enter these problems are range, elevation, initial velocity, and jump. The first is given by range-finding, however executed; the second is obtained by calculations involving the remaining two; the third and fourth are obtained—where? The Ordnance Department completes its work when the guns and powder are turned over to the artillery. A certain grade of powder is furnished, amply marked on the barrel with kind, date of manufacture, &c., &c., for use, say, with the 8″ rifle. The charge to be used and the initial velocity obtained under trial are also given. We have curves of jump for this gun from both Captain Ingalls and Lieutenant Whistler. Apparently then nothing remains but the calculate reliable range tables for this rifle.

Have we such tables? There is one in Tidball's Manual, based on an initial velocity of 1430 f. s. This table, probably correct as far as it goes, does not seem to have satisfied those handling the guns; for we find, at Fort Monroe, a later table, computed by a student officer, based on an initial velocity of 1252 f.s. and giving jump as 29′. The introduction of jump was a step in the right direction, but the table did not fill the requirements, inasmuch as it assumed a certain initial velocity, and, so long as this initial was not obtained, the table did not apply.

The next advance toward practical tables of fire were made by Major Rodgers. They apply to the 8″ converted rifle and the 15″ S. B. These tables give ranges and elevations corresponding to standard initial velocities, weights, &c., &c., accompanied by coefficients of reduction in case of variation from these standards. These tables also give the allowance for jump at three elevations. These allowances for the 8″ C. R. correspond to those given by Captain Ingalls's jump curve. The most complete and most easily applied range table that has yet appeared is Lieutenant Whistler's graphic table of fire for the 8″ converted rifle. It differs from Major Rodgers's table in that it gives a graphical presentation of the problems to be solved, and hence insures rapidity of solution and continuity of results; it also gives a jump curve deduced from actual firing records.*

Complete as this table is, there is still a gap. Knowing beforehand the initial velocity, we may enter the table with fair prospects of getting the correct elevation. But can we know this beforehand? Lieutenant Whistler's method of reduced velocities depends on the assumption that all errors arise from variations in initial velocity. In the absence of a thorough knowledge of the causes of variations in range under supposed similar conditions, this assumption is probably as practical a solution as any; still it assumes that we may confidently expect to reproduce in a second shot the same velocity as in the first. Is this the case? Records of firing will show that it is not. In the ordinary target practice it often occurs that a shot strikes so close to the target that the officer in charge determines to fire the next with the same elevation and with a resulting hit at a distance of anywhere from 10 to 100 yards from the preceding one. Is it uncommon to hear that "I gave two minutes more elevation and the range was seventy-five yards less."

While this state of affairs exists, any range table, however correct and complete, will be of little value. Being dumb, neither the gun nor the range table can retaliate by declaring that failure is due as much, if not more, to the ignorance of the operator as to their own inaccuracies. Evidently then, the first thing the artillerist must learn is to be able to reproduce all the conditions over which he has control, and to recognize and appreciate any changes in those beyond his control. When this is accomplished, and not till then, he may expect good results from the use of good range tables.

The only place to acquire this information is at the gun and hence the necessity for what is here termed Ballistic Firing.

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* This firing was done in season and out, in hot weather and cold, and under many discouraging conditions. Sometimes *but one shot was fired during the day*. (Learned from officers who assisted in the work). This is the kind of work the writer pleads for, and the inside history of this firing, as well as that cited later, shows that when undertaken, it need not fail from lack of assistance from a sufficient number of officers, willing to work *out of hours*.

A FEW POINTS.

It was proposed, in June, 1892, to fire, from the 8″ converted rifles at Fort Monroe, a few shots to test the applicability of Lieutenant Whistler s graphic table, particularly with reference to the practicability of his reduced velocity method. Recognizing the difficulty of reproducing conditions and the necessity for this in applying the reduced velocity method, the writer requested an extension of the programme. It was extended and the scope is set forth in a report of Captain Mills, 5th Artillery, instructor of practical exercises. The following extracts are from this report:

"The objects of these experiments were to determine the initial velocities of the different powders that we were to use this summer with the different sea-coast guns—viz: the 8″ C. R., 15″ S. B. and the 10″ S. B., that we might have more reliable data to guide us in the usual target practice; also to verify the accuracy of Whistler's Graphic Tables for the 8″ rifles, and further to obtain some experience in ballistic firing with *heavy guns which the student-officers do not receive.*

"All the student-officers voluntarily gave me their services, but only a few could be advantageously used all the time. I desire to call attention to the intelligent zeal, interest and unceasing hours of labor enthusiastically given by those whose services were utilized.

"The general objects of these experiments were:—

"*First.*—To find the initial velocities of all shots fired, then to determine if the powder and gun would give uniform velocities.

"*Second.*—To fire five (or more) shots at each of the several ranges, under as nearly identical conditions as possible and, after correcting for variations in atmospheric conditions, &c., to find the center of impact of each group of shots. From this, by applying Captain Ingalls's tables, as given in Lieutenant Whistler's diagrams, to find the necessary corrections (jump &c.) to be applied to the tabulated elevations for any given range; thus completing and adapting Whistler's diagram to these particular guns.

"*Third.*—To note carefully lateral deviations for data as to wind and drift corrections.

"*Fourth.*—To vary the controllable conditions as to amount of moisture and absolute density of the powder, and density of loading; and to find from these results data for future estimates.

"This was carried out generally as follows:—

"*First.*—A sufficient quantity of powder for all experiments with the 8″ C. R. was thoroughly mixed.

"*Second.*—Carefully weighed cartridges (weighed on the standard scales in the Densimeter Room) were made up each day as needed, and tied in a uniform manner.

"*Third.*—Projectiles of the same weight, for each group of shots, were carefully selected and weighed.

"*Fourth.*—For each shot there was observed and recorded the following:—

"(*a*). Absolute density and moisture of powder,
"(*b*). Weight of charge and shot and density of loading,
"(*c*). Thermometer, barometer and hygrometer,
"(*d*). Velocity and direction of the wind,
"(*e*). Angle of elevation,
"(*f*). Range, deviation and time of flight,
"(*g*). Initial velocity."

Captain Mills then gives the organization of, and instructions to the personnel for this work. This is omitted here as the object of this article is to *arouse* interest in this kind of work rather than to suggest how the work should be done.

Before giving further extracts, attention is called to the fact that the shortness of time available, in this case, both for preparation for and execution of this programme, prevented the obtaining of all the useful information desired, but the experience gained as to the methods to be adopted and the arrangement of details for obtaining the desired end, was very valuable.

Owing to absence of favorable conditions (which could be obtained in future) no accurate data as to deviations was obtained. The ranges were obtained by using a single base-line. Several anomalous and unaccountable variations in observed ranges led, in subsequent firing, to the establishing of a third observation station: The necessity for these additional observations was clearly indicated by the results.

This check, as well as all others possible, should be used in ballistic firing, for, on the accuracy of the observations depends the value of the data obtained.

Owing to the absence of sufficient connecting lines, the wire for which could not be obtained in time, but one velocimeter, Bréger's Chronograph, was used. The same cause prevented the adoption of any more accurate method of getting times of flight than that by the stop watch.

Lack of time also prevented the determination of the effect of—

(*a*). Variations in moisture of the powder,

(*b*). Sunning the cartridges while on the range,

(*c*). Fouling of the bore,

(*d*). Heating of the piece,

(*e*). Compressing the cartridge by ramming the shot, and of several other causes which readily suggest themselves to the artillerist.

The following extracts are from a report on the preparation of cartridges for the 8″ C. R.:*

"Previous experience had shown us that the ordinary scales, furnished for weighing, were not accurate or sensitive enough for nice work, especially when the determination of important experimental data was involved." Hence the balance connected with the Mallet Densimeter was used.

"In all cases the weight was this amount (35 lbs.) to within the weight of a single grain of powder. It was not deemed practicable to split grains to obtain greater refinement.

"The bags were carefully examined and compared before using. So far as the eye could detect, there was no difference in their size. After filling, it was ascertained by measurement that the cartridge was much less than 8″ in diameter, hence longer than it should have been. Some of the cartridges were used on the day of filling and others were used from day to day, being handled many times in taking them from the magazine to the guns and back again.

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* Report of Lieutenant Ruckman, who had this matter in charge.

"All the cartridges were shaken down, tied, and the 'chokes' cut short just before insertion into the gun. It was soon observed that, the more they had been handled, the shorter and thicker they became. This had the effect of admitting the projectile further into the bore.

"It was also noticed that, on filling, the cartridges appeared to differ in size. This fact was verified by measurement.

"In the process of shaking the cartridges down, just before tying, it was discovered that some went down to a fixed length without much trouble, while others could only be so reduced by much shaking and gentle pounding by raising and dropping them on a platform. It is quite probable that this difference in churning motion produced, in the charge, different amounts of dust and fine particles, with corresponding effects on inflammation and combustion.

"It is only by considerable stretching of the bag, that the cartridge can be shortened much below its first length. When the cartridges were reduced in length to about 21 inches, they accurately filled the cylindrical case used for carrying them from the service magazine to the gun. In shaking and jamming them down to this length, about one-third burst. It became apparent, in the case of others tried, that they also would have burst before reaching this limit. It is safe to say that, had all been pushed to this limit, one-half, at least, would have been ruptured.

"The shape of the bases of those which did stand this reduction was materially changed. As these shapes differed in different cartridges, the latter could not be made to occupy the same space in the gun without different amounts of ramming, and hence uniform conditions of loading became impossible.

"When the length of the cartridge varied from 20.5 to 21 inches the cross-section of the cartridges fitted the bore. Under these conditions the initial velocity varied from 1400 to 1425 f. s., with an average of 1415.* Hence the fair inference is that this gun will, contrary to the accepted opinion, give this velocity when loaded as above specified.

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* See following report on velocities obtained.

"The shape of the forward end of the cartridge is such that it may cause variations in the conditions of loading. This end is more or less convex outward as is also the base of the Butler projectile. In loading, these two surfaces come together and the position of the choke, upward, downward, to the right or left, may affect the position of the shot and density of loading accordingly."

The report suggests:

"*First.*—The weighing, under the supervision of an officer, of all powder charges, on the most accurate scales available, before putting them into bags.

"*Second.*—The obtaining, for the service, of suitable weighing apparatus for this purpose.

"*Third.*—The securing of better apparatus for seating the charge and projectile.

"*Fourth.*—The correction of the defects in the cartridge bags as noted above. This may be done:—(*a*) By making them larger in diameter, so that, when filled, but little shaking will be required to bring them to the correct length. (*b*) By using some inextensible material for the bags, thus securing the proper shape for the base. (*c*) By closing the front end of the cartridge with a disk corresponding in shape to the shape of the base of the projectile, thus causing a uniform bearing surface between the two."

For this practice it was considered necessary to obtain a greater degree of accuracy, in determining the direction of the wind, than could be obtained by holding up a handkerchief, or a wet finger near the gun. The direction of the wind near the ground is often materially changed from that higher up by surrounding objects, hence the necessity for raising the vane above all eddies.

The following extracts are from the report of the officer having this matter in charge:*

"A simple wind vane was constructed for temporary use. It consisted of a wind vane mounted on the top of a piece† of wrought-iron pipe, so as to be free to move with the wind. Rigidly connected with the vertical spindle of the same, was a

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* Lieutenant Parkhurst, 4th Artillery.

† Twenty feet, and placed on top of the parapet.

long, light, iron rod, extending downward through the tube. The lower end of the tube was mounted on a skeleton framework, and the interior rod from the vane projects downward and carries a light index which moved over a dial placed horizontally below it. The index and the vane being parallel, the former indicated on the dial the direction of the wind. The dial was movable and could be set so that the zero line was parallel to the line of fire of the group of guns in action."

"Fig. 2 shows a sketch of a proposed permanent 'wind clock.'[*] It consists of a wind vane rigidly attached to a vertical axis, carrying a mitre wheel which gears with four other mitre wheels. The axes of these are horizontal, at right angles to each other, and perpendicular to the faces of a large box. On these faces are clock dials over which, when the vane is turned, sweep indices connected with the shafts of the four mitre wheels.

"This gives a wind clock which, showing the direction of the wind on each of four faces, can be read from any direction.

"This box, or clock, is to be mounted on a long piece of 3 or 4-inch wrought-iron tubing; the axis of the vane may be continued downward with a horizontal dial at the base, as in the vane first described.

"This clock has the objection that it is not readily adjustable for the varying directions of fire of different groups of guns, but may be adjusted to agree with the greater number of groups, while the movable horizontal dial can be adjusted for any particular group, for fine observations.[†]

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[*] [The wind clock here described is essentially the vane of the Anemometer which was constructed at Fort Wadsworth by Lieutenant Whistler and which has been in use there several years.—ED. JOURNAL.]

[†] This objection is easily overcome by mounting permanently at each group of guns a "converter." This converter consists of a stationary horizontal dial plate whose zero line is parallel with the line of direction of the vane on the clock when its indices points to XII, or zero. Concentric with this circle and turning about its vertical axis, is a second smaller circular disk, graduated like the first, and provided with a movable pointer of length greater than the radius of this disk.

Operation: Read the indications of wind clock and turn the pointer of the converter to the corresponding graduation on the outer circle, hold or fasten it at this point. Now turn the small circle till its zero line corresponds to that of the fire. The indications of the pointer *on this* circle gives the direction of wind for this group of guns. This will allow the central clock to be adjusted once for all.

A great gain, in both time and accuracy, will be made if we take directly from the dials the *components* of wind velocity expressed *decimally*, instead of using the method now in vogue. H. C. D.

"There is nothing difficult or complicated about the construction of the clock shown in Fig. 2. It should be well within the resources of the School's shops, the only special material being the brass mitre gears."

The following extracts are from the report of the officer in charge of the gun:*

"Figure 1 gives a curve showing the relation between the variation in initial velocity and density of loading. In this connection attention is called to the fact that the variation in density of loading, there shown, viz: 0.33 ft. (nearly 4 inches), was not forced but occurred under service conditions. The shot was pressed home against the cartridge, as per drill regulations, and the variations shown arose from varying lengths of cartridge.†

"For this variation in density of loading the curve shows a variation in initial velocity of 90 f.s., which, at an elevation of 7° 30′, corresponds to a variation of 300 yards in range."

Two consecutive shots fired under the same conditions, except as to density of loading, may then fall at a distance apart of 300 yards, plus the instrumental error of the gun. If there are also variations in other conditions, and if all of them should tend to increase the variation in range, we may easily account for some of the results recorded in the target records.

"It was found that the projectiles were not of uniform length, or perhaps there was a variation in the distance to which the nose of the shot entered the open rammer head. This difference, when measurement was made from the base of the projectile to a fixed point on the rammer staff, corresponded to a variation in velocity, taken from the curve in Fig. 1, of 10 f.s. Hence making a *mark on the staff and always inserting to that point* is not so accurate as has been supposed."

The shot may always be placed at the same point as follows:—Attach a scale to the rammer staff, and make a measuring rod, equal in length to the required distance to the base of the shot from the muzzle of the piece. Place the rammer head against the point of the shot, as when in the bore, and one end of the rod at the base of the shot and note on the scale to what point

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* Lieutenant H. C. Davis.

† See extracts previously quoted.

the other end of the rod reaches: when the shot is in the bore force it down till the point noted on the scale is at the muzzle. A collar with projecting ends clamped around the staff at the proper point will greatly facilitate the placing of the shot.

"It must be remembered that the curve in Fig. 1 applies to the particular gun used. The variations in velocity corresponding to the variations in the density of loading may be relatively true for all of this type of gun, while it is very doubtful if the absolute values taken from the curve will apply to other pieces.

"The firing was also used to note the instrumental error of the gun," but the number of shots fired at each range was too small for conclusive results.

"By using Whistler's chart and assuming it correct for this purpose, the ranges of the several groups of shot were reduced to standard conditions, and the center of impact of each group was taken. This reduction was made possible by having the initial velocity of each shot. The following table contains the results of this reduction and, in addition, shows a comparison of the *deduced* jump with that given by Lieutenant Whistler:

Angle of elevation used.	Range of Center of Impact.	Angles called for by Whistler's chart.	Difference or jump.	Jump from Whistler's Curve.
2° 30′	1492	2° 37′	7′	11′ 00″
3° 15′	1897	3° 28′	13′	12′ 30″
4° 15′	2362	4° 30′	15′	15′ 30″
5° 20′	2885	5° 47′	27′	19′ 00″
6° 00′	3113	6° 22′	22′	21′ 30″

"The last two columns are plotted in Fig. 3, together with the curves given by Lieutenant Whistler and Captain Ingalls." The latter's curve stops at 5° elevation, while the other two go beyond that point and agree in showing a cusp. Whether a greater number of shots will confirm this result remains to be seen.

The foregoing extracts are given in the hope that they may excite interest in that kind of target practice. The curve of density of loading and velocities, it will be seen, gives merely the average of results, and, while the general law is clearly shown, the variations are sufficient to indicate that there are probably other causes not accounted for.

With the breech-loading rifles, there will not be this same difficulty, but we may rest assured that there will be just as many, and any investigation of the old difficulties will better fit us for grappling with the new; it will certainly be better than doing nothing.

It is true that all the material for ballistic firing is not to be found at all our posts: Fort Monroe is pretty thoroughly equipped if everything within reach is *made* available; the New York posts are believed to be in condition to do much, while all the others can do something more than fire shot into the sea.

There may, at first, seem little that can be done, or that it is desirable to do, but, as the work goes on, the horizon will widen and one thing will lead to another. Points which, at first, seem of too slight importance, will, when those of relatively greater significance have been thoroughly investigated and are understood, present themselves as being of prime importance.

Target firing.—It was seen that in ballistic firing the prime object was not to hit a target but to learn to obtain uniform conditions. The best target for this is some well defined stationary object, beyond any possible range: for target firing, however, there may be a target within reach, as well as some means of determining and communicating ranges.

This firing should be at known and unknown distances. In the first case the shot should be plotted for range with reference to that *range for which the elevation was taken* and *regardless of the position of the target at the time of firing;* this will indicate ability to hit at *given* ranges. In the second case ranges should be sent in at intervals, and the artillerist must make allowance for probable change in position: now the shot will be plotted with reference to the *target's position at the time of firing*, and this is a test for hitting under service conditions.

In both cases the demolition of the target is the object of the firing; but, for all that, hap-hazard changes in elevation should be avoided. An accurate knowledge of what the gun will do is supposed to have been previously attained, and there should be sufficient confidence in the accuracy of this, to prevent the artillerist from changing his data after he is satisfied that the center of impact is properly placed.

During this firing the artillerist in charge of the guns must be kept as fully informed as possible, as to all obtainable data that is of importance to him: moreover, he must have confidence in the reliability of what is furnished him. This confidence, unfortunately, does not exist to any alarming extent. We have all noted the unanimous verdict, of those around the gun, given as to when a shot struck to hear the plotters reverse it. No attempt will be made to show where the trouble lies, but the case is cited merely to call attention to the injurious effect this state of affairs has on target practice. The uneducated eye is easily deceived and operators may make mistakes; it matters not which has been responsible for the variance in the past, let us make sure of the future by perfecting the system of observation, by using checks,* and then educate the eye.

It is just as much a part of target practice to learn to place a hit, by eye, with reference to the target, as is the firing of the piece; for, in service conditions, the placing of the center of impact will depend largely on the accuracy of the eye. Almost no attention is at present paid to this and no headway can be made till confidence is established in the accuracy of range determination.

The record of firing should be accurate and full, but giving only such data as is of use. In this connection let us note that deviation right or left should only be taken from the transit observations; better trust the eye for this than the base line observations, for, on account of the length of the splash and other causes, these latter may displace the shot 5 or 10 yards, which is not much in range but very material in deviation. This is specially true when the shot is plotted to the right when it was observed by eye to the left: The eye is quite accurate so far as this determination is concerned and if the plotters give a verdict against it, there will be a case of "convinced against the will," with a resulting loss of confidence and consequently a blow to a vital principle involved in learning how to shoot.

The details of this and all firing must be worked out. They should not be subjected to cast-iron rules, but must be changed,

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* Three stations and the transit in rear.

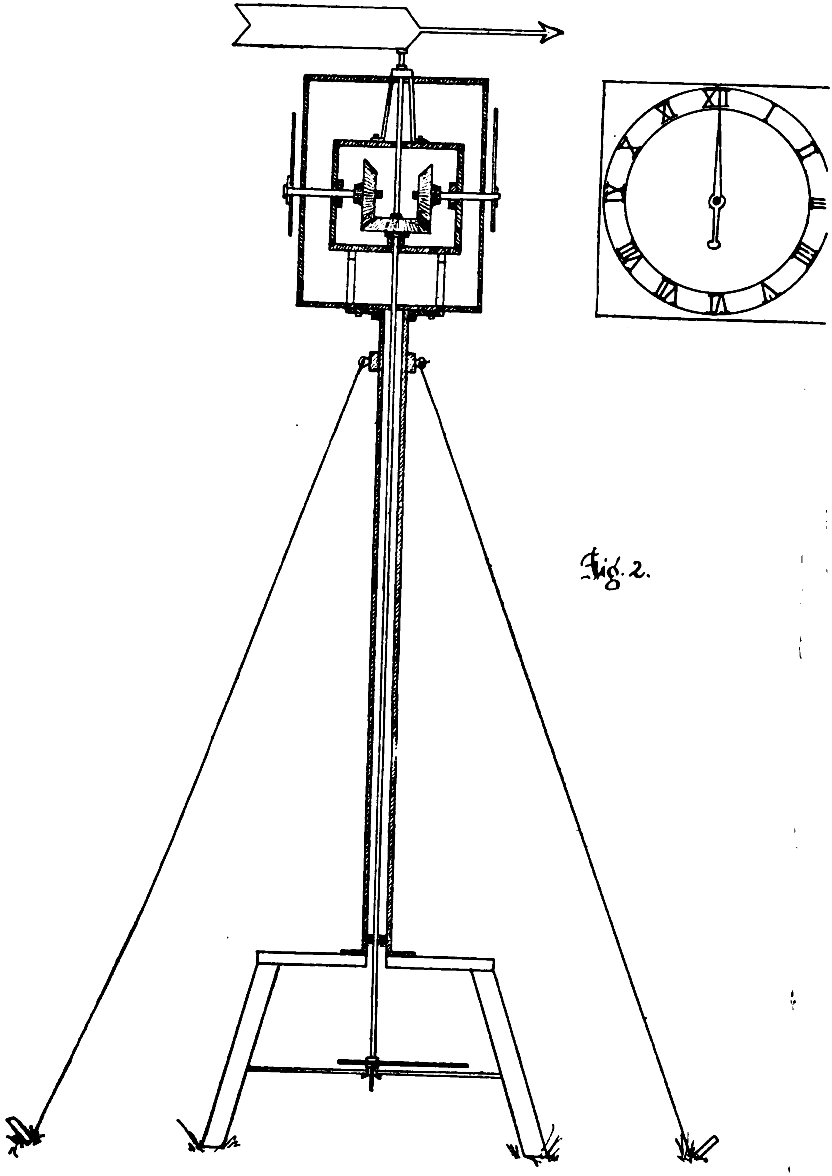

Fig. 2.

as often as necessary, to get the best results. The general good should not be sacrificed by special constructions of competition rules. It seems an absolute wrong to the service, to allow a gunner, through an error, noticed by the officer in charge, to fire a shot under conditions other than those supposed by him to exist and *recorded as existing*, merely to satisfy some rule of competition.

Tactical firing.—This corresponds to infantry fall manœuvres. It will test all arrangements made for the defense of the place, and will consist in assigning certain work to each battery and having it perform it in conjunction with all the others.

A given problem may be taken, as the demolition of a target, fixed, drifted or towed, by the united efforts of all the batteries. This gives an opportunity for simultaneous and concerted action by the battery officers, while field officers will have work commensurate with their rank.

The length of this article precludes going further into this division of target practice, and the desired object is attained if thought is directed to it.

Conclusion.—The first objection to the system, herein indicated, will probably be that it calls for more ammunition than is at present allowed; that would probably be true if it was contemplated that each individual officer, or battery, should go through the whole course. This is not at all necessary, for those concerned may be divided into groups, each to be assigned a certain part of the investigation. A thoroughly digested plan is presupposed; this plan should be the result of full and exhaustive discussion of all suggestions made, such suggestions being invited and fully received.

If this arrangement does not provide sufficient ammunition, continue the programme from year to year: in fact more than a year may be given to the first division with the result, it is hoped, of subsequently taking up the work where it was left off instead of beginning anew each year as at present.

Whether the writer has struck the key-note for changes in the method of target practice, remains to be seen, but it will scarcely be controverted that some change is necessary. Anyone doubting this should betake himself to the large posts at the opening of target practice; he will see a lack of continuity in the work and how little use is or can be made of the records of preceding years. That is, we begin anew each year.

To remove present defects, and elicit the best results, will require time and patience, but if our arm is to be of any use, it must be able to hit and that without any loss of time.

The other arms must be able to march, manœuvre, and place themselves where they can use their weapons. As heavy artillery is fixed in position it has nothing to do with these things and must depend alone on its fire for success. Target practice under such conditions becomes of prime importance; for when the enemy comes within its range, the artillery *must* be able to fire quickly and accurately, or fail to accomplish the single object of its existence.

A NEW PERCUSSION FUZE.

By HENRY P. MERRIAM.

The fuze to be described in this article was the outcome of a series of experiments made at the Sandy Hook Proving Grounds during the years 1890-91. It was the purpose of these experiments to produce a base percussion fuze which would be suitable for shells of the larger calibers and more especially for rifled mortar shells. The chief requirements to be fulfilled were: 1st. Safety, in handling and transportation; 2nd. Certainty of action upon concussion on a target; this to mean that a burst should occur whether the shell strikes point foremost or sidewise; 3rd. Delay after concussion, to allow time for the shell to penetrate before exploding.

The first fuzes to be fired were made with a spherical hammer mounted loosely in a recess in the fuze case, the percussion caps, of which there were three, were circularly disposed in front of the spherical hammer. This arrangement of hammer and caps is similar to that shown in Fig. 1. The action of this is such that a direct axial retardation of the shell causes the ball to strike all three caps simultaneously, while a side blow causes the ball to be displaced laterally and to move forward in the cavity, thus coming in contact with one or more of the primers. In this fuze the safety device consisted of a small weight and a spring which positively held the ball away from the caps until the shell was fired, then the small weight, in taking up the velocity of the shell, was forced over the spring and the spring and weight retreated together into the ball. Several of these fuzes were fired from an 8-inch M. L. rifle with satisfactory results. On further trial of this type in a 12-inch B. L. mortar, two out of the first three fired failed to explode. These two were recovered and it was found that the safety device had not been released. To investigate this point further, experiments were made with a 3.6-

inch B. L. field mortar, using small charges; the shells, not being loaded, were recovered and the fuzes examined. The results thus obtained served to confirm previously calculated results as to the relation between the total force applied to the base of the shell and that applied to the small releasing weight or plunger. This relation may be stated thus:—

$$\frac{\text{Total force acting on base of shell}}{\text{Force acting on plunger}} = \frac{\text{Total weight of shell}}{\text{Weight of plunger}}$$

This is strictly correct, only when the shell and the plunger are regarded as freely moving bodies; the total force imparting velocity to the shell is less than the total force applied by an amount necessary to overcome friction, to set up the rotation of the shell, etc. If the force applied to the starting of the plunger is calculated by the above equation, using the pressure per square inch as given by a crusher gauge, the result obtained represents the greatest possible force to which the plunger can be subjected in starting—frictional and other losses being neglected. The actual force applied is always less than this theoretical amount: some experiments showed a loss of upwards of 50 per cent.; this, however, may have been largely due to irregular friction of the plunger: To illustrate by an example:—Suppose a shell for a 12-inch B. L. mortar weighs 650 lbs.; that the maximum pressure applied in its discharge is 6000 lbs. per square inch—this being perhaps the extreme lowest pressure that would be used: the plunger may be assumed to weigh two ounces: The total force applied to the base of the shell equals $6000 \times 113 = 678{,}000$ lbs.

$$\frac{678{,}000}{X} = \frac{650}{\frac{1}{8}} \text{ from which } X = 130$$

This is the maximum limit of the force applied to the starting of the plunger. As is usually the case the plunger is pierced by a pin or spring which is forced through the plunger at the instant of discharge, this action serving to arm the fuze. For safety against premature explosion considerable force is required to overcome the friction of the pin or spring. If with such a plunger as this it is assumed that a force of 130 lbs. is necessary to start the pin, then, theoretically, the fuze would just be capable of arming by the shock of discharge.

To see to what extent such a fuze can be roughly handled:—Suppose that the pin can be forced $\frac{3}{16}$ of an inch through the plunger and that the frictional resistance of 130 lbs. is constant for this travel. The energy necessary to arm the fuze is $130 \times \frac{3}{16} \times \frac{1}{12} = 2.03$ ft. lbs. and the height from which two ounces, the weight of the plunger, must be dropped to give this amount of energy is, $\frac{2.03}{\frac{1}{8}} = 16.2$ ft. It such a fuze be dropped 16 ft. and its velocity be suddenly checked by striking squarely on its base the fuze will be effectually armed; but to be reasonably sure that this will take place when fired under the conditions stated the fuze should be capable of arming with a drop of about half this distance. This then reduces the fall to eight feet which is much too small, and moreover a succession of shocks or falls from a less height will have the same effect as the single drop of eight feet. It is apparent that there is not margin enough between safety on one hand and certainty of action on the other, and for this reason there is required some means for releasing the plunger that in its action shall be more positive than the inertia of a weight; for to change merely the proportions of the weight and resistance will not solve the difficulty.

The gas pressure at the base of the shell presented a satisfactory means for operating the releasing device, and accordingly, experiments were made with a type embodying this principle. To avoid unnecessary expense, a 3".6 field mortar and a 3".6 field gun were used. Fuzes were fired under pressures varying from 3000 to 38000 lbs. per square inch and as no failures occurred, it was concluded that their certainty of action was fully established; as a final proof, however, a number of shells were fired successfully from a 12-inch B. L. mortar. During these experiments some difficulty was encountered in shells bursting in the gun, but this was not attributed to the action of the fuze; for, as was afterwards shown, bursts occurred with equal frequency in the firing of shells from the same lot, loaded with powder but with the opening in the base closed by a base plug instead of a fuze.

The delay was next taken up. To discuss this part more clearly take the case of a loaded projectile without a fuze—sometimes known as a "blind shell"—fired against armor. It is a well known fact that when the armor exceeds a certain thickness—this thickness varying with the size and character of the projectile—the heat developed at the instant of concussion is sufficient to ignite the contained bursting charge and cause explosion after the shell has passed through. With a still more resisting target the heat would be more intense and more quickly developed and the burst would then occur before penetration, in which case comparatively little damage would result unless the explosion be so violent as to shatter the plate. Attempts have been made to overcome this difficulty of premature bursting by enclosing the charge in non-conducting bags, but no advantage has been thus secured. For this reason it is considered advisable by some authorities to dispense with bursting charges in projectiles for use against armor and to trust to the destructive action resulting from the penetration of such a missle into the body of a ship.

In cases, however, where the resistance encountered is insufficient to develop the required amount of heat a fuze is a very necessary part of the shell and greatly increases the destructive effect. The greater proportion of war vessls are not provided with such effective protection as would require explosive projectiles to be dispensed with, and against these vessels armor piercing shells, loaded and fuzed, would do most effective work. If examination is made of the action of a shell at the instant of concussion it is seen that there is required a certain brief interval of time—about .005 second—in which to set up the action of the fuze and develop the force of the bursting charge. This causes a certain delay, but a delay in addition to this is necessary at times to insure complete penetration. To secure so short an interval of time by a train of powder is impossible; by restraining the plunger in its movement towards the caps, a limited delay may be obtained, but this renders the fuze less sensitive, and moreover would cause a shorter delay with a thicker target, which is the reverse of what is wanted. What is required is that the delay be proportional to the resistance overcome by the projectile in penetrating the target: i. e., if thin plating is encountered the shell should explode with no delay beyond the time required to ignite the charge; while if thicker plating is encountered the time before exploding should be proportionally greater; this discrimination should be made automatically.

It was with a hope of realizing, in a measure at least, this action that experiments were made on delay. At first the arrangements tried were complicated and the results showed that they were too slow in action, the shells bursting about seventy-five feet behind the target which was of 3-inch plank; finally the arrangement shown in the accompanying diagram was tried and this showed a marked improvement. With this device shells were fired from a 3″.6 field gun through a 3-inch plank target, through a 4-ft. butt of sand, and a plank target of varying thicknesses: shells fired through the three inches of plank burst about five feet beyond, and with a thickness of 52 inches of plank the burst occurred at practically the same distance in the rear. About thirty shells were fired in these experiments and the results were highly satisfactory. The final proof that the delay is proportional to the resistance would be a trial with armor-piercing shells fired against armor plates, so far this has not been attempted.

The fuze as now constructed will be readily understood from the following description and diagram.

Figure 1 shows a longitudinal section of the Fuze, showing parts as they exist previous to firing.

Figures 2 and 3 are end elevations.

Figures 4 and 5 are sections along x-x and y-y respectively, looking in the direction of the arrows.

Figure 6 shows in separate view, the valve upon which the delay action depends.

Referring to Figure 1. In the fuze case which screws into the base of the shell, the plunger or hammer A for exploding the caps is in the form of a sphere. This is held securely in the position shown by the clips B, B, which abut at one end against a circular recess in the ball, and at the other end against a shoulder in the fuze case. When, in the discharge of the shell, pressure is applied to the trips C, the clips B, B, are forced off from the shoulder in the fuze case and thus free the hammer A. A flat spring D serves to keep the ball to the rear of the cavity during the flight of the shell.

When the velocity of the shell is suddenly checked upon striking a target, the ball by its momentum, strikes one or more of the small balls E—see also Fig. 4—placed above the fulminate caps F and explodes the latter. The resulting flame escapes through the channels G—see also Fig. 5—into the chamber H. It is also evident from the arrangement of the ball A and its surrounding cavity that should the shell strike squarely on its side, the ball in being thrown to one side of the cavity is forced to move forward and thus explode at least one of the caps. In the chamber H is placed the delay mechanism which consists of a disc I of closely pressed powder carried on the front of the valve J. This valve is capable of a slight movement in an axial direction. This disc of powder when compressed between two surfaces and ignited at the edge burns in successive concentric rings, and it requires an appreciable time for the flame to reach the center; when the disc is not thus compressed, the igniting flame reaches the center immediately.

At the instant of impact the sudden stopping of the shell causes both the hammer A and the valve J to move forward, but the valve J, on account of its shorter travel, reaches its seat an instant before the hammer strikes the caps. When the flame from the fulminate caps enters the chamber H, the valve J. is pressed firmly against the front surface and the flame ignites the edge of the disc of powder through the windows K—see Fig. 6. As long as the shell is undergoing retardation, the disc I remains forced against the forward face and the flame advances slowly as before stated: when the shell has passed through or has stopped in the target, this force, due to the momentum of the valve, ceases and the gas pressure between the two surfaces forces the valve away from the forward face, thus allowing the flame to at once reach the center. A wisp of dry gun-cotton closing the channels O serves to conduct the flame to the powder contained in the radial chambers L. and from thence it passes to the bursting charge in the shell; these chambers L contain supplemental flashing charges to further ensure the ignition of the bursting charge.

A screw M, when screwed down serves positively to hold back the valve J, should it be desired to have the explosion as nearly instantaneous as possible at all times.

The pistons on the trips C are rendered gas tight by means of copper caps—arranged after the usual manner of crusher guages—and tallow or wax fills the space above these.

When screwed into the shell, leakage of the powder gas by way of the threads is prevented by a washer at the shoulder f, f.

The small balls E are secured in place by being set in the recesses somewhat deeper than half a diameter, a burr at the edge of the recess then holds them.

The safety of this fuze in handling has been abundantly tested by dropping and throwing about. As for certainty of releasing upon discharge, this is fully secured by the size of the pistons and the fact that there are two; either one releasing being sufficient. Certainty of exploding upon striking is secured by employing three percussion primers instead of one; that three defective caps should happen to be in the same fuze is well nigh impossible. Finally, the delay mechanism for mortar shells would seem to be all that could be desired. It may be said by way of anticipating a criticism, that the apparent complication is due to a duplication of parts which secures greater certainty of action—over sixty of these fuzes have been fired and not one has failed to act.

FIELD-ARTILLERY DRAFT.

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In every well organized and equipped army a system of field-artillery comprises mountain, horse, light and heavy guns, the necessary carriages and ammunition trains, and also the siege guns proper and their material which accompany the movements of an active army in the field during war. The subject of this paper is confined to field-guns proper. In the days of the old smooth bore guns, each kind of battery of the field artillery was armed with the particular gun best suited to its expected conditions of service. For horse batteries, mobility was, and is to-day to a far greater extent than ever before, the controlling factor, to secure which the power of fire of the gun is necessarily limited, as is the weight of the projectile which insures this power, in order to enable the battery to carry the number of rounds necessary to meet the demands of war conditions. At the other extreme is found the heavy field-gun, not infrequently supplemented in a favorable field of operations by siege guns used as field-artillery, as provided in our *Heavy Artillery Manual* for the 4½-inch siege gun. For this gun the weight of projectile is the greatest permissible; the power of fire of modern guns of this class being equal to that of our old siege gun, yet at the same time without exceeding the proper measure of mobility for field artillery. Aside from the natural desire to have such powerful guns, the necessity for their presence with an army is enforced by the number and strength of modern field-works and the character of their defense, so astonishingly developed during our late war. These defenses are such that, despite the great power of present field guns, the same use for the powerful modern siege gun as field artillery will exist as is indicated in the *Manual* for the old 4½-inch gun. As the heavy field batteries are generally confined exclusively to the corps artillery, or at least should be when the power of the gun is worked up to the full measure of mobility permissible for such batteries, and are also restricted in their use to reasonably favorable fields of operations, the measure of mobility called for is at the minimum. There still remains the necessity for a gun suited to the service of the light batteries forming the divisional artillery, and which constitutes the "backbone" of the artillery of an army. This gun must not only possess the maximum possible power of fire, only to be insured by the greatest weight of projectile which can be carried in sufficient number, but it must also be capable of a mobility which will permit of efficient service with the infantry in every phase of its marching, manœuvring or fighting, and over any ordinarily practicable ground. Strenuous efforts, in the interest of simplicity, have long been made to successfully use a single gun for both horse and light batteries; never, however, with satisfactory results.

With the advent of really rapid marching for cavalry, increased from twenty to twenty-five miles a day, and over much greater distances, and of present arms and methods of warfare, not only has horse artillery become of far greater importance than ever before; not only to insure the offensive and staying powers of the cavalry, but for quick work with the infantry on the battle-field; but also has the degree of mobility demanded of it become very much greater, consequently maintaining a careful proportioning of the loads behind the trains to what these new conditions demand. If the light field gun of sufficient power to insure its efficiency with a medium number of rounds per gun, be adhered to for horse artillery service also, simply discarding the weight of the cannoneers carried with the light battery, it will not give proper loads for a horse battery especially for the gun carriages, and a reduction of the permanent loads to the proper limit for the latter service becomes inevitable. This at once maintains a reduction in the amount of ammunition carried, and as a consequence the horse battery finds itself without a sufficient number of rounds per gun to meet war requirements, especially when serving with the cavalry, when a re-supply of ammunition is always small, frequently precarious, and sometimes not at hand at all. As a result the tendency is much stronger than ever to return to the old practice, and design guns of course with the greatest possible power, but with mobility suited to the varied requirements of war service with respect to the various arms, their tactical subdivisions and uses, the trains, roads, &c. Hence mountain, horse, light and heavy field, and even siege guns of different calibers, suited to each particular battery, and with degrees of mobility carefully proportioned to the character of the service required under the conditions of modern warfare.

As the power of fire depends directly upon the *weight of the shrapnel shell and its sectional density*, the tendency is to increase this weight to the maximum with a minimum of caliber, but as the demand is also for greatly improved mobility, this latter demand is met by decreasing the number of rounds per gun, a noted example being the new English 12-pounder gun, with which this number has been reduced to 108 rounds even for horse batteries, due to the fact that in modern battles the average number of rounds fired is small as compared with the old smooth bore guns.

As the efficiency of field artillery depends primarily upon the powers of horses, it is of the utmost importance that a thorough understanding should be had as to such powers, as limited by the conditions of artillery service in war, *i. e.* bad roads or none at all, bad or insufficient forage, rapid movements and forced marches, and unusual and often excessive marches in daylight and in darkness, in sunshine and in storm. For short distances over level roads in good condition, wagoners with small teams often make them draw more than 2000 pounds per horse, but the gait is always a walk with every condition favorable for the horse, while nothing of the kind would obtain for him in war.

Given the ordinary powers of a horse under ordinary circumstances, in order to determine what his powers will be when applied to the service of drawing artillery carriages, it is first necessary to determine the distance and time of marching in an army in the field. It is generally held by modern authorities that the marching capability of cavalry should be, and in fact is, 20 to 25 miles a day. But the weight carried by our cavalry during the late war was considerably less than is used in Europe, and it has since been reduced to an average of 234 pounds, a less weight than is carried by cavalry horses in any service. It has been asserted by General Merritt, based upon a careful study of the results of that war, verified by a wide personal experience, that "our cavalry can march 25 miles a day for six days in every week during a campaign." General Wilson's cavalry corps, in 1865, marched 253 miles in ten consecutive days, and our horse artillery must be prepared to make such marches, *maintaining their horses in as good condition as those of the cavalry*, which was very far from being the case in this instance.

WEIGHTS CARRIED BY CAVALRY HORSES:

		Pounds.
United States;	Average man, clothing, &c.,	146.
	Equipments, &c.,	88.
	Total	234.
England;	Man and clothing,	150.
	Equipments,	130.
	Total	280.
France;	Light Cavalry,	232.
	Dragoons,	241.
	Cuirassiers,	263.
Germany;	Hussars,	257.
	Cuirassiers,	322.
Austria;	Hussars,	293.
	Uhlans,	297.

Russia; from 253 to 289 pounds.

The powers of our cavalry horses as indicated by General Merritt appear quite reasonable, even when marching in large bodies. General Wilson's cavalry corps above referred to, in thirty-one days, twenty-five only being on the march, covered 537 miles, or 21½ miles a day for this large command, much of it over a very unfavorable country, and terrible roads. During the time indicated this command captured five fortified cities, twenty-three colors, 288 guns and 6820 prisoners. The rate of cavalry marching, including halts, is about three miles an hour.

The distance and rate of marching for a separate division of infantry is usually given as fifteen miles a day at about two miles an hour, and twelve miles a day at a somewhat less rate for an army corps or larger body of troops.

From the *Aide-Mémoire*, R. E., it appears that a heavy London dray horse can exert a *tractive* force of 360 pounds for a short time. In regular work, day by day for eight hours, 250 pounds, but that for the "average" horse this latter is only about 150 pounds, and that a good horse at three miles an hour can exert a force of 125 pounds for eight or ten hours. A powerful horse can carry 350 pounds, and a good cavalry horse can carry from 260 to 280 pounds twenty-five miles a day in seven or eight hours.

Now an artillery horse is by no means a heavy London dray horse. On the other hand reasonably well selected artillery horses are certainly much better than the "average" horse. Therefore his tractive force will fall somewhere between the 250 pounds for the dray, and the 150 for the average horse, and it would appear reasonable to place the measure of the tractive force of good artillery horses of heavy weight, such as would naturally constitute the teams for the heavy field batteries, at about 200 pounds. These batteries will generally be assigned to the corps artillery and march over the best roads.

As to the light batteries from the divisional artillery, their mobility must conform to the marching capabilities of the infantry division, whose distance and rate of marching have been given, and from which the tractive force of the light battery horse can be deduced, as compared with that for the other battery. It thus appears that good horses, under ordinarily favorable circumstances as to condition, roads, &c., can exert a tractive force as follows:

At 3 miles per hour for 8 hours, 125 pounds 25 miles a day.
" 2 " " " " 7½ " 178 " 15 " "
" 1.8 " " " " 6¾ " 200 " 12 " "

which may be considered as a very correct basis for theoretically determining the loads which artillery horses can draw for horse, light and heavy field batteries, as the distances, times, and rates accord very closely with what obtains with troops marching in armies in war service. If the rate be increased, the load decreases for the same time.

It is quite evident that this measure of tractive force is a high one by which to measure the amount of work a horse will be able to do under the adverse conditions of war service, and makes but little if any allowance for the general character of artillery draft horses, their probable condition from insufficient or bad forage, bad roads, forced marches, &c. It is true that when these conditions obtain for the artillery horses, it may be expected that they will also apply in kind equally to those of the cavalry, or impose other equally unfavorable conditions upon the infantry soldier. Unquestionably in the organization of the artillery for a completely equipped army, the horses would be classed and the heaviest assigned to the heavy, while the lighter and most active would be given to the horse batteries; thus to the greatest extent favoring the horse's condition for draft purposes. But after all, when the tractive force is taken at its full limit in the shortest time—eight hours—for a good horse in excellent condition, with good care and forage, and over fair roads, as the measure for horse artillery; at twenty-eight pounds above this force for the "average" horse as that for light, and at fifty pounds above for heavy field batteries, it may be confidently asserted that these limits are as high as can safely be assumed, no matter how good may be the class of horses we can obtain for our artillery service. This fact will presently be demonstrated. It may be of interest to call attention to the fact that the measure of tractive force which has been indicated is almost exactly what was assumed by the officers who determined the loads for our old smooth-bore material.

When double teams with mounted drivers finally succeeded the old tandem style in artillery, in every country in Europe hundreds of routes for postilion coaches had existed for generations, conducted by good horsemen and shrewd business men—to make money.

The powers of horses under such conditions were known to a pound from actual experience, and all of this vast experience and knowledge thus acquired was ready to the hands of artillery officers, to be but slightly modified to meet the conditions of his service, as the general run of the post roads of the time were but little better than the open country. One can to-day take a map of Europe and, judging by the topography and history, put his finger in succession upon those countries wherein the postilion coaches made the best time or carried the greatest weights; then turn to the loads behind the respective artillery teams of the present and find them to correspond, even only slightly modified for the more mobile artillery by the new conditions, because, as a rule, of the poor condition of the road, the artillery team going across country being about as well off as the coach on the road. And here be it particularly noted that, as the roads improved and coaches driven from the box appeared, the teams were hitched to double trees, while those driven by mounted drivers continued to the end to be hitched to a rigid splinterbar, additional teams being hitched-in upon the same principle as are our artillery teams. Then as now, these different methods were applied for the purpose of equalizing, so far as possible, the work done by the horses of a team, the rigid splinterbar being the only practicable means of equalizing this work when one horse in each team has to carry a rider, a "rule of thumb" determined by practical horsemen. The extra work done by the horse carrying the driver, at a walk, is a small factor compared with what he has to do when traveling at a rapid gait, which latter was the normal one for the postilion coach, while for the artillery teams the loads are always based upon the trot, and of course with a riding driver on each team. The slow gait, with only one mounted driver for the team, accounts for the fact that the teamster finds his riding animal to stand the extra work so well, coupled also with the fact that he generally selects the most powerful animal in the team for the saddle, the gait not counting as it often does in artillery, as it is always a walk.

In the artillery service all horses are trained to work anywhere in a team, to meet cases of emergency. But for regular service, each horse is assigned to the place he is best fitted for. He is a creature of habit to a wonderful extent and soon becomes accustomed to and knows his place, and in it will work quietly along till he drops in harness if need be, an example of devotion to duty not to be excelled. Change him, however, as might be advocated to relieve him of an undue share of work, and he at once begins to fret, and continues to do so until put back into his accustomed place, his fretting wearing out his strength quite as much if not more than his work. Hence the practical horseman in artillery—most certainly not anywhere else—never changes his horses about in order to "equalize" their work, notwithstanding that he well knows that one horse in each team has to do very much more work than the other. With the rigid splinter-bar the driver can make his off-horse do his full share, with the double-tree this becomes beyond his control and is impossible. Men born since the advent of the steam engine have not a tithe of the experiences with horses performing this kind of work, that was acquired by those engaged in it before this period, and they certainly do not know any more about the practical working powers of a horse. We now have plenty of accurate formulas with which to determine with great exactness what a horse can reasonably be expected to do under any given circumstance. But these formulas are all empirical, based upon a vast and varied experience, and verified for use in artillery service, not alone by the practical experiences of generations of capable artillery officers. but by the most complete and careful experimental determination with dynamometers, &c., of the powers of artillery horses, under every probable condition of ground, roads, &c., likely to be met with in actual service, and, what is no doubt quite as much to the point, these so-called theoretical results accord wonderfully with the conditions imposed by the "rule of thumb" deduced by the practical horsemen who doubtless never heard of "tractive force" or of an "angle of traction." It is not necessary for us now to subscribe to the contention that there really "were giants in those days," in order to accept the fact that our predecessors determined wisely and correctly as to the proper loads for our artillery teams in *this* country under the then existing conditions of service. Whether these conditions have since changed in the direction of lighter or heavier loads, will presently appear. Attention has already been called to the fact that the measure of tractive force assumed is probably almost exactly the same as that used by our predecessors, but it has thus far been impossible to learn just how they arrived at their loads. It was most likely by the formula that the total tractive force of the team P, divided by the load W, should be equal to the tangent of the angle of the traces B, which was taken at 7°, equal to the assumed "obstacle" for our wheel and over our roads. $\left(\frac{P}{W} = \tan 7^\circ\right)$.

According to Gibbon's *Manual*, no doubt largely based upon the experiments made by the French artillery at Metz in 1825, a horse carrying a rider loses his force in proportion to the gait; this loss, which is about one-half at a walk, becomes two-thirds at a trot. This is the reason why "practical and experienced" horsemen adhered to the rigid splinter-bar for postilion coaches, and why in almost every service, save for our new and utterly untried carriages, the splinter-bar is adhered to for field artillery carriages. Single-trees and spring tug-links have been introduced, the latter of unquestioned value, rendering the former unnecessary. The single-tree is advocated for the purpose of compensating for the "forward and backward" movement of the "shoulders" of the horse, causing sores at the point of the shoulder when the rigid bar is used, of which more presently. To hitch an artillery team with a mounted driver to double-trees is not only a useless cruelty to the horses, but is also a piece of folly so evident as to scarcely require pointing out—save to the not uncommon exception of the man who, though having had a wide "practical experience," is yet incapable of clearly understanding or demonstrating the true meaning of the lesson such experience teaches—and one which the wisest and most experienced artillery officers in every service have combatted or carefully avoided time out of mind.

In proportion as the number of horses is increased, the relative force of each couple diminishes, in consequence of the difficulty of making them act together, and the results obtained are respectively about as 9:8:7:6, according as the teams are composed of two, four, six or eight horses. For field-artillery purposes it is generally conceded that six horses is the greatest number that can be worked or manœuvred to advantage. Applying these carefully determined conditions to the measured tractive force a horse can exert, at a trot—which gait every kind of field-battery must be capable of maintaining for long distances, very long ones Prince von Hohenlohe assures us—the tractive force for artillery horses as heretofore assumed becomes:

TRACTIVE POWER OF FIELD-ARTILLERY HORSES.

	ONE HORSE.			Totals for 6-horse team.	
	Without rider.	Team of 6 horses with riders.			
	Walk.	Walk.	Trot.	Walk.	Trot.
Horse Artillery, . lbs.	125	74	65.0	444	390
Light Field Arty. "	170	104	92.3	623	554
Heavy " " "	200	117	103.7	702	622

It has been demonstrated that the tangent of the inclination of the traces should equal the ratio of the tractive force to the load. In 1825, at Metz, Migaut and Bergery found that this ratio over fine turf was $\frac{1}{22}$, and over recently ploughed and hoed ground $\frac{1}{10}$. It was found in general, that the most favorable angle for the traces of an unloaded horse was from 10° to 12°; and for a horse that carried his driver, from 6° to 7°.

Under the conditions of artillery service in our country, for a 57-inch wheel (58 being the limit), the "obstacle" to be surmounted was equal to a slope of 7°, and as the tractive force should be applied parallel to the plane of motion, the angle of the traces was also 7°, the limit for the horse carrying the driver. In the English service with a 60-inch wheel, these angles are 6° 30′.

The best formula at hand for determining the load is, for equirotal carriages, that of Colonel Kemmis, R. A.—Proceedings of the *R. A. Institution*, Vol. 9, 1875-6, Nos. 3 and 8—viz:

$$W = \frac{R(P - W' \sin E)}{ru \cos E + R \sin E}$$, in which;

$W =$ weight of carriage-body in pounds.

$W' =$ weight of wheels in pounds (here taken as 640—720—800, for the different batteries, i. e.: 160—180—200-pound wheels).

$P =$ tractive force in pounds in direction of traces (7°).

$R =$ radius of wheel in inches $= 28.5$.

$r =$ mean radius of axle-arm in inches $= 1.225$.

$u =$ coefficient of friction between wheel and axle $= 0.01$.

$E =$ angle of slope due to height of obstacle $= 7°$.

By substitution, and, as compared with the loads as deduced from the ratio already mentioned, and those from our old material—cannoneers mounted—we have:

MAXIMUM LOADS FOR ARTILLERY TEAMS OF SIX HORSES:

		Kemmis.	Ratio.	Old U. S.
Load for horse battery, 6 horses.	lbs.	3191	3176	3183
Load for light field battery, 6 horses.	lbs.	4533	4511	4432
Load for heavy field battery, 6 horses.	lbs.	4955	5065	5031

These are the maximum loads which our artillery teams can draw under the conditions and limitations imposed. It will be noted that, with either formula the weight of wheel has a great influence upon the *load of ammunition carried*. In the horse battery for instance, whether the wheel weighs 160 or 200 pounds, the formulas will give practically the same load, but with the 200-pound wheel there will be 160 pounds less ammunition carried than there would be with the lighter wheel. So the size of the wheel, should not exceed fifty-eight inches in diameter. Although the 60-inch English wheel gives a better angle, &c., thereby enabling the same team to pull 216 pounds more than it can with a 57-inch wheel, it must be remembered that the English wheel weighs 234 pounds, which makes the apparent gain of 216 pounds due to the large diameter, an actual loss of eighty pounds in the weight of ammunition carried, as against the 160-pound wheel. If the wheel weighs 180 pounds, this difference in the weight of wheels exactly compensates for the greater load of 216 pounds which the larger wheel enables the team to pull. It is thus apparent that it is nothing to the point to compare our loads directly, with foreign ones. To infer, for instance, that because the new English gun gives a load of 4032 pounds, we can impose the same weight upon our teams. As has just been pointed out, 4032 pounds under the English condition of draft means 3816 under our condition other things being equal. and this too without their being able to carry any more ammunition than we can with a lighter wheel. This takes no account of the class of horses, nature of the country and conditions of artillery service generally. What is more to the point is the fact that the 60-inch English wheel, with 3-inch tread to insure proper traction for the heavier load, leaves but 3096 pounds for the gun, ammunition, &c.; while we can, for our smaller wheel with a less tread suited to our lighter load, make it weigh 180 pounds with ample strength, when we should have 3816—720=3096, or the same weight at our disposal with 216 pounds less load. The ponderous weight of the English wheel is not alone due to its diameter and tread, but to the absurd idea that the value, especially of a field gun, is measured by a high velocity and tremendous energy secured *at the muzzle* with a light projectile of very poor sectional density thereby insuring excessive strains on the carriage, wheels, &c., without any corresponding advantages at battle ranges. The French, and more particularly the German artillerists, have always recognized the fallacy of this idea, and the latter fire an 18-pound shrapnel with more than fifty per cent. greater killing power at *battle* ranges than for this English gun, with forty-two pounds less weight of wheel, 168 for the carriage. But the reaction has set in against these fallacious ideas, and the plane teachings of ballistic science are beginning to be heeded. This, as a subject of ballistics, might appear a digression from that of draft, but it is most intimately related thereto. For, by adhering to a heavy projectile of good sectional density, we can secure at battle ranges, far better results in every respect than is possible with reverse conditions, and can then reduce the weight of gun, carriage and wheels, and still carry the necessary number of the heavy projectiles without exceeding the proper loads behind our teams. The size, tread, and weight of wheel are the most important factors which enter into the proper determination of the construction and mobility of field artillery material, as respects the weight of ammunition carried, and instead of constructing a gun developing a tremendous muzzle energy with a projectile of poor sectional density, requiring a ponderous wheel to stand the recoil, the part of wisdom is first to construct a good wheel of proper weight, and then by the use of good sectional density, favor the gun with a proper muzzle energy, but obtaining as good if not much better results at battle ranges. With the designing of the wheel naturally goes the proportioning of the tread or width of tire, to the load imposed. Over good roads this load should not exceed from 373 pounds per inch of tire for small wheels of narrow treads, to 560 for large wheels of broad tread. Over poor roads or the open country these loads should be considerably reduced for field artillery.

It will be observed that the theoretical loads given by both formulas are practically the same as those for our old smooth-bore material, and that our predecessors rigidly adhered to theory for the horse, and light field *gun-carriages*, and for all of the carriages of the heavy battery, while the caisson for the horse battery exceeded the limit by 310 pounds, and for the light battery caisson by 483 pounds. The reasons for these conditions no doubt are that. in the case of the heavy battery the full limit of the power of the team had been reached and the power of the gun was developed up to this limit, giving a gun-carriage considerably heavier than the caisson when the cannoneers were dismounted, but with the latter mounted making the loads practically the same—it being noted that for the old material but three men were carried on the gun limbers, while six were carried on the caissons. For the other batteries where greater mobility as well as much more manœuvring was required, the limbers being kept constantly filled, the expenditure of ammunition consequently fell to the relief of the caisson teams, while for the light battery at least, when on the march the permanent loads for the two carriages were about the same. As it has generally been held that artillery ammunition should always be transported in caissons formed into trains properly horsed, manned and equipped—for it is quite as necessary to supply a battery after a battle with men and horses to replace those killed or wounded, as it is the ammunition expended—it is possible that the caissons in question were given the additional weight to meet the conditions of the service of the caisson with the train, when it might be expected a greater load could be handled, the spare wheel being removed the load would not much exceed the proper one. In any future war our artillery ammunition trains would be properly organized to meet the conditions of supplying the waste of battle, whether of ammunition, men, horses, or equipments; the empty caissons of the train readily going back to the depot unloaded with fewer men and horses. The caisson, without spare wheel, when loaded and equipped for service with its six cannoneers *should not weigh any more than the gun-carriage with its five cannoneers.* The caisson with spare wheel would thus be heavier than the gun-carriage when moving at a rapid gait, by the weight of one wheel—160—180—200 pounds, respectively. If it be deemed practicable to carry greater weight on the caissons when with the train, this can readily be done by adding to the load ammunition in the original packages, placed on the foot-boards of the caisson-body or other convenient place. In this way, and for this purpose, the caisson load can be increased to any desirable extent without interfering with what it unquestionably should be when the caisson forms part of a battery, and where the maximum load should be substantially the same as that for the gun-carriage, both with cannoneers mounted. During our late war the 3-inch rifle, which was our proper horse artillery gun, taking the place of the old 6-pdr. smooth-bore, when used with horse batteries in the Western armies had one ammunition chest removed from the caisson-body, the load for the gun team being 3315, and for that of the caisson 3323 pounds.

There were two such batteries with General Wilson's cavalry corps when it made its famous march in 1865, both, however, experiencing a considerably greater loss of horses due to the long and hard marching than did the cavalry, tending to show that these loads were too great for horse artillery under such conditions of marching, as will presently more fully appear. Toward the close of the war the same method was resorted to to lighten this caisson in the Eastern armies also, it being found that its 4081 pounds with three chests was entirely too heavy when long and rapid marching was required, especially when the work of the team was compared with that of the gun weighing 766 pounds less. Even when this gun was used with the light batteries this great disparity caused most artillery officers to seriously complain of excessive weight of the caisson, the contrast being made much more prominent as the gun limber carried only three men while the caisson carried six.

The "permanent" load for the carriages in horse artillery is of course the total load of about 3200 pounds. Those for the other batteries; the total load less five cannoneers—800 pounds—

for the gun-carriage, and less six—960 pounds—for the caisson, the knapsacks being carried in a wagon, and we should have, adhering to our old and war-tried practice:

PERMANENT LOADS FOR FIELD ARTILLERY CARRIAGES.

	Gun Carriages.			Caissons.		
	Horse.	Light.	Heavy.	Horse.	Light.	Heavy.
Permanent loads lbs	3183	3532	4234	3343	3652	4274
With men, "	3183	4432	5034	3343	4612	5234

While every other service has been seeking to reduce the loads behind artillery teams ever since the wars of 1870 and 1877, ours have been greatly increased, and as an excuse therefore, the example of a single battery out of nearly a thousand is cited as ample justification. The experience of Horse Battery "D," 2nd Artillery, in its march with Sheridan, 10th—26th of May (inclusive), 1864, is cited, a period of seventeen days during which it is stated that "the marching and fighting was continuous." Divested of the poëtic license which attaches to a somewhat distant past, and coming down to the sober facts as recorded in the morning report book of this battery, the "continuous fighting" is reduced to two "engagements," in which the battery lost neither man nor horse killed or wounded. The "continuous marching" is reduced by five days spent in camp when not a mile was marched. During the remaining twelve days a distance of only 214 miles was covered, an average of less than eighteen miles a day, the longest continuous marching being 108 miles in six days. As is well known, General Sheridan started out for the express purpose of demonstrating the fact that he could go where he pleased despite the enemy. He was in no hurry and could not be hurried. The record proves that the march of this battery, which is made the excuse for the preposterous increase in our loads, and cat's-paw to rake them out of trouble, was an exceedingly commonplace affair; whether with respect to fighting or marching. As for the latter, it could have been done with the greatest ease by any 12-pdr. light battery in the army, and was absolutely no test whatever as to the proper measure of mobility for horse artillery.

Horse Battery "I," 4th Artillery, also a 12-pdr. battery, made a march during this war that might have been cited as evidence of some real value, as being something which no light battery could accomplish, to discredit a horse battery record. It left camp at Chickasaw Landing on the Tennessee river March 21, 1865, and reached Macon, Ga., April 21st following, spending April 3rd, 4th, 5th, 6th, 8th and 9th in camp and twenty-five days on the march, thus covering by the morning report book, 537 miles in twenty-five days, as measured by the engineer officer; an average of 21½ miles per marching day, 3½ per day short of what it is claimed our cavalry can readily accomplish when occasion requires "six days in every week during a campaign." Eleven of these marches were of twenty-four miles a day or over, six of thirty miles a day or over, and 253 miles were made in ten consecutive days. During this campaign of General Wilson's cavalry corps it captured five fortified cities, twenty-three stand of colors, 288 guns, and 6820 prisoners, so that the battery probably had something to do in the way of fighting, besides marching and keeping up with the command. This is certainly tremendous marching for a battery of this kind, and so far as a single exceptional case can be relied on as data upon which to base general conditions, is probably as good an example as can be found in the records of the war. But instead of six it had *eight* horses to every carriage and even with this number, in a month's time over twenty per cent. of the horses were knocked-up or disabled from marching, and the battery commander asserts without qualification that with six horses to a team the march never could have been made at all, quite conclusive evidence that the loads were entirely unsuited for horse artillery in this country, a fact already well-known to all of our artillery officers of rank and experience. Had Horse Battery "D," continued its march after reaching Haxall's Landing, to Appomattox and Lynchburg, Va., Greensboro and Charlotte, N. C., Columbia, S. C., to near Augusta, Ga., its march would have about equalled that made by Horse Battery "I," and had such a march been made with six horses to a team we would know much more about the ability of this team to pull the loads under such conditions.

But had it been possible to make these marches with six horses to a team "one swallow (or even two) does not make a summer." They would by no means be, as isolated and exceptional marches, accepted as conclusive evidence as to what the loads for horse artillery should be under the general conditions of the service, save that the latter march would conclusively prove that the loads for the 12-pdr. carriage were greatly in excess of what should obtain. Then it must be remembered that the first march cited was actually performed in a very limited field of operations—and that conditions which were found to be entirely satisfactory in such limited fields, were found by wide and varied experience to be entirely unsatisfactory under other conditions. There is nothing in our war experience when fully stated and correctly weighed, to indicate that our old artillery loads were lighter than the general conditions of artillery service demanded; nothing in the conditions of either the past or of the present to indicate any change necessary save by a *reduction* of the loads.

As to present conditions, Prince von Hohenlohe in his *Letters on Artillery* says: * * * "At the time of smooth-bore guns and muskets it was possible to stand safely at a distance of one mile from the enemy's guns. At this distance the lines of artillery could quietly deploy, and when they received orders to move into action, an advance of 1500 paces was quite sufficient, in order to fire on the enemy's position at the most favorable range of 1000 paces. Very little was thus demanded from the mobility of the artillery. Field artillery required to trot only a few hundred paces. Horse artillery was indeed called to move very fast, but when it had rapidly passed over a total space of 1500 paces, galloping over the last 500, in order to reach its position, it was then considered to have done its utmost, indeed all that was necessary or possible. * * * The introduction of the rifle guns and the experience which was obtained in 1866, considerably altered the demands which must be made on the mobility of the artillery. The necessity of employing the great artillery masses early at the beginning of the fight demands quickness of movement not over distances of 200 or at most 500 paces, but over distances measured by miles and days' marches In order to come into action * * * I had to trot fourteen miles in a hilly country. And even this, as far as one can see, will not be enough in the future. General von Dresky, on the 6th of August (1870), after a march of thirteen miles up and down hill, went into camp, but received orders to proceed to Saarbruck. The country was terribly hilly, but his brigade made fifteen miles in three hours and went into the battle. * * * The war of 1870-71 is rich in such events. * * * (1) *Artillery must seek to crown its efficiency in learning to shoot well*, with all that belongs to it. (2) Artillery must *in its exercises direct the whole of its attention principally to render itself capable of being in position in masses at the proper moment;* that is to say, *it must be able to get over long, very long distances, even many miles, at a fast trot either in column of route or as a battery in line.* * * * It must be in condition *to come into position at the right moment*, and, with this object, it must practice itself in getting over distances of many miles, and even forced marches of a day or so, at a rapid pace. * * * In war, many miles must often be passed over at a trot in column of route. * * * We also ought to practice forced marches of at least thirty miles a day, so that all may learn how this is to be done without injuring the horses. We shall then be able in war to get over sixty miles, when we are ordered to do so at whatever cost."

This tremendous rate of marching now required to get the artillery into its position promptly, is not confined to horse artillery as might be supposed, but applies to field artillery in general. It is needless to say that the conditions and maxims laid down by this accomplished and experienced artillery officer are everywhere recognized as correct, and are to be found embodied in modern artillery drill manuals and tactics the world over.

If the distance required to be passed over at a rapid gait has changed from a few hundred paces to many miles, as our horses are no better than were those of our predecessors, it at once becomes very evident that the loads behind our teams is a matter of grave moment. If the loads for our old smooth-bore guns were correctly determined and applied according to the conditions of artillery service in our country, it is also very evident that under the new conditions of warfare, imposing such greatly increased powers of mobility—that there cannot possibly be any increase above the old loads if efficiency is to be secured, but on the other hand if any change is to be made it must be a reduction from the old loads. The German artillery has already applied these maxims as to practice marches, with the result that already in their horse artillery the loads have been reduced 420 and 460 pounds behind the gun and caisson teams, respectively: for the light batteries the reduction is about the same, and for the heavy batteries it is some 250 pounds behind the teams. This reduction in the loads has been secured by substituting hollow axles for the old solid steel ones, and in other ways by lightening the carriages, and by improvements and reduction in the equipments of the carriages.

[TO BE CONTINUED.]

SOME APPLICATIONS OF GLENNON'S VELOCITY AND PRESSURE FORMULAS.

By CAPTAIN JAMES M. INGALLS, FIRST ARTILLERY, U. S. A.

In the third number of this journal Mr. Benét gives an interesting and instructive account of an application of D'Arcy's method for determining the law of velocity and pressure in the chase of a Hotchkiss 57-mm. gun loaded with a service charge of smokeless powder. This method consists in cutting off successive lengths from the chase of the gun and measuring in the usual manner the new muzzle velocity at each shortening. In this way, and by lengthening a similar gun to fifty calibers travel of shot, Mr. Benét obtained velocities for eight different travels of projectile, these latter ranging from 8.8 dm. to 28.45 dm. From these observed velocities Mr. Benét deduces an empirical velocity formula similar in form to that adopted by Hélie for gunpowder, determining the constants by the method of least squares so as best to represent the observations. He also gives several other formulas for the velocity in terms of the distance travelled by the projectile, among them Sarrau's monomial and binomial formulas, the latter of which has a probable error of 20.53 m. s.!

The object of this article is to invite attention to Glennon's velocity and pressure formulas, in connection with Mr. Benét's experiments. These formulas, which do not seem to have received the consideration they deserve, were first published in the Proceedings of the United States Naval Institute in 1889;* and, as slightly modified by the author of this article, are the following:—

$$v^2 = M_1 \frac{\tilde{\omega}}{d} \left(\frac{z_0}{w} \right)^{\frac{1}{2}} X_0 \left\{ 1 - N_1 \frac{(w z_0)^{\frac{1}{2}}}{d} X_1 \right\} \qquad (1)$$

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* See also, Ingalls' Interior Ballistics, Artillery School press, 1890, where may be found many applications of these remarkable formulas.

and

$$p = M_2 \frac{\bar{\omega}}{d^3} \left(\frac{w}{z_0} \right)^{\frac{1}{2}} X_3 \left\{ 1 - N_1 \frac{(wz_0)^{\frac{1}{2}}}{d} X_2 \right\} \qquad (2)$$

in which

v is the velocity of the projectile at any point within the bore.

p is the corresponding pressure per unit of area on the base of the projectile.

$\bar{\omega}$ is the weight of the powder charge.

d is the diameter of the bore.

w is the weight of the projectile.

z_0 is the reduced length of the initial air-space.

M_1 and N_1 are constants for the same kind of gun and powder, and are determined either by two firings from similar guns but with different conditions of loading—or from two firings with the same gun under the conditions of the Benét experiments.

$$M_2 = \frac{2M_1}{\pi g}$$

X_0, X_1, X_2 and X_3 are functions of the number of expansions of the powder gases. Thus if u is the distance travelled by the projectile from its seat, and if we make $x = u/z_0$, we have

$$X_1 = \int_0^x \frac{x}{(1+x)^{\frac{1}{2}} \sqrt{(1+x)^{\frac{2}{3}} - 1}} \qquad (3)$$

$$X_0 = X_1 \left\{ 1 - \frac{1}{(1+x)^{0.4}} \right\} \qquad (4)$$

$$X_2 = \left\{ X_0 \frac{dX_1}{dx} + X_1 \frac{dX_0}{dx} \right\} \div \frac{dX_0}{dx} \qquad (5)$$

$$X_3 = \frac{dX_0}{dx} \qquad (6)$$

The values of these functions have been computed and tabulated, with x as the argument.* This makes it as easy to use Glennon's formulas as Sarrau's.

In applying these formulas to the data of Benét's experiments we take the observed velocity for the longest and shortest travel of the projectile, respectively, which are (see Benét's paper), for a travel of 28.45 dm., $V=682.1$ m. s.; and for a travel of 8.80 dm., $V=543.1$ m. s. From these velocities and travels, in connection with the given values of $\bar{\omega}$, d, w, and z_0 (this latter depending upon the density of loading and density of the powder), we deduce the following expressions for the velocity and pressure at *any point within the bore:*

$$v^2 = 189737 X_0 \left\{ 1 - 0.065637 X_1 \right\} \qquad (7)$$

and

$$p = 4431.7 X_3 \left\{ 1 - 0.065637 X_2 \right\} \qquad (8)$$

In these formulas the units have been so chosen in computing the constants that v will be given in metre-seconds and p in kilograms per square centimetre. The tabular quantities X_0, X_1, X_2 and X_3 being functions of the number of expansions of the powder-gas, are independent of the units employed.

Since the constants M_1 and N_1 were determined by means of the two extreme observed velocities, equation (7) will of course reproduce these velocities; but whether it will also give the six intermediate observed velocities depends entirely upon the correctness of the theory by which X_0 and X_1 were obtained; and we are thus afforded a good test of the practical value of Glennon's velocity formula. The pressure formula is deduced from the velocity formula by differentiation and simply expresses the force necessary to produce the acceleration of velocity of translation of the projectile. The following table gives the observed and computed velocities, with the corresponding number of expansions and the distances travelled by the projectile:

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* See Table II, Ingalls' Interior Ballistics.

CHARGE 0.46 KILOS. OF SMOKELESS (BN_1) POWDER.

Travel of Projectile.	Number of Expansions.	Velocities.		Diff.
		Observed.	Computed.	
Decimetres.	x	Metres.	Metres.	Metres.
28.45	12.2237	682.1	682.1	0.0
20.20	8.6786	648.3	651.5	−3.2
17.92	7.6981	636.5	638.5	−2.0
15.64	6.7187	622.3	622.3	0.0
13.93	5.9841	612.6	608.0	+4.6
12.22	5.2495	595.0	590.6	+4.4
10.51	4.5149	574.4	569.4	+5.0
8.80	3.7803	543.1	543.1	0.0

The differences between the observed and computed velocities average less than one-half of one per cent. of the former. If we take Mr. Benét's computed values of the velocities—which are their most probable values—and deduce a new velocity formula which satisfies the extreme velocities, namely, 679.9 m.s. and 545.5 m. s., we shall have

$$v^2 = 194295X_0 \left\{ 1 - 0.067657X_1 \right\} \qquad (9)$$

The following table shows the agreement between the velocities computed by Mr. Benét and those furnished by equation (9). The travel of projectile and number of expansions are the same as those already given: The differences between the two sets of velocities are less than one-seventh of one per cent. of the velocities themselves, and are practically *nil.*

CHARGE 0.46 KILOS. OF SMOKELESS (BN_1) POWDER.

Velocities Computed by		Differences.
Benét.	Ingalls.	
Metres.	Metres.	Metres.
679.9	679.9	0.0
651.0	651.4	−0.4
639.0	638.9	+0.1
623.9	623.3	+0.6
610.0	609.3	+0.7
593.1	592.3	+0.8
572.1	571.4	+0.7
545.5	545.5	0.0

These tables show that for this gun and charge, Glennon's formula gives the velocity of the projectile with all desirable accuracy through nearly 70 per cent. of its entire travel in the bore; and, therefore, the corresponding pressures are correctly furnished by equation (8).

Mr. Benét also computes the velocity of the service projectile in the chase of the 57-mm. gun for a charge of 0.92 kilos. of brown cocoa powder (double the charge of smokeless powder) for the same travels of projectile as before, using Hélie's formula, which he has shown to be perfectly trustworthy. Glennon's formulas in this case, deduced as before, are the following:

$$v^2 = 87533 X_0 \left\{ 1 - 0.027648 X_1 \right\} \qquad (10)$$

and

$$p = 3399.5 X_3 \left\{ 1 - 0.027648 X_2 \right\} \qquad (11)$$

The table below gives the velocities computed by the two formulas, with their differences. These latter average less than one-third of one per cent. of the velocities.

CHARGE 0.92 KILOS. OF BROWN COCOA (C_2) POWDER.

Travel of Projectile.	Number of Expansions.	Velocities Computed by		Differences.
		Benét.	Ingalls.	
Decimetres.	x	Metre-seconds.	Metre-seconds.	Metre-seconds.
28.45	20.321	645.6	642.6	+3.0
20.20	14.428	600.0	600.0	0.0
17.92	12.890	583.8	584.6	−0.8
15.64	11.171	565.3	566.9	−1.6
13.93	9.950	549.6	551.4	−1.8
12.22	8.728	532.0	533.8	−1.8
10.51	7.507	511.9	513.2	−1.3
8.80	6.286	488.7	488.7	0.0

Having now shown that Glennon's formula can be relied upon to give the correct velocity of a projectile in the chase of the 57-

mm. gun, we will subject it to a much more severe test by extending our calculations of the velocities and pressures back to the origin, or seat of the projectile, where the velocity and pressure are both zero. We will first employ equations (7) and (8) which pertain to a charge of 0.46 kg. of smokeless (BN_1) powder, bearing in mind that the constants entering into the first of these equations were deduced from two velocities in the chase of the gun at a distance of 19.65 dm. apart, while the form of the curve depends upon the functions X_0 and X_1; and that the pressure formula is derived from the velocity formula by differentiation. The function X_1 is deduced in accordance with Sarrau's hypothesis that the velocity of combustion of the grains of powder which make up the charge is proportional to the square root of the pressure to which they are subjected. This hypothesis furnishes the following expression for the weight of powder burned for any given travel of the projectile:*

$$y = a\omega K X_1 \left(1 - \lambda K X_1 + \mu K^2 X_1{}^2 \right) \qquad (12)$$

in which y is the weight of the powder burned in the gun, a, λ and μ are numbers depending only on the form of the grain, and

$$K = \frac{N_1}{\lambda} \sqrt{\frac{w z_0}{d}} \qquad (13)$$

For the smokeless powders employed by Mr. Benét in his experiments $a = 2$, $\lambda = \frac{1}{2}$ and $\mu = 0$. We therefore have in this case, in kilograms,

$$y = 0.120774 X_1 \left(1 - 0.065637 X_1 \right) \qquad (14)$$

The following table computed by equations (7), (8) and (14) gives in the first column the values of $x = u/z_0$, taken as the argument of the table, and in the following columns the travel of the projectile, the pressure upon unit area of its base, its velocity and the weight of powder burned:

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* Ingalls' Interior Ballistics, page 68.

SMOKELESS (BN_1) POWDER.

$a = 57$ mm. $\bar{\omega} = 0.46$ kg. $w = 2.72$ kg. $z_0 = 2.32783$ dm.

$x = \frac{u}{z_0}$	u decimetres.	u calibres.	p kg. per cm².	v Metre-seconds.	y kilograms	$\frac{y}{\omega}$
0.0	0.0	0.0	0	0	0	0
0.1	0.233	0.408	2132	81.0	0.112	0.243
.2	0.466	0.817	2574	129.6	.152	.330
.3	0.698	1.225	2741	168.9	.180	.392
.4	0.931	1.634	2787	200.2	.202	.440
.5	1.164	2.042	2770	228.0	.221	.481
.6	1.397	2.450	2720	252.5	.237	.515
.7	1.629	2.859	2651	274.3	.251	.545
.8	1.862	3.267	2573	294.0	.263	.571
.9	2.095	3.676	2491	311.9	.274	.595
1.0	2.328	4.084	2408	328.3	.283	.616
1.1	2.561	4.492	2325	343.4	.292	.635
1.2	2.793	4.901	2244	357.3	.300	.653
1.3	3.026	5.309	2166	370.3	.308	.670
1.4	3.259	5.717	2090	382.4	.315	.685
1.5	3.492	6.126	2018	393.7	.322	.699
2	4.656	8.168	1702	441.3	.349	.758
3	6.983	12.252	1254	507.2	.385	.836
4	9.311	16.336	962	551.6	.408	.887
5	11.639	20.420	759	583.8	.424	.922
6	13.967	24.503	612	608.3	.436	.947
7	16.295	28.587	500	627.5	.444	.965
8	18.623	32.671	413	642.8	.450	.978
9	20.950	36.755	343	655.3	.454	.987
10	23.278	40.839	286	665.4	.457	.993
11	25.606	44.923	239	673.8	.459	.997
12	27.934	49.007	199	680.7	.460	.999
12.244	28.450	50.000	191	682.1	.460	1.000

The results of this table—that is, the pressures, velocities and powder burned—are shown graphically in the accompanying plate by the continuous curves. The first two of these curves are at once recognized as the typical pressure and velocity curves as deduced by Noble and Abel from their experiments. The maximum pressure occurs when the projectile has moved 1.634 calibres and when 0.44 of the charge has been converted into gas. The theoretical maximum pressure on the base of the projectile is 2787 kilos. per square centimetre, while the pressure given by the crusher guage was 2550 kilos. This difference is easily explained: Glennon's formulas were deduced for *gunpowder* for which, according to the experiments of Noble and Abel, the volume of the solid products (including the unburned powder) at any period of the combustion is always equal to the original volume of the powder charge, exclusive of interstices; and therefore the volume occupied by the gas is constantly proportional to z_0+u. In the case of the new powders, which are supposed to be entirely converted into gas, the volume occupied by the gas is proportional to $u+z_0+\frac{y}{\omega}\left(u_0-z_0\right)$, u_0 being the reduced length of the powder chamber. At the point of maximum pressure in the case under consideration we have, since $u_0=3.4760$ dm.,

$$z_0+u=2.3278+0.9312=3.2590 \text{ dm.};$$

and if we add to this

$$\frac{y}{\omega}\left(u_0-z_0\right)=0.44\left(3.4760-2.3278\right)=0.5052 \text{ dm.},$$

we shall have 3.7642, which represents the volume actually occupied by the gas. We therefore have, for a rather rough approximation to the actual maximum pressure on the base of the projectile,

$$p_m=\frac{3.2590}{3.7642}\times 2787=2413 \text{ kgs. per cm}^2;$$

and this is probably very near its true value. Equation (2) when applied to powders which are entirely converted into gas, probably makes the pressures somewhat greater than they actually are for the entire breech; but the difference between the actual and computed pressures, is most marked near the point of maximum pressure, and practically disappears near the muzzle. This equation may however be used as a guide in determining the longitudinal profile of a gun designed for firing the new powders, since its errors (which are by no means great) are on the side of safety. There is a point of inflection on the pressure curve at, or near, where $x=0.9$ and $u=2.09$ dm.

BROWN COCOA (C_2) POWDER.

$d = 0.57$ mm. $\tilde{\omega} = 0.92$ kg. $w = 2.72$ kg. $z_0 = 1.400$ dm.

$x = \frac{u}{z_0}$	u decimetres.	u calibres.	p kg. per cm².	v metre-seconds.	y kilograms	$\frac{y}{\omega}$
0.0	0.0	0.0	0	0.0	0.0	0.0
.1	0.14	0.246	1726	56.1	.075	.081
.2	0.28	0.491	2135	90.5	.103	.112
.3	0.42	0.737	2317	118.1	.124	.135
.4	0.56	0.982	2395	141.6	.141	.153
.5	0.70	1.228	2417	162.0	.155	.169
.6	0.84	1.474	2407	180.2	.168	.182
.7	0.98	1.719	2378	196.5	.179	.194
.8	1.12	1.965	2337	211.4	.189	.205
.9	1.26	2.211	2289	225.1	.198	.215
1.0	1.40	2.456	2238	237.7	.207	.225
1.1	1.54	2.702	2185	249.3	.215	.233
1.2	1.68	2.947	2132	260.2	.222	.241
1.3	1.82	3.193	2079	270.5	.229	.249
1.4	1.96	3.439	2027	280.1	.235	.256
1.5	2.10	3.684	1976	289.1	.241	.262
2	2.80	4.912	1747	327.9	.268	.291
3	4.20	7.369	1404	384.4	.308	.334
4	5.60	9.825	1168	425.1	.337	.367
5	7.00	12.281	998	456.6	.361	.393
6	8.40	14.737	871	482.2	.381	.414
7	9.80	17.1[illegible]3	772	503.6	.398	.433
8	11.20	19.650	692	522.0	.413	.449
9	12.60	22.106	627	537.9	.426	.463
10	14.00	24.562	573	552.1	.438	.476
11	15.40	27.018	527	564.7	.449	.488
12	16.80	29.474	488	576.2	.459	.498
13	18.20	31.930	454	586.6	.468	.508
14	19.60	34.386	424	596.1	.476	.517
15	21.00	36.842	397	605.0	.484	.526
20.321	28.45	50.000	297	642.6	.518	.563

The following table gives the same calculations for the brown cocoa (C_2) powder as have been given above for the BN_1 powder; and the velocity, pressure and powder curves are also delineated on the plate. These calculations agree with experiments at all points where these have been made, and we may therefore accept equations (10) and (11) as the practically correct equations of the velocity and pressure curves, respectively, for the given conditions of loading.

The deductions that may be legitimately drawn from these velocity and pressure curves are substantially those made by Mr. Benét, and need not be here repeated. We will only add that the theoretical time of burning of a single grain of each of the two powders, in free air, is for the BN_1 powder 0″.169, and for the C_2 powder 0″.487.

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ELECTRICITY AND THE ART OF WAR.

[By First Lieutenant C. D. PARKHURST, Fourth Artillery, U. S. A.]

Discussion [*Continued*].

Lieutenant *W. S. Hughes*, U. S. Navy.—Lieutenant Parkhurst's article, "Electricity and the Art of War," printed in the October Journal of the United States Artillery, contains so much that is excellent, and shows withal such familiarity with the history of the military uses of electricity, that little can be said concerning it except in commendation.

The subject which forms the title of the article is no new one to military or naval men, or to the public at large. It has been frequently treated, both in a popular way, in various current periodicals, and from technical points of view, in military, naval and other scientific journals. But it is, nevertheless, a subject of which the repeated and continued discussion is amply justified by the rapid development of electrical science and by the constant advances that are taking place in the methods and requirements of modern warfare. The historical portion of the article gives a number of examples illustrating the value of military telegraph lines that are interesting and indisputable; but there are a few points in Lieutenant Parkhurst's statements and recommendations to which some exception might be taken when considered in connection with the present state of electrical science.

The article advocates the immediate installation of electrical power and lighting plants in our sea-coast forts. Let us consider for a moment whether this should now be done: Our present land fortifications and their armaments are practically worthless as a means of defense. Modern forts and guns require years for their construction and manufacture. Until these shall have been built and manufactured, it would seem that the providing of search-lights and electric-power plants on land may well be deferred. Such appliances, however essential they may be, are only adjuncts to forts and guns; and an eminent military authority has said, in substance, that in providing for national defense those preparations should first receive attention which will require the greatest length of time for their accomplishment, and for which there will be the most urgent need in case of war. It may not be practicable to assign to each detail of preparation its proper place in the scale of importance, according to the rule of the authority mentioned, but it will hardly be questioned that forts, guns, gun-carriages and ammunition—all requiring relatively long periods of time for their production—stand among the first upon the list. All these are imperative requirements of war for which the pursuits of peace furnish no demand; while, on the other hand, the ordinary commercial interests of the country are causing electrical science to receive the constant study of an army of experts and inventors. Again, great as have been the advances of the past, in the development of electricity, that science, in all human probability, is now only in its early infancy. Judging wholly by the achievements of recent years, who at the present day will venture to assign limits to its future field of application? With a successful alternating current motor, with alternating "multiphase" current systems in practical operation, with the wonderful results so recently obtained from alternating currents of high frequency, with probably successful storage batteries, and with encouraging prospects of the practical generation of electricity directly from heat, may we not look for changes and improvements in the future at least as great and rapid as those of the past? Why, then, should the present military developments of this infant, but gigantic and rapidly growing, science be applied to our antiquated fortifications; only, in all likelihood, to be again and again discarded for better apparatus long before modern land defenses shall have been constructed for the protection of our sea-ports? The definite adoption of such accessories, it is believed, should *follow*, not precede, the building of forts and the manufacture of cannon.

Everyone will agree with Lieutenant Parkhurst that the applications of electricity are destined to play an important part in wars of the future. One of these applications, the military telegraph, has indeed already become, as he asserts, "an absolute necessity in the handling of troops, in mobilization, and in concentration of food, stores and munitions of war;" but the suggestion that trainmen, telegraph operators, and other employes of all our railroads and telegraph lines, should be "regularly enrolled in the event of war, as a part of the army's working force," would be hardly practicable and rarely necessary. No emergency of war is likely to arise in which more than a limited section of the vast railroad and telegraph systems of this country would be demanded for military operations; and the history of such cases, where they have arisen, goes to show that the efficiency of railroad and telegraph companies can be usually depended upon. Any symptom of disaffection or inefficiency on the part of such companies, in the exigencies of war, justifies the immediate seizure and control of their lines by military authorities. The general plan suggested, if carried out, would require, as well, the enlistment of the employes of inland water-routes, and, possibly, in some localities, those of coast-line steamers.

That the land torpedo-service "should belong to the artillery" is but the natural and pardonable belief of an officer of artillery, and is a point which the present writer hardly feels called upon to criticise or discuss. Such minor questions of personnel, in the event of war, will always be subordinated to the great object of attaining the highest possible efficiency in the common defense of our country. But, whatever arm of the service may be charged with the management of torpedoes operated from the land, no one will deny that officers and men of that arm should be given an opportunity to acquire a practical knowledge of "loading, connecting, testing and firing" these weapons of defense. Fields of fixed-mines, however, which are alone considered by Lieutenant Parkhurst, will require of their operators much less time and practice in order to become efficient in their use than will controllable, moving torpedoes; and to have included these latter in his argument would have added greatly to its force. But our sea-ports cannot be defended by any number, or class, of torpedoes alone, and until we shall have forts and guns, it would seem that a few experimental, or practice, stations, for acquiring and disseminating information, would be all that are required.

Beyond all doubt, incandescent lamps are in every way superior to any other known system of lighting "gun-platforms, casemates, galleries, magazines, shell-rooms, and all approaches thereto," and will assuredly be supplied to our future coast-defenses. The question of economy, in such a matter, is of infinitesimal importance; yet, as Lieutenant Parkhurst has cited authorities to indicate that an incandescent plant is cheaper than gas, or kerosense, the writer ventures to assert his belief that this is only the case, at the present day, under exceptional circumstances and conditions. That electricity surpasses in efficiency and desirability every other motive power for the handling and service of modern heavy ordnance, is now so well established as to render almost superfluous any comparison with other systems.

Lieutenant Parkhurst rightly regards the search-light as an indispensable equipment of modern fortifications, and of armies in the field, and quotes authorities to illustrate its incalculable value in a clear, or nearly clear atmosphere; but his paper might give an exaggerated idea of its *general* utility, for he fails to state that on thick, foggy, or rainy nights, when aggressive operations of an enemy are most likely to be attempted, it has been found in practice that the search light is nearly useless.

Upon the whole, it is but justice to Lieutenant Parkhurst, to say that his article is a valuable contribution to the military literature of electricity. It does not deal in generalties, but makes specific suggestions and recmmendations, which—while they may not all meet with unqualified approval—cannot fail to be of substantial benefit to the service at large, by directing attention to, and causing discussion of, a most important subject.

Lieutenant *Hamilton Hutchins*, U. S. Navy.—I have been interested in this subject for several years, chiefly of course, from the naval standpoint. I think Lieutenant Parkhurst's article very complete, and he can rest assured that bringing the subject before the authorities and others interested is bound to tell. As we in the navy, who have to handle the appliances on board ship, are the only ones who are familiar with the conditions on shipboard and must decide what form of energy is most suitable, the system of supply and, in fact, all the details of the installation—so the artillerist alone can know what is best suited to fulfill the conditions to be met in our sea-coast defenses.

Surely a great variety of electrical apparatus will be required to meet the modern necessities—search lights, incandescent lights and electric motors will be the principal consumers of energy, to say nothing of the telephones, telegraphs, fire-alarms, range-finders, range-telegraphs and indicators, torpedo- and gun-firing circuits, &c. Though unfamiliar with the details of design and construction in our forts, I will ask you to "excuse the bluntness of a sailor" if I make a few general suggestions for your consideration.

Taking the propositions in turn:

First: The Search Light.—This would pay for itself even were its use confined to occasions of emergency in time of peace. A lookout suddenly discovers a vessel that has come to grief, for instance. He at once signals to the dynamo room, almost immediately a search light is turned on and may be the means of saving life. This has been strikingly illustrated in the last few years, as in the case of the floods on the Mississippi, on the occasion of the sinking of a large passenger steamer in Gibraltar bay, and many others.

An electric light apparatus portable enough to follow an army in the field, can be used for a variety of purposes. They should be kept in store ready for an emergency. Most of those so far manufactured have been found to be too heavy and noisy; but we need them. Foreign nations will continue to experiment until one is obtained that meets the conditions, and in this, as in all other war material, we should be independent of foreign manufacture. But the chief province of the search light is with the defense. Recent manœuvres abroad have demonstrated that for the defense of a port, the simplest and most effective adjunct is the search light in sufficient number to illuminate the entire approach. It is safe to say that you will require large and powerful lights electrically controlled from a distance. These are now being manufactured for the navy by at least one American firm. In the 30″ projector a current of 100 amperes is used. Some of the German projectors for coast-defense are enormous, currents of 200 to 250 amperes being used. Not only is the search light difficult to hit, but it can be worked from under cover if desired.

Second.—Inside illumination for night work, as well as general illumination for every day affairs. I take it that the necessity for the incandescent lamp is apparent and needs no argument. It is a mistake, however, to suppose that the naked lamp without extra protection is not dangerous, for if the lamp is suspended in an atmosphere of explosive gas, on puncturing the globe the gas is exploded by contact with the filament. I do not agree with the writer that the incandescent light is cheaper than gas. Besides it is a better quality of light than gas and we should expect to pay a higher price in proportion. Again, it is healthier than gas. But its chief value for naval (and I take it also for military) purposes, is in the fact that it can be utilized effectively to light important spaces that by gas or oil could not be lighted at all, or if at all, only indifferently. In running the circuits for the incandescent system those lamps that are required on board ship in time of battle are on independent mains from all others, so as to materially reduce the chances of important stations being suddenly plunged in darkness at perhaps a critical moment. I take it that some such arrangement would be desirable as well in a fortress.

Third.—The generation and transmission of power.

This subject, particularly the application of the electric motor to the serving and working of the guns, has been most ably handled by Lieutenant Parkhurst, and will surely receive consideration by those who will be responsible in the reconstruction of our sea-coast defenses. Dr. Louis Bell, in the "discussion," has stated in a nutshell the special advantages of the electric motor in distributing power to the guns of a fort, and these features are bound to be important both ashore and afloat. In addition, I should say that in a fortress the electric power would be required at numerous points as is the case on shipboard, thus adding economy to the other advantages gained in transmitting the required energy by electricity.

Signaling Installations.—The necessity for these is obvious.

I am of the opinion that if a proper electric plant were installed in some of our important forts, that the government would be repaid even were they never used for other than purposes of instruction for officers and men.

In conclusion I trust the good work of the writer will bear fruit, and if the mite that I have said will assist therein, I shall be content.

2nd Lieutenant *George O. Squier*, 3rd Artillery.—I have read with a great deal of interest Lieutenant Parkhurst's excellent article on "Electricity and the Art of War." What most interests us, as members of the Artillery, is—What will be the application of electricity to our new sea-coast fortifications, and what should be done now towards the solution of these problems? Before speaking of this, however, a word in regard to the use of the telephone for field service in time of war. Some recent experiments abroad by Captain Charollois,* on the use of a field telephone outfit for military operations, indicate that it has great possibilities as a means of communication in the field. Captain Charollois uses a bi-metallic wire with steel core surrounded by copper. Thus it is not easily oxidized, and has great strength for a given cross-section. This wire is unwound naked upon the surface of the ground, the earth return being completed through the operator himself, or his horse in case he is mounted. The small magnetic receivers can be used as the wire is being paid out on the ground, and this constant communication is kept with the starting point as the line progresses. By the use of such small wire the entire material for a line of one mile weighs less than five and a half pounds. Each reel carries 10,000 feet of wire, and is conveniently and compactly strapped to the soldier as a part of his equipment. On account of the extremely minute currents required in telephony, the only limit to the smallness of the wire, and its consequent weight for a given length, is the fear of breaking while it is being laid. Cavalrymen, or infantry on bicycles, could establish a line with great rapidity. In some recent experiments in the field, a 14-mile line was completed in five hours and taken up in one hour; and the passage

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* *Annales Industrielles.*

of a division of cavalry over the wire did not interrupt the communication of a dispatch that was being sent at the same moment. No batteries are required; no poles of any kind; no heavy cumbersome wire to be strung, and anyone can operate.

In view of the above, and that we are now talking between New York and Milwaukee, there is but little doubt that the telephone is the instrument both for the field and for permanent lines.

The writing telegraph, when perfected, will undoubtedly have its important *rôle*, as by its use maps, plans of battle and fortifications, and drawings of all kinds can be reproduced with accuracy at any distance.

Passing to the use of railroads in the mobilization and supply of armies, those familiar with recent street-railway progress believe that the steam locomotive must give way to the electric motor for passenger service and also that with this change a speed of one hundred miles an hour will be the rule and not the exception. An electric line is now under construction between Chicago and St. Louis, which is to make the trip in three hours.

The suggestions of Lieutenant Parkhurst as to the applications of electricity to the modern sea-coast fortification are excellent, and instead of being, as some may think, the predictions of an enthusiast, they are not as progressive as the present state of electrical science warrants.

In regard to the security of the main power-plant against the long range fire of the enemy's guns, it is remarked that there seems to be no limit as yet to the distance which electrical power can be economically transmitted. We have recently before us the Lauffen-Frankfort line in Europe, where 300 horse power was transmitted 112 miles at a tension from 16,000 to 30,000 volts, at an efficiency of 74 per cent. As soon as we obtain a perfectly satisfactory alternating current motor, I see no reason why electrical power cannot be transmitted and converted into useful work at distances much greater than the above.

Electricity threatens to revolutionize our whole heavy artillery orgaization. With an enormous engine of war, weighing many tons, costing thousands of dollars, which can, however, by the application of results *already accomplished* in the industrial world, be lowered, raised, aimed, and fired by the movement of simple levers in the hands of a gunner—does not this point to *fewer* men and *more skilled* men in our organization?

The dozen men in a detachment required for the doomed "heave and embar" system, must be replaced by not more than half that number of carefully trained cannoneers. Each round fired from our new 12-inch rifles will cost $217.00, the gun itself costs $52,365.00, and these amounts in conjuntion with the cost of the carriage, and the limited life of the weapon, compels us to adopt that means of control which insures the most rapid, accurate, and reliable service.

Granting that the modern fortification will be equipped with an elaborate electrical plant, ought we to rely upon civilian electrical engineers to design, install, and care for the same? This brings up a subject of policy of which

I have been firmly convicted for the last five years, and which is strengthened more and more as time goes on. Electrical science has reached the theoretical stage—that, given the set of conditions which the motor is to fulfill, and which in sea-coast matters the artillerist alone fully understands, the design of the machine to do this particular work can be made with accuracy, *e. g.*— speed under variation of load, field windings for perfect control, and the size of every minute part can be calculated in the office, and when assembled in the work-shop it will do the work required near perfection.

We have only to look at our new navy for a practical illustration of the way things are drifting in this regard. Every modern cruiser now has its officer in charge of all electrical matters on ship-board, and the generators and motors already in use are specially designed for conditions afloat. In like manner each group of guns ashore, with its electric lighting system, search light system, range finding system, generators and motors, will of necessity be under the supervision of an electrical engineer directly responsible to the senior artillery officer in command. If present conditions point to anything, they seem to me to point to the neeessity of the following:

The War Department should speedily educate a limited number of officers as electrical engineers at our best institutions of learning. The word "*speedily*" is used because one cannot become an electrical engineer in six months, nor yet in one year, and he certainly cannot be created at pleasure by a general order from the War Department.

I am aware that objection would be made by some to such details; the applicant is supposed to desire to shirk his legitimate battery duties, and what not; but such reasons seem to me on too low a plane to merit serious consideration. The weeding process of requiring periodical reports of the work accomplished, and the efficiency reports already in vogue, would insure the details being given to those who would make the most of them for the Department.

Thanks to the foresight of the General Commanding the Army, officers of artillery have recently been sent to our principal arsenals to coöperate with the Ordnance in the manufacture and testing of our modern guns. With half a dozen expert electrical engineers at Sandy Hook, and the sea-coast gun carriage factory at the Watertown arsenal, coöperating and in perfect harmony with the ordnance experts already at these places, to design, test, and work out step by step the details of the plan, I doubt not that rapid progress would be made towards the selection of type carriages for our new guns and mortars, and we no longer would be threatened with the condition of possessing finished weapons with no carriages on which to mount them.

Mr. *Irving Hale*, General Electric Co. (Late 1st Lieutenant U. S. Corps of Engineers).—The paper under discussion takes a broad and impartial view of the applications of electricity to warfare and covers the ground about as thoroughly as possible without taking up the various branches of the subject in their technical details. Without attempting any such analysis of the question, a few points suggest themselves in regard to the benefits to be derived from electric light and power and the general methods that would give the best results.

The suggestion that army posts ought to keep abreast of the times in the adoption of the electric light seems a most natural one to those who are familiar with its general use in small towns, factories, hospitals, prisons, schools and other institutions where the electric plant is considered almost as much of a necessity as plumbing, heating and ventilating appliances. The only wonder is that it has not long since been adopted at all large and permanent posts, especially when it is considered that there are few situations where the advantages of electric light are more striking or where it can be produced so cheaply. It is especially desirable in hospital and barracks on account of its safety, cleanliness, healthfulness, non-pollution of the air, cheerfulness, saving of labor, and general convenience. Moreover the lights could all be under the control of the first sergeant, who could turn them off at taps and on at reveille, and could instantaneously light up any room or the whole barracks at any time in the night in case of fire, disturbance, inspection, or the long roll, thus avoiding confusion and facilitating the movements of the men. In short, it would contribute to health, safety, comfort, morals and military discipline. Electric light can be produced at unusually low cost at a post on account of the small expenditure for superintendence and labor and the avoidance of certain items of general expense. There would be no salaries of Manager, Superintendent and Book-keeper, as their duties would be performed by the ever-willing Quartermaster and his assistants. Enlisted men on extra-duty pay at fifty cents per day would replace firemen and engineers at two to four dollars per day. Ground for the power-house costs nothing, taxes would be nil, and while private enterprise demands a profit of at least ten per cent. on the investment and must pay five to eight per cent. on its bonds if issued, "Uncle Sam" can borrow money at three or four per cent. and should be satisfied with a correspondingly small return on the invested capital.

A ten company post would probably require a plant having a capacity of about 1000 16 c. p. incandescent lights with perhaps 1400 lights wired, including, if desired, a few arc lamps on the incandescent circuit. Such a plant including building, steam-plant, dynamos and appliances, linework, street lights and inside wiring of buildings would cost in the vicinity of $20,000. Assuming that 600 lights are burned regularly from 6 P. M. to 10 P. M-, and an average of 100 lights from 5 P. M. to 6 P. M. and 10 P. M. to 7 A. M. (a liberal estimate), the annual operating expenses, with coal at $4.00 per ton would be about as follows, the estimate being based on experience of plants in actual operation.

Two men at 50 cents per day each	$ 365.
490 tons coal at $4.00	1960.
Oil and waste	180.
	$2505.

Transfer	$2505.
Lamp renewals	600.
Incidentals	120.
Depreciation and repairs, 5 per cent on $20,000	1000.
Total operating expenses	$4225.
Interest at at 4 per cent on $20,000	800.
Total including interest	$5025.

As the estimate covers 1,241,000 lamp-hours per annum, the cost is about $\frac{4}{10}$ cent per lamp-hour. While electricity does not pose as a rival of coal-oil on the basis of cheapness, except under conditions especially favorable to the electric fluid (cheap coal and dear oil), still when the items of chimneys, wicks and broken lamps are considered, to say nothing of labor of cleaning and filling lamps, lighting and extinguishing the outside lamps, damages from smoke and spilled oil, and damages from fire, it is probable that electricity, under the favorable conditions for economical production at a post, would compare very favorably in economy with the dangerous, dirty, ill-smelling, smoke-producing, oxygen-absorbing, semi-barbarous fluid now used in enlightening the army. This statement is of course based on the assumption that *the same amount of light* is produced by the two methods. The amount of illumination provided for in the preceding estimate on the electric plant undoubtedly exceeds greatly the amount usually produced by oil at a post of that size, and if the latter were considered sufficient, the size cost and operating expenses of the electric plant could be considerably reduced. It is usually the case, however, that when electricity is substituted for oil two or three times as much light is demanded and used, and it is probable that army posts would be no exception to the rule. While the subject hardly comes under the head of "Electricity in Warfare," still as the army will probably have twenty years of peace for every year of war, improvements which increase the comfort and welfare of the troops in time of peace are of about as much importance as those which increase their efficiency in time of war.

The designing of an electric plant for a fortification would be a more complicated problem, as it must supply arc and incandescent light and power, and should be so planned as to make failure of current for any of these purposes practically impossible, while preserving the greatest possible simplicity. The following general principles suggest themselves as being of fundamental importance:

First.—The voltage should, if practicable, be so low as to make fatal or even painfully severe shocks impossible. While the high-tension current has established itself, in the face of all opposition, as a valuable and necessary servant, without which the proverbial "infancy" of electricity would be likely to be a permanent condition, it is generally admitted that the low-tension current is preferable where it can accomplish the desired results without too great expenditure for copper. The dimensions of a fortification would in most cases be well within the limits of a 250-volt current. A safe voltage is especially important in a fortification, for in the smoke, confusion and excitement of action men would almost certainly come in contact with abraded or broken wires or parts of apparatus carrying the current. Low-voltage dynamos and motors usually give less trouble than high-voltage machines from burn-outs, grounds and breakdowns and are more easily managed—points of considerable importance where reliability and simplicity are so essential. The low-tension direct current dynamo is the only machine that can satisfactorily supply incandescent lights, arc lights and motors from the same circuit,—a consideration of some weight in connection with the sixth condition given below. Moreover the low-tension current can be more easily handled with underground wires.

Second.—The circuits should, as far as practicable, be underground, to reduce to a minimum the danger of cutting wires in action. With the direct low-tension current, this method of distribution presents no difficulties and is successfully accomplished in many of the large cities.

Third.—The circuits should, as suggested, be so arranged as to prevent failure of current at any point by the cutting of one or even of several sets of wires. This could usually be easily accomplished by multiple feeders supplying the mains at different points, duplicate or triplicate mains with the lights in each locality divided among them so that the disabling of all these mains would be necessary to leave the place in darkness, and by a proper system of switches and cut-outs. The detailed arrangements would be a matter of special study in each particular case.

Fourth.—The incandescent light is preferable to the arc light for most uses about a fort, as it has no mechanism to get out of order or carbons to change, requires less attention, is safer around explosives, and enables the light to be subdivided into small units distributed where they will do the most good, which is what is required in casemates, magazines, posterns, galleries, around the guns, and in fact in most portions of the works. In some places where large open areas are lighted the arc light could be advantageously employed. Of the two types of arc light, the one for operation on incandescent (constant potential) circuit would seem to be the most suitable. The distances would not be so great as to bring out the principal objection to these lamps,—the large amount of copper required to supply them at long distances,—and their advantages would be important. Their use would avoid the employment of a dangerous voltage, they are connected in independent pairs, instead of in a single dependent series, arcs and incandescents can be used interchangeably on the same wires, and their relative proportions varied, and the same type of dynamo can supply them both, thus securing greater simplicity of plant.

Fifth.—Although all the lights and motors of such a plant would seldom and probably never be in use at once, the dynamo capacity should certainly be sufficient to supply them all simultaneously, not only because such a contingency might arise, but also because where absolute reliability is of such vital importance, there should be a considerable reserve capacity.

Sixth.—The use of only one kind of dynamo for incandescent light, arc light, and power, will greatly enhance the simplicity, flexibility and effectiveness of the plant. If a different kind of dynamo be used for each of these three purposes, not only will the operation of the plant be more complicated, but it will be necessary to have a reserve dynamo of each kind, making the capacity of the plant twice that actually required, whereas if all the dynamos are of the same type, a reserve of one dynamo, or one pair of dynamos (if on the three wire system) would be sufficient. Moreover, with three kinds of dynamos, it would be quite possible for all the dynamos of one kind to be disabled, thus entirely crippling that branch of the work, which might be the one most needed, while by the other plan, as long as a single dynamo remained fit for service, all kinds of apparatus could be operated, although the total amount of current would have to be kept within the capacity of that machine. It is not intended to recommend the habitual operation of motors and lights from the same dynamos, as the variation in voltage caused by the starting and stopping of the motors effects the steadiness of the lights; but the plant should be so arranged that this can be done when necessary.

In view of the above considerations it would seem that the best plant to fill the conditions imposed, would consist of direct current 110-volt dynamos, connected in pairs on the three wire system, giving 220 volts between the outside wires; one pair being used regularly to supply incandescent lights and arc lights of the constant potential type, the latter being connected in pairs across either side of the system, another pair supplying 220-volt motors on a separate circuit, and a third pair in reserve; switches being so arranged that any pair of dynamos can be thrown on any circuit, or all the circuits and all the dynamos thrown in together.

The relative merits of steam, compressed air, shafting, cables, water, and electricity for the distribution and application of power, are thoroughly and impartially presented. The superiority of electricity, under ordinary conditions, is now generally admitted. Concerning the successful operation of the guns and machinery of a fortification by electric motors, there can be little doubt. The street-railway and mining-machinery problems have presented more serious difficulties than are likely to be met with in fortifications, and these have been solved. Let the government say what it wants, and the electric companies will be ready to furnish and guarantee it. In this connection, however, one point should be emphasized. The working up of the details of any new application of electric power requires much time and study and most of the electric factories are so over-crowded with work equiping lighting, power, and railway plants, that is difficult for them to find time to design special applications of electric power. This work properly belongs to the officers of the army. They know what they want to do better than anyone else, and can work out the details of the gun-carriage, gearing, etc., ready for the motor. And in doing this, it would be well to visit the electric roads and factories and familiarize themselves with what is being done and the types and dimensions of motors in actual use, and then design their appliances as far as practicable to fit these motors. Motors which have done good service under a car or in a mine, will probably be equally satisfactory on a gun-carriage or shot-hoist or tram, and the utilization of such existing and tested types of motors will avoid not only the bugbear of special design but the danger of unforseen defects in new and untried types.

Professor *D. M. Greene*, C. E., Consulting Engineer, Troy, N. Y.—I have read, with great interest, the paper entitled "Electricity and the Art of War," published in U. S. ARTILLERY JOURNAL of October, last.

In this paper the writer has covered the entire ground so completely, and so thoroughly, that there seems to be nothing left for one to do but to congratulate him upon the thorough grasp of the subject, and the able and comprehensive treatment of it, which must be manifest, even to the casual or non-professional reader.

While endorsing, fully, his general conclusions, a single suggestion may be permitted, as follows: Would not the necessary plant be greatly simplified by the adoption of either hydraulic or pneumatic power for the operation of *ammunition hoists?* It seems to me that the necessary piping for these could be so far removed from possible danger from hostile projectiles, that they would be as secure and reliable as would be any part of the more exposed electrical installation.

Lieutenant *T. C. McLean*, U. S. Navy.—I regret very much that I have not been able to contribute properly to the discussion of Lieutenant Parkhurst's paper on "Electricity and the Art of War," in compliance with invitation to do so. I wish to say, however, that, in my opinion, there are no great electrical difficulties involved in carrying out the propositions made by Lieutenant Parkhurst, and also that there does not appear to be any good argument opposed to the adoption of the propositions in regard to the management, control and use of all of the electrical apparatus and the material operated by it.

The artillery officers are competent to perform the duties. The Artillery School affords facilities for any special instruction that may be needed.

The intelligent enlisted man could perform properly such work as would not require the constant attention of a commissioned officer; and, in addition, they would be trained artillerymen, available for service at the guns, or in any other duties of artillerymen.

Needless permanent assignments of certain duties to special classes of men, unnecessary departures from a uniform scheme of organization and performance of duties in concert, and interruptions in the natural sequence of authority for direction and control, are worse than useless in military establishments.

The search light is necessary to the proper defense of any fortified position, whether it is or is not subject to a naval attack. Under certain conditions it is capable of great service in operations in the field. In which case the search light outfit most naturally would go with, and be a part of, the field artillery. If the dynamos for field service were arranged to be worked by horse power, as has been proposed by foreign officers, the dependence on uncertain supplies of fuel and water would be avoided; and also the many derangements to which steam boilers and engines are liable when subjected to the rough usage unavoidable in field work.

In regard to who is to perform the duties of design and construction of the electrical apparatus and other material for army use, that is not a matter for me to discuss.

1st Lieutenant *C. D. Parkhurst*, 4th Artillery.—The very flattering manner in which this article has been received cannot but be both gratifying and encouraging to the writer. Thanks are due to all the commentators and critics for their great assistance in bringing this matter prominently into notice.

It is particularly gratifying to learn that the main ideas and suggestions contained in the article had already received thought and attention by those whose duty it is to provide us with the best system of sea-coast defense. We can therefore look forward to the time, which should not now be so very far distant, when we may see a modern gun mounted in a modern fort, and upon a modern carriage, provided with modern power for its manipulation.

If I may be allowed a moment for a side remark, I would say that it is very much to be regretted that some means of intercommunication of ideas does not officially exist. Until I saw General Abbot's statement in the October JOURNAL, I had no idea that any such consideration of electric power had been entertained; and, furthermore, knew of no one who did have any such knowledge: although I searched for information, certainly none was found on the subject. Any reports that may have been made were beyond my knowledge and reach, and I therefore wrote in utter ignorance of what was contemplated.

Now, would it not be a good idea if some means of imparting information from one department to another was officially adopted? Would it not conduce to harmony and unity of action if all those interested and who are writing were kept informed as to the desires and intentions of each separate branch of service in regard to the problem of our sea-coast defense?

We of the artillery are particularly interested in this matter. Upon us will fall the main brunt of sea-coast battle when necessity requires; we, and our sea-coast defense must stand or fall as we successfully or unsuccessfully man, handle, and defend the works and "tools of our trade" with which we have been provided by the labor and thought of the Corps of Engineers or the Department of Ordnance. We have no desire to usurp or acquire any of the duties pertaining to either service. The Department of Ordnance is making our guns, and making them well, as rapidly as the limitations of congressional appriations will permit, and we have, or should have, no desire to interfere with such manufacture. The Engineers are building our forts, and providing foundations for our gun-platforms and carriages, and certainly that is not the practical artilleryman's duty or proper function. Yet *we have got to fight with that with which we are provided*, and hence it would seem that we should be kept informed as to what that is to be, in the first place to enable us to look ahead and study up the requirements of successful service in regard to new apparatus with which we are to be provided; in the second to enable the service which has to put the "tools" to practical use, to study and investigate, and perhaps to suggest some ideas as to what we want, and how we want it.

It would seem to me that engineer, ordnance and artillery branches of the service are inseparable in this matter; we all must work for the common good, each in our proper sphere; life is too short, and time too precious for any of us to waste any of it in "plowing old ground," or in working without harmony and accord in every way.

With such an interchange would not the present tendency to exclusiveness and jealousy of ideas be removed? Would we not *all* be benefited by being brought closer and closer together and getting better acquainted? Would we not in the end be thereby compacted into one harmonious whole, each striving as best he might for the common good, independently of corps, department, or arm of service? When differences of opinion arise, as arise they must and will, should we not each be willing to "give a little, and take a little," and thus arrive at the inevitable "compromise" that attends *all* adjustments of human affairs, where the "greatest good to the greatest number" is sought? We should stop growling and grumbling and captious fault-finding. We should find out what we want (do we always know?) and then approach the matter in a rational, reasonable and reasoning spirit, ready to give credit where credit is due, ready to acknowledge difficulties and ready to try to overcome them, and ready to accept any valuable idea, no matter whence it comes.

To resume the question under discussion, if General Abbot will allow me, I would now explain my position upon the torpedo service.

Far be it from me, far be it from the artillery service at large, to try and create any heart-burnings, jealousy, or bitterness of spirit upon any question pertaining to our common service. Honest differences of opinion, honestly expressed should not do so, but rather lead to knowledge as to what is best for all. Though "silence may be golden" at times, an honest expression of views and opinions relieves one's mind, gives others new trains of thought, and perhaps leads to changes of opinion, or the correction of faults. When the best has been found, then all should work in hearty accord to further it in every way.

In the matter of torpedo service it would appear to me to be mainly a question of unity of service, of numbers ready to perform that service, to be prepared at all times with perfected *materiél* and instructed *personnel* in such numbers as the service may require. When needed, it will be needed in a hurry, judging from the suddenness of all modern wars; to quickly plant and to successfully watch, guard and manipulate the vast fields of mines that we must have would require a large force of well trained officers and men, to prevent that "failure" which "would be certain if officers and men without experience should suddenly be called upon to defend the coasts with mines." *

It is then, as said above, a question of numbers and previous instruction, rather than branch of service. It is a question of

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* **Board on Fortifications—Report Committee No. 2.**

unity of service rather than of comparative ability to perform the service. Granted that the calls that may be made upon us may be varied and multifarious in the modern system of coast-defense, are they any more so than those that will be made upon and must be met by the Corps and Battalion of Engineers? Our sphere is compartively limited, while that of the engineers must embrace the whole field. We will have harbors to defend and will be or should be separate and distinct from any field army and its campaigns, unless of course the field of operations embraces the districts that contain sea-coast works. The Engineers on the contrary belong to the *whole* army, and must be with it everywhere to aid and direct in the location and establishment of such field or siege works as may be required.

The questions then become, can Willets Point educate enough *engineer* officers whose services can be spared for torpedo service in time of war? Is the Battalion of Engineers large enough to provide all the men that will be needed for the multifarious duties *it* will be called upon to perform, *in addition to torpedo service?* If educated officers and men are needed as sappers, miners, and pontoniers for *general* operations, will there be "enough to go around" and provide other educated officers and men for the special torpedo service? Will not the demands be such that the torpedo service may "be left" in this distribution of talent, or, if provided for, only at the expense of some other equally important service?[*]

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[*] The Corps of Engineers embraces 117 commissioned officers and 500 enlisted men. These officers are in rank as follows:

1 Chief of Engineers—with rank as Brigadier General, 6 Colonels, 12 Lieutenant Colonels, 24 Majors, 30 Captains, 1 Battalion Adjutant, 1 Battalion Quartermaster, 26 1st Lieutenants, 10 2nd Lieutenants, 8 Additional 2nd Lieutenants.

The enlisted men comprise:—1 Sergeant Major, 1 Quartermaster Sergeant, 34 Sergeants, 34 Corporals, 8 Musicians, 210 1st class and 212 2nd class Privates. (See Army Register, Organization of Army.)

The Battalion of Engineers consists of 1 Major, 1 Adjutant, 1 Quartermaster, 5 Captains, 5 1st Lieutenants, 5 2nd Lieutenants. The enlisted men enumerated above comprise this Battalion. (See Army Register.)

The legal strength of the Battalion of Engineers is 5 companies of 150 men each. Its present strength is 18 officers and 437 enlisted men. The authorized strength of Cos. A, B, C, stationed at Willets Point, is 133 men each; of Co. E, stationed at West Point, 100 men.

The battalion has been employed during the past year at engineer, pontoon and torpedo drills, infantry drill, rifle practice, and photography. Co. E, at West Point, has assisted in

From the course that is being pursued it would look as though the fear existed that some of the above questions must be answered in the negative. Officers of cavalry, infantry and artillery, as well as engineers, are justly entitled to Willets Point for a course of instruction in torpedo warfare. As a matter of general education, or to fit them for special service with their own arms of service, this is to be commended. But, when war comes, are these cavalrymen, infantrymen and artillerymen to be detailed for torpedo service upon our sea-coast to make good any deficiency that may be found to exist in the numbers of the

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the instruction of cadets in military engineering and pontoon drill (see Report of Chief of Engineers, 1892. Page 19). Co. D, Battalion of Engineers, appears to be a shadow.

The post of Willets Point comprises 24 commissioned officers, and 353 enlisted men. At the U. S. Engineer School, "during the year 6 engineer officers, 2 cavalry, 1 artillery, and 5 infantry officers completed the course, and 7 infantry officers who have completed the laboratory work are still engaged in the practical work of planting and operating torpedoes, which it is expected will be completed October 1st, 1892." (Report of Chief of Engineers, 1892. Page 19.)

The commissioned officers of engineers were distributed as follows during the year 1892:

Commanding Corps of Engineers and Engineering Department	1.
Office of Chief of Engineers	3.
Board of Engineers, fortifications, river and harbor works and Division Engineer	1.
Board of Engineers, Board of Ordnance and Fortification, and Division Engineer	1.
Fortification, river and harbor works and Division Engineer	2.
Board of Engineers, Mississippi River Commission, Division Engineer and Board of Visitors	1.
Board of Engineers, fortifications, river and harbor works and Board of Visitors	2.
Washington Aqueduct, and light house board	1.
River and harbor works	33.
Fortifications and river and harbor works	30.
Mississippi River Commission and Missouri River Commission	1.
Fortifications, Post of Willets Point, U. S. Engineer School, and Battalion of Engineers.	1.
River and harbor works, and Missouri River Commission	1.
Public buildings and grounds, Mississippi River Commission, Missouri River Commission and Light-house Board	1.
Battalion of Engineers and U. S. Engineer School	14.
Mississippi River Commission	1.
Fortifications	1.
Missouri River Commission	1.
Leave of absence	1.
Detached service	20.
Total	117.

(See Report Chief of Engineers, 1892. Page 3.)

The artillery comprises:—5 Colonels, 5 Lieutenant Colonels, 15 Majors, 60 Captains, 5 Adjutants, 5 Quartermasters, 120 1st and 65 2nd Lieutenants, 5 Sergeant Majors, 5 Quartermaster Sergeants, 5 Chief Musicians, 10 Principal Musicians, 60 1st Sergeants, 260 Sergeants, 240 Corporals, 120 Musicians, 120 Artificers, 60 Wagoners, 2790 Privates, or total of 280 commissioned officers and 3575 total enlisted. (See Army Register.)

The stations and duties of the artillery cannot be given for want of data.

engineers? If so, who will supply the deficiency thus made in the cavalry and infantry? There will be no deficiency in the artillery, for torpedo service and artillery service can go on simultaneously. Will not the cavalryman and the infantryman be needed, and be fully occupied with their own arms of the service? Will not all their knowledge of torpedo service be valuable for field and land operations, in demolition and kindred work? If they are detailed for sea coast torpedo service will it not be at the expense of their proper arms of service, which must suffer from such loss? Will we be able to find cavalrymen and infantrymen who will willingly accept such work? And, if we do, will we not be "robbing Peter to pay Paul" in a most decided manner, to gain an end that can be accomplished much more easily and consistently?

I think it may be safely stated that every sea-coast artillery garrison is equipped with boats, and has one or more boat's crews in regular training. If there are any that are not so equipped I do not know of them, while I do know of many that are.

So much of the training necessary is thus already established, and certainly men constantly on the ground at our sea-coast forts can be and are fully as familiar with all the details of channels, tides, shoals, &c., &c., as any other body of men who only know of them by the aid of charts.

Would it not be well then if, in addition to Willets Point, we had a school of application for torpedo service for the artillery alone? Would any harm be done if offcers and men of the artillery were to receive *practical as well as theoretical* instruction in mines, so that we would know the practice as well as the theory of "loading, connecting, watching, testing and firing?" Would money be wasted if we used a torpedo now and then, and thus learned by observation what "effects are to be expected?" Would we not, on the contrary, be fitting ourselves in advance for the performance of a legitimate and proper duty, a duty that circumstances may some day, in spite of all plans to the contrary, force upon us? This would add to our work, and to the demands to be made upon us; but if we are tried and not "found wanting" in the schools of Peace, we will be but more ready to respond to any and all of "the multifarious calls which will be made upon" us in time of War.

Now having expressed my views, and those of a large number of artillerymen at perhaps too great a length, let us in all harmony come to a conclusion as to what is best, and, when this has been ultimately decided, all accept it gracefully and labor honestly and faithfully for its accomplishment.

To touch upon another point, it was well known that experiments had been made for some years past at Willets Point with the electric search light. However much good these experiments may have done they have not as yet spread any great amount of information throughout the artillery service.

And in this arm, I respectfully submit, is where the knowledge and experience is needed for successful operations of sea-coast defense in time of war. The dynamo and general plant will have to be manned and supervised by artillery officers and men. Light for battery use must be under control of battery commanders, and, no matter how expert other specialists may be, we must have our own experts and specialists right at home and in our own service, and not be forced to depend upon others who doubtless would be able, and who would gladly give us their aid, but they "cannot serve two masters," or be in two places at the same time. Hence we need the outfit *right now* at some one, if not all of our artillery posts, to give the necessary instruction to train the specialists we need. When war comes we do not want to have many and multifarious duties suddenly thrust upon us. We wish to have time for preparation in order to be ready and able to respond to all demands.

In this connection let it be said that the defects of the search light as to fog piercing power are well known. The sun is often obscured by clouds and fog, yet we could hardly get along without him. Though the search light may not be able to penetrate through fog, it yet has a vast field of usefulness for sea-coast defense, and no fort should now be considered as properly equipped until it has one or many as the case may demand, the same as with our battle-ships and cruisers.

As to the size of the units of power, doubtless the modern tendency in the commercial world is to larger and larger engines and dynamos, capable of supplying large amounts of power, or maintaining a large number of lights, at an economy not dreamed of in the beginning. Yet it is within the knowledge of the writer that this has sometimes proved of very doubtful expediency. So long as everything runs smoothly, well and good; but when an engine breaks down (and they will sometimes), serious trouble results from the cessation of power or light over large districts, with no spare engines ready to put to work to supply the demand.

We must then be careful not to have all of our eggs in one basket; we should so install our plant as to be able, with spare engine or engines, and spare dynamos, to replace any disabled part at once, and thus insure certainty and constancy of action at all times during an engagement. Ships of war and merchant steamers now have twin and some triple screws each with engines complete, not only for the greater power, but also for greater safety. We too should provide against all contingencies, leaving the matter of mere economy as of secondary consideration.

As to waiting for something better than we now have before making a start: granted that what we now have is far from perfect, when will it be so perfect that further improvements will not be made? *When are we to begin*, now, or at some distant day? If we wait for any time short of the millennium, will we then have any guarantee but that we might have done better by *waiting just a little longer? I say we want to begin right now,* just as we have with guns both large and small, without further delay or further improvement. We have sat with folded hands long enough. and we need to wake up and get to work with what we now have, and have a hand in developing improvements in our own special line, so as to be ready for the time when our guns, carriages, and forts are ready for their full use.

It is not so long since our navy had no ships worthy of the name. Such ships as they had were lighted in the old way. Yet they made a beginning, and to-day we have a "White Squadron"*

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* Report of Secretary of the Navy, 1892.

constantly growing in size, the vessels of which are now all lighted by electricity as a matter of course.* It cannot be claimed that constant improvement has not been made in ship building and in marine electric light plants. Yet the first ship and the first electric light plant are by no means obsolete. Even if they are they can well be relegated to the scrap-heap, having paid for themselves many times over from the practical demonstration of the possibilities that they have afforded. To-day in the electrical world we have dynamos, engines and the details of wiring and installation that possibly never would have existed except for the demands made upon inventors by the necessities of the marine electric light plant. The *Trenton's* plant showed the defects, the necessities as well as the possibilities, and we need a first plant as soon as we can get it to demonstrate defects, necessities and possibilities in a similar measure.

And are we as badly off for means of application as would at first appear? Have we no guns, carriages or forts that can be utilized? Let us turn to statistics and look for a moment and find what we have, and what we soon shall have.

GUNS ON HAND.

Rodman guns, smooth bore, two 20-inch, three hundred and eight 15-inch, nine hundred and ninety-eight 10-inch and about two hundred and ten 8-inch converted rifles,† to say nothing of the one hundred 200 and 300-pounder Parrotts.

These guns are not obsolete, for "some of these smooth bore and rifled guns will be used to defend the torpedo lines, and the remainder may be attributed to existing forts and batteries, as well as to ports not mentioned in the foregoing report."‡

To mount these guns we now have on hand 136 altered 10-inch carriages for service with 8-inch C. R.; sixty 15-inch carriages for 15-inch guns, using increased charges of powder.§ These carriages are being altered and strengthened yearly in limited numbers for use with the above guns for secondary battery. The

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* **Electricity on Board Warships. Annual of the Office of Naval Intelligence, 1892.**

† **Report of Endicott Board 1886, page 20.**

‡ **Ibid.**

§ **Report of Chief of Ordnance 1892, page 17.**

field of usefulness of these guns and carriages may have become restricted, but it is not yet extinct, and we may just as well recognize the fact and shape our course accordingly. There is much yet to learn that can be taught by the proper use of these guns. When we have learned all they can teach it will then be time for us to give exclusive attention to the 8, 10 and 12-inch high powered rifles of modern character.

Besides the above we now have or soon shall have fifteen 8-inch guns, eight 10-inch guns and three 12-inch guns, together with forty-four 12-inch cast-iron steel hooped mortars.* Thirty-seven of these mortars have already been delivered (October 21st, 1892) to the government.† For these mortars the Builder's Iron Foundry has delivered the first carriage under its contract, and "work on the remainder is so well advanced that the entire eight carriages should be completed by the end of 1892."‡

Now with all this material on hand shall we consent to wait? Shall we quietly sit by and "take another nap" while we are waiting for a perfect dynamo, motor, engine and installation to be developed? If we do consent to wait we may wake up and find something more surprising than ever greeted Rip Van Winkle after his sleep, as our slumbers are disturbed by a hostile fleet knocking at our doors with no timid touch. No! We have waited long enough! We have worn out enough trowsers sitting around, and we need to wake up, off with our coats and go to work; to insist upon having such tools of our trade as are available, and to put them all to use to learn their capabilities and defects, and with them to develop all the improvements possible in the application of power for their speedy use.

No fort is really needed in order to experiment with and develop our appliances. We can set up a gun anywhere and use it, and thus find out what the fort as well as the power must be. Our engineers are not idle. Work is going on at New York, Boston, San Francisco and Hampton Roads. Sites for forts are being enlarged and secured as rapidly as legal questions and

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* Report of Chief of Ordnance, 1892.

† See "Our Share in Coast Defense" Part I, Builders Iron Foundry.

‡ Report of Chief of Ordnance, 1892.

limited appropriations will permit.* Before we are fully awake we will have forts, gun carriages and guns, and these will be with or without electric power, depending to a great extent upon our desire and demands for *immediate* installation.

It is evident that some ideas exist looking to the utilization of alternating currents of high voltage from points of generation and distribution far remote from our works. Though the possibility is recognized and granted, the advisibility of such a project may well be questioned.

Our forts should be as self contained as possible. We should be independent of any outside aid or resource for our power and its application. We should be able to control its generation as well as its distribution, and not be liable to be cut off from it by any sudden dash of raiding parties, purposely sent out to cut wires and isolate us. We should use currents that are safe and harmless, as is most concisely stated by Mr. Hale, and not introduce any man-killing or demoralizing element, for we may have enough of that from the shells of our enemy. All of these reasons and many others, point to the use of direct currents for low voltage and large ampereage, such currents as are now to be had for the asking, without further investigation or development.

Lieutenant Hutchins strikes a key note when he says "that if a proper electric plant were installed in some of our important forts, that the government would be repaid even were they never used for other than purposes of instruction of officers and men." That is just what we want, what we must have, if we are to be ready to do our full duty in the event of war. It takes time to learn new duties. We cannot expect to succeed at many things we may be called upon to perform unless we are given a chance for study, practice and preparation. Duties that might be hard, in fact impossible, when suddenly thrust upon us, become easy and as a matter of course with such study and preparation as might be given to them by a little forethought. With such a plant the full possibilities and capabilities of both the light and power would become familiar to many; we would be training our experts to be ready to serve us in time of need; we soon would

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* Report of Chief of Engineers, 1892.

have confidence in ourselves in ways and methods now unknown, and would have nothing new and untried staring us in the face to add to our labors, to our need for knowledge, to make us afraid or to disconcert us at a time when we would if ever need the full use of all of our powers to enable us to perform our full duty.

In this connection the remarks of Lieutenant Squier as to the speedy training of experts is exceedingly to the point. We need them and we need them badly. It would be a wise policy on the part of the government if it would begin to recognize the fact that all of us may possibly become "jacks at" but not *masters* of "all trades." I doubt the ability now for the first proposition; certainly we are not all universal geniuses; yet each officer probably has one, perhaps two or three well recognized abilities and characteristics; these should be developed to their utmost capacity, when they are such as to be of any possible use use or benefit to the service. Then we soon should have our work done well in every department, by experts in that department, instead of being done sometimes very indifferently, as is now too often the case.

If the government would but allow it, there is no doubt that many of our officers would gladly avail themselves of all advantages as to special courses of study that might be offered, either at the schools of learning of the country or at our post graduate military schools. There are plenty of "willing horses" ready to make themselves as fully proficient and expert as education and practice can make them; some are doing so, as best they can by their own efforts; none within my knowledge are "shirks" seeking "soft snaps" to rid themselves of routine military duty. On the contrary they are eager for honest whole-souled *work*, work that would pay the government "an hundred fold" in the zeal and intelligence that these specialists could and would bring to bear upon any tasks that might be given them, for which they had become or were becoming specially fitted.

It is impossible, without going to too great a length to notice all the comments that have been made, or to try to reconcile all differences of opinion. It is impossible also to outline or define a full plan for the use of power of our guns. Many things that none of us have now thought of may be developed as experience and trial tests the general subject. It may be that in some cases a combination of electric, pneumatic or hydraulic power may be advisable. As a general proposition however it is the writer's opinion that the power should be uniform and simplified, in the generation and application in every conceivable way. Thus in these cases where hydraulic or pneumatic power is not called for imperatively by the nature of the mount and electric power can do all the work, there should be no combination. While pneumatic or hydraulic power is imperative, as may be the case with some types of disappearing mounts, then perhaps it can be applied for *all* purposes, for shot hoists, for training and elevating as well as for raising or lowering the gun, platform or carriage. We then would not have double power plant or double installations, but one plant for all work.

In closing this discussion I would now submit the following proposition:

It should be evident that the time has come for "deeds and not words." We have guns, gun-carriages and platforms in plenty of old model, still useful for secondary batteries, and we also have a few guns, mortars and carriages for the latter of more modern type.

We have an Artillery School that, no matter what its faults, has yet many merits. It is striving in the face of many adverse circumstances to be of benefit to us all. We should therefore try our best to give it a helping hand and to make it what it should be, the source from which we are to get the latest and the best of everything pertaining to our service.

To this school every two years a class is sent for special instruction. At this school should we not then put up a complete trial plant? Aside from its importance in a strategic sense, is it not one of, if not *the* most important of all of our forts?

Here guns and mortars are in time to be mounted as a part of our sea-coast defense. Here secondary batteries are to be erected for the protection of mine fields. Here mine fields are to be planted in the event of war. Work is already being done; but here it is contended is where—*first of all*—a *full* equipment of *all* guns should be allotted and installed. Here, *first of all*, should electric search lights, incandescent lamps and the application of electric power be attempted, and experiments and trials be made looking to its full use and development for any and all our forts.

With such a plant practical and theoretical instruction in the use of this power and these guns would be the soonest spread amongst the greatest number. As classes come and go, every two years would see a certain number of trained experts, ready to spread their knowledge wherever they went, ready to take hold and do expert work whenever and wherever needed, in the installation of similar plants elsewhere, or in the grim ordeal of battle that may come to test our works.

On the other hand if San Francisco, Boston or New York each receive its quota of guns and perhaps a power plant to work them, leaving Fort Monroe until one of the last, will there be the same possibility for a solid and thorough dissemination of knowledge? True enough *the local garrison at each fort* will be more or less instructed; but who else? Unless these forts are made special schools of instruction in addition to Fort Monroe, only that small part of the artillery stationed at these forts would ever receive instruction; the rest of the artillery stationed for years at small and perhaps obsolete works or garrisons, that will never receive a modern equipment, others at other works that will not be equipped for years, would be wholly uninstructed, the length of time necessary to "make the rounds" by regular changes of station precluding the idea that any general instruction could ever be given. The majority might therefore remain in entire ignorance of how a modern gun looks, to say nothing of how it should be handled. They might remain wholly uninstructed in anything pertaining to electricity in any of its applications to the art of war.

In the writer's opinion Fort Monroe and the Artillery School can be made the salvation of the artillery service. As I understand the question it is not necessary to wait for any legislation to accomplish this. The Board of Ordnance and Fortification has but to make an allotment of money for the purpose, and there is authority to say the word and it could be soon put in a condition such that all might look to it for the latest and best principles, instruction and practice relative to our service. Here then our experts could be trained; here should everything required for such training be centralized; here it should and could be possible for the experts and the specialists to pursue special courses of study, so as to fit themselves for the full use of Electricity in the Art of War.

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THE ARTILLERY-FIRE GAME.

An introduction to the applicatory study of the firing regulations, and an aid to the acquirement of familiarity with the practical effects of fire. By H. ROHNE, Colonel, commanding the Schleswig Field Artillery Regiment No. 9.

TRANSLATED BY FIRST LIEUTENANT JOHN P. WISSER, FIRST ARTILLERY, U. S. A., 1892.

PREFACE.

The new firing regulations for the field artillery contain the important direction that each and every lieutenant must be instructed so as to be able, independently, to conduct the fire of a battery. A number of the lieutenants will go into the field at the head of batteries even at the outbreak of a war, on account of the reorganization that must necessarily take place and the consequent formation of new subdivisions; but, in consequence of the great and ever increasing losses, a much greater number will probably have to take command of batteries under the most unfavorable circumstances imaginable, in the hottest part of the conflict with an equal adversary. Woe to him then, who is not fully competent to fill the position which the fortune of war has assigned to him! On his knowledge of firing may depend not only his honor, but also the very existence of the battery, nay, even the result of the battle.

The increased importance of these requirements make it necessary, however, that the instruction of the officers in firing be not entirely confined to the artillery practice. The time devoted to this is too short; every day makes too great a demand on the individual officer as it is; so much so, indeed, that it may be said that only he who appears on the firing ground fully prepared beforehand, will be enabled to reap the proper benefit from the firing practice.

From his experience of many years as instructor at the Artillery Firing School, the author is of opinion that he can offer his comrades in the following proposed scheme a means whereby complete mastery of the application of the firing regulations—and this is next to correct observation the most important point—may be acquired. The method here proposed, when once it has become familiar, is remarkably simple, and in the course of the past winter was actually applied in all the subdivisions of the regiment under the command of the author, without any difficulty whatever being experienced, and everywhere with uniformly good results. A part of the evenings usually given up to professional meetings or to *Kriegsspiel* was devoted to these applicatory exercises—which can best be designated an "artillery-fire game."

This artillery-fire game can also be used with advantage at the war schools (*Kriegsschulen*) in the special instruction of artillerists, but more particularly at the Artillery School, and perhaps with certain changes at the battalion firing-schools of the heavy artillery.

A great advantage of this system of play lies in the fact that it is possible to gradually increase the difficulties or obstacles in the way, and thus introduce ever new and more interesting situations. The complete mastery of the firing regulations which may thus be acquired will permit of making the actual firing practice really useful, particularly by thus enabling the officers to perfect themselves in the difficult art of observation.

It may be remarked in passing, that in the French as well as in the Russian artillery similar exercises are prescribed. The French call them "Tir simulé," the Russians have the artillery game of Muratow. My proposed scheme originated quite independently of these systems, which, so far as I know, are limited to firing with shells and are not so carefully worked out in the details.

Rendsburg, December the 20th, 1890.

THE AUTHOR.

TABLE OF CONTENTS.

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* *Sprenggranaten*, shell charged with a quick-burning (brisant) explosive and furnished with time fuses. J. P. W.

INTRODUCTION.

The art of conducting properly the fire of a battery rests entirely on correct observation and the skillful application of the firing regulations. While the former can be learned only by continued practice on the firing ground, the proper application of the firing regulations—at least up to a certain point—can undoubtedly be learned without the use of ammunition. It is only necessary to imagine a target, at which the firing is directed, to assume the determination, by observation, of a fixed target distance and the corresponding range ordered,* and on these to base corrections in conformity to the firing regulations.

Such exercises in application are remarkably useful means of instruction, indeed they are quite indispensable; for without them it is quite impossible to obtain a clear mental picture of the subject, and without a clear mental picture it may be possible to comprehend the letter of the firing regulations but not their spirit. And yet is the latter quite necessary; for success does not belong to him who follows the firing regulations blindly, but to him who thoroughly grasps their significance.

As a rule such exercises are undertaken during the gun drill, at which the commanding officer, acting as instructor, imparts the results of the observation of the shots to the battery commander or other officer. But such exercises suffer in two ways. In the conditions imposed it is almost always assumed that the shot fired will strike the centre of impact. All possible dispersion of the shots is entirely neglected, and yet, even assuming *correct* observation, this may considerably interfere with striking the target. On the other hand the observations are also usually taken to be correct. By this method the officer does not learn how to tell in firing whether mistakes have occurred in the service of the piece or false observations been made, nor how such errors can be rendered without effect in the quickest and best way. Of course, as long as the object is simply to

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* Thus, if the distance to the target, as determined by observation is 2813 meters, the battery commander would probably order the range 2800 to be used.—J. P. W.

teach the officer the first principles of the firing regulations this is not a matter of any great importance.

In the following pages will be shown how, in a very simple manner—"in play" we might say—without any great effort both these factors (dispersion and uncertainty of observation) may be taken into consideration.

I. THEORETICAL FOUNDATION OF THE GAME.*

A. PERCUSSION SHELL.

When a shot is fired at a fixed elevation, it cannot be known just where in the horizontal diagram of hits that would be made by the continuation of the firing under exactly the same conditions, it would strike. Whether the shot fall short or over, whether it be little or far removed from the centre of impact, appears to us to be a matter of chance, and quite the same chance as that, out of an urn containing a hundred chances, numbered from one to one hundred respectively, the number drawn at any time will be under or over fifty. Indeed. the decision of this point, whether the shot will fall short or over, in the horizontal target may be left to chance. Evidently the chances for either a short or an over shot are even, and it would therefore be perfectly proper to take any chance number from one to fifty to represent a short shot, and any over fifty as an over shot. This would not, of course, determine how far a shot is removed from the centre of impact. But even that may be left to chance. If the number drawn is near fifty a slight deviation is assumed, if far from it a large one. Such assumptions be it remarked, are in accord with the probabilities in the case. The absolutely accurate determination of the deviation (longitudinal) of a shot is not at all necessary, it is more than sufficient if it be estimated to within five metres.

Let us take a horizontal target, laid out in zones five metres wide, by passing lines perpendicular to the projection of the line of fire, and symmetrically arranged with respect to the centre of impact (see Fig. 1). Now if we know the probable deviation of the shots, the probability of striking any one of these zones can be readily calculated.

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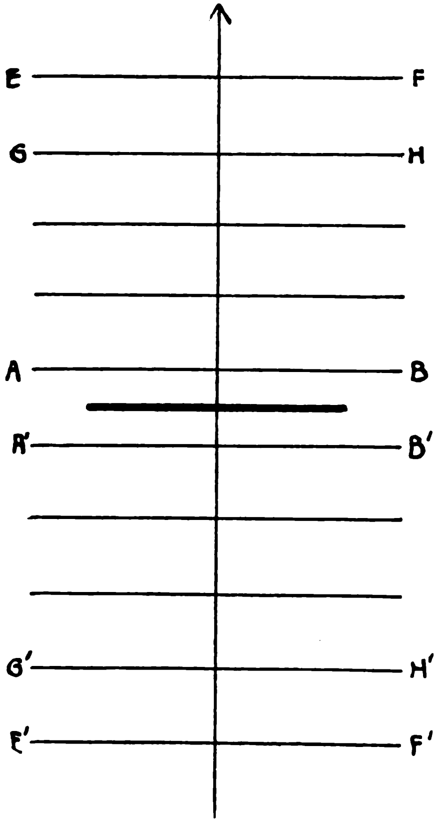
* The knowledge of the theoretical foundation is not absolutely necessary for the correct application of the game. It shows, however, that it is based on true principles.

Fig. 1.



The zone *A B A' B'* for example, five metres wide, lying on either side of the centre of impact, receives, if the probable longitudinal deviation amount to 2.5 metres, 50 per cent. of the hits. If the probable longitudinal deviation increase to 10 metres, the probability of hits falls to 13.5 per cent. ;[*] for the probability factor is $\frac{5}{2 \times 10} = \frac{5}{20} = 0.25$, corresponding to 13.5 per cent. hits.

To calculate the probability of striking the zone *E F G H*, we must first determine how many hits will fall in the space *G H G' H'*, then how many in the space *E F E' F'* ; half the difference of these two numbers will be the percentage of hits in the space *E F G H*.

Example. — Probable longitudinal deviation 15 metres. What is the probability that a shot will strike short at least 17.5, but not over 22.5 metres—20 metres in the mean then?

The probability of striking a target 45 metres (2×22.5) wide is first calculated. Probability facter, $45 : 15 \times 2 = 45 : 30 = 1.5$; probability of striking, therefore, 68.7 per cent. Then the probability of striking a target 35 metres (2×17.5) wide is calculated. Probability factor, $35 : 15 \times 2 = 35 : 30 = 1.17$; prob-

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[*] See Text-book of Gunnery, MacKinlay, page 120, and Handbook of Problems in Direct Fire, Ingalls, page 202, *et seq.* Probability factors, $\frac{5}{2 \times 2.5} = \frac{5}{5} = 1$, corresponding to 50 per and $\frac{5}{2 \times 10} = \frac{5}{20} = 0.25$, or 13.5 per cent. J. P. W.

ability of striking therefore, 57 per cent. Half the difference is $\frac{1}{2}$ (68.7—57)=5.8 per cent. The probability that, in case of a probable longitudinal deviation of 15 metres, a shot will strike in round numbers 20 metres (not less than 17.5 and not more than 22.5) short is, therefore, nearly 6 per cent. Exactly the same degree of probability holds for a shot striking over by that same amount. The probability that a shot will strike 20 metres short (or over) is, therefore, exactly the same as that, in 100 chance numbers any *one* out of six pre-determined numbers, *e. g.* 17, 18, 19, 20, 21 or 22 (79, 80, 81, 82, 83 or 84) will be drawn.

It may, therefore, readily be calculated with what probability a shot will strike, in round numbers, 0, 5, 10, 15 metres etc., short of or beyond the centre of impact, when the probable longitudinal deviation is known.

From the firing table—accuracy of fire in case of percussion shells—it is seen that the probable longitudinal deviations increase with the range, but very slowly, so that for the actual battle ranges (1500 to 3500 metres) they may be taken as nearly equal to 10 metres. In firing in actual battle such small deviations cannot be counted on; and experience, moreover, teaches that even under ordinary circumstances in target practice they are in reality more than twice as great, on the average 25 metres. The reason for this is that the firing tables are calculated for the most favorable conditions—carefully prepared ammunition, fair weather, good service—but above all, on the supposition that the firing is all done by but a single piece. All these conditions are changed in the actual firing by troops in the field; the deviation of a battery of six pieces, the centres of impact of which never coincide, is naturally always greater than that of a single gun. As this is felt even in simple practice firing, it will be much more apparent in the field manœuvres, not to mention firing in actual battle at all.

We will not, therefore, make any great mistake if we take the probable longitudinal deviation of projectles provided with perpercussion fuses, under ordinary circumstances, as 25 metres; under particularly favorable circumstances it may possibly fall to 15 metres, under very unfavorable it may rise to 35 metres. On the basis of these assumptions the deviations of percussion shell, given in the columns *A*, *B* and *C* of Appendix 1, were computed.*

Every lottery number drawn corresponds then, to a particular deviation of a shot from the centre of impact, as indicated in columns *A*, *B* or *C*, in which it is assumed that the centre of impact lies at a distance from the battery equal to the range ordered by the commandant.

The distance of the target, say, is 1980 metres. If in a supposed practice firing, the range at which the firing is ordered to be conducted is 2000 metres and the lottery number 22 is drawn, this indicates that under ordinary circumstances—column *B* of the table—the shot will fall 30 metres short. It strikes consequently at 1970 metres, or 10 metres *in front of* the target. Had the lottery number 60 been drawn, it would have indicated that the shot went 10 metres too far, *i. e.* it struck at 2010 metres, consequently 30 metres *beyond* the target. On the supposition of specially favorable dispersion conditions on the one hand, or unfavorable on the other, the lottery number 22 would indicate that the shot went in the former case 20 and in the latter 40 metres too short, consequently it would strike in the former case just on the target and in the latter 20 metres in front of it; the number 60 on the other hand, would indicate that it went 5 metres too far in the first case, 15 in the second, consequently it would strike 25 metres *beyond* the target in the former case and 35 in the latter.

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* From the data of the firing of the 3.2-inch gun at Sandy Hook—Report of Chief of Ordnance, 1887, page 99 (8 shots), the probable deviation (in range) at 5280 feet is about 19.3 metres; from data of firing at Ganahl, Texas, Lieutenant E. Russel, 3rd Artillery—Journal Artillery, No. 2, page 112, at 4500 feet (12 shots) it is about 23.7 metres; from same report at 5280 feet (20 shots) it is about 17.6 metres; and at 6150 feet (19 shots) it is about 21.2 metres, or an average of 20.4 metres. Evidently, the data of the table (Appendix I) as regards percussion shell, may be used for our gun, the probable deviation under the most favorable circumstances being there taken as about 15, under average circumstances as 25, and under unfavorable circumstances as 35. The above number 20.4 is determined under *rather* favorable circumstance (a single gun being used in each case) but certainly not under the most favorable, so far as weather and other conditions are concerned. J. P. W.

B. SHRAPNEL.

The representation of the deviations of the points of explosion from the mean point of explosion in firing with time fuses is not quite so simple as the representation of the deviations in firing with percussion fuses. The reason is that in the former case the deviations must be reckoned in two directions, longitudinally and vertically, while with percussion fuses deviations in only *one* direction are considered. Were the deviations of the points of explosion in the two directions, longitudinal and vertical, independent of each other, as is the case, for instance, in a vertical target with the vertical and lateral deviations, the horizontal target on which the points of explosion are projected, since the deviations are known from the firing table, could readily be divided into one hundred rectangles, each of which would receive one per cent. of the points of explosion.* But this method is not applicable, because, as is readily seen, a shot, the fuse of which burns 30 metres too short, the distance of the point of explosion of which from the target will therefore be 30 metres greater than the average, will in all probability have also a greater height of explosion than one, the fuse of which burns correctly or indeed even too long. For this reason the data of the firing table relating to the dispersion of the points of explosion, cannot be adopted without some modification.

A further difficulty exists in this, that the law according to which the grouping of the points of explosion over the horizontal target takes place is not known. To arrive at a result, which shall be practical at least in a degree we must make certain assumptions, which cannot of course claim perfect accuracy, yet are very near the truth.

Undoubtedly the dispersion of the points of explosion is a consequence of the varying behavior of the fuses, and the differences in position of the trajectories of different shots. The *longitudinal deviations* (in range) are influenced by the varying behavior of the fuses in different shots as well as by the different velocities of the projectiles; while the differences in

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* Compare Rohne: "Das Schiessen der Feld-Artillerie," page 33.

elevation are of but slight effect in this particular. On the other hand variations in the *vertical deviations* (heights of the points of explosion) are caused of course by variations in the longitudinal deviations, but in addition to this cause and quite independently thereof, they are due to the different positions of the separate trajectories.

When, for instance, at a range of 2000 metres—angle of fall $6\frac{4}{16}°$—a fuse burns 30 metres too short or too long, as the case may be, the point of explosion will, in the normal trajectory lie $30 \times \tan 6\frac{4}{16}° = 3.4$ metres higher in the former case, lower in the latter, than the normal point of explosion. Now if the trajectory also varies from the normal, the point of explosion will naturally also rise or fall corresponding to the higher or lower position of the trajectory.

Hence it will be possible to represent the grouping of the points of explosion on the target in a manner approaching reality in case the following are known:

1. The probable longitudinal deviation of the points of explosion from the mean point of explosion.
2. The probable vertical deviation.
3. The angle of fall.

For a range of 2000 metres, for instance, the probable longitudinal deviation of the points of explosion is 17 metres, the probable vertical deviation 0.95, or in round numbers 1 metre, the angle of fall $6\frac{4}{16}°$.

We can calculate now—exactly as we did in case of firing with percussion fuses above—what per cent of all the points of explosion will have a longitudinal deviation of 0, of + or — 5, 10, 15, &c., metres from the mean point of explosion.

For the range 2000 metres (probable longitudinal deviation 17 metres) this calculation gives:

8 per cent. of the points of explosion will have a deviation of 0 metres.*
8 per cent. of the points of explosion will have a deviation of + and — 5 metres.†

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* Calculations are made to within 5 metres only, so that this means up to 2.5 metres, and the zone will be 5 m. wide. $\frac{5}{2\times 17} = \frac{5}{34} = 0.15$ as probability factor, giving 8 per cent. J. P. W.

† 7.5 metres deviation, zone 2 times $7.5 = 15$ m. wide. $\frac{15}{2\times 17} = \frac{15}{34} = 0.45$, as probability factor, giving 24 per cent. $24 - 8 = 16$. $\frac{16}{2} = 8$ per cent. in the zone + 2.5 to + 7.5 and 8 per cent. in the zone —2.5 to —7.5 m. For assistance in regard to every point in this paper relating to probabilities, I am much indebted to 1st Lieutenant F. S. Harlow, 1st Artillery. J. P. W.

7 per cent. of the points of explosion will have a deviation of + and —10 metres.
7 per cent. of the points of explosion will have a deviation of + and —15 “
5 per cent. of the points of explosion will have a deviation of + and —20 “
5 per cent. of the points of explosion will have a deviation of + and —25 “
4 per cent of the points of explosion will have a deviation of + and —30 “
3 per cent. of the points of explosion will have a deviation of + and —35 “
2 per cent. of the points of explosion will have a deviation of + and —40 “
2 per cent. of the points of explosion will have a deviation of + and —45 “
1 per cent. of the points of explosion will have a deviation of + and —55 “
1 per cent. of the points of explosion will have a deviation of + and —65 “
or over.

Since the angle of fall is $6\frac{4}{16}°$, all points of explosion which lie short of the mean point of explosion (the deviation of which points therefore, will be negative) would have, were there no variatians in the trajectories, a greater height of explosion, all points of explosion which lie beyond the mean point of explosion a less height of explosion than the mean. If A represent the deviation, ε the angle of fall, the difference in the height of explosion would be $A \tan \varepsilon$. If we place the height of explosion for the mean point $=0$, the height of those shots which have a longitudinal deviation of ± 15 metres will be, as an average, $\mp 15 \times \text{tang } 6\frac{4}{16}° = \mp 1.7$.

In consequence of the vertical dispersion of the trajectories, however, one-half the points of explosion will lie higher than that corresponding to the normal trajectory, one-half lower. By the assistance of the method already employed on several occasions, it is possible to calculate what per cent of all the trajectories coincide with the normal trajectory, *i. e.* lie not more than 0.5 metre vertically away; also how many are ± 1, 2, 3 metres away. In case of a probable vertical deviation of one metre, the calculation shows that:

$26\frac{1}{2}$ per cent. of all trajectories coincide (practically) with the normal.

21 per cent. of all trajectories deviate ± 1 metre vertically.

11 per cent. of all trajectories deviate ± 2 metres vertically.

4 per cent. of all trajectories deviate ± 3 metres vertically

1 per cent. of all trajectories deviate more than $3\frac{1}{2}$ metres vertically.

If, as we saw, out of 100 points of explosion some seven have too great a distance for the point of explosion from the target by about 15 metres, hence in the mean, a height of explosion of +1.7 metres referred to the mean point of explosion, then 26½ per cent. of these, in all, therefore 7 × 0.265 = 1.85 will have a height of explosion of nearly +1.7 metres.

21 per cent. or 7×0.21=1.47 a height of explosion between +2.2 and 3.2.
11 per cent. or 7×0.11=0.77 a height of explosion between + 3.2 and 4.2.
4 per cent. or 7×0.04=0.28 a height of explosion between +4.2 and 5.2.
1 per cent. or 7×0.01=0.07 a height of explosion over 5.2 m.
21 per cent. or 7×0.21=1.47 a height of explosion between + 1.2 and 0.2.
11 per cent. or 7×0.11=0.77 a height of explosion between + 0.2 and—0.8.
4 per cent. or 7×0.04=0.28 a height of explosion between —0.8 and—1.8.
1 per cent. or 7×0.01=0.07 a height of explosion below —1.8.

As it is a question only of probabilities and not of exactness, and as the heights of explosion can only be recorded in entire metres, it may be assumed that of the seven shots, the explosion distance of which from the target is greater than the mean by 15 metres in round numbers.*

1 will have a height of explosion differing from the mean by + 4 metres.
1 will have a height of explosion differing from the mean by + 3 "
2 will have a height of explosion differing from the mean by + 2 "
2 will have a height of explosion differing from the mean by + 1 "
1 will have a height of explosion differing from the mean by — 1 "

In this number the data under *E* in the appended table (see Appendix I) are obtained. A similar method is applied to compute the data under *D* and *F*, in which the figures of the firing

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* For the range 2000 metres for our own gun (3.2-inch), the angle of fall as given in the table computed by Major John I. Rodgers (Artillery Memorandum No. 2, 1892, pages 14 and 15) is 5° 10′ 08″ (I. V. 1608, ϕ 3° 48′ 28″); as determined from the firing practice at Ganahl, Texas, August 1891 (Journal Artillery, April 1892). it is 4° 49′ (I. V. 1595, ϕ 3° 20′) or as an average about 5°, somewhat less than the German.

Assuming this as correct, the above table becomes by calculation of the probabilities.

1 will have a vertical deviation of 3 metres.
2 will have a vertical deviation of + 2 metres.
2 will have a vertical deviation of + 1 metre.
1 will have a vertical deviation of + 0 metres.
1 will have a vertical deviation of — 1 metre.

So that the probabilities are very little changed, if we remember that the "3 metres" above is really 3.3 and the "4 metres" in the text is really 3.7 being rounded off to entire metres. In the absence of reliable practical data giving the dispersion of the points of explosion of time shell or shrapnel, it appears that these tables (Appendix I) may also be used for our field gun. J. P. W.

table for the ranges between 1000 and 3000 metres served as a basis for computation.

Appendix II gives two horizontal projections of 100 points of explosion at 2000 and 3000 metres range respectively, the examination of which will, it is hoped, assist the comprehension of the method just developed.

Whereas, for firing with percussion fuses, the three columns given in the table, though good for all distances, apply to different degrees of dispersion, in case of shrapnel the three columns are intended for different ranges. The data under *D* can be used approximately for ranges from 300 to 1450 metres; those under *E* from 1500 to 2500 metres; those under *F* from 2550 to 3000 metres. Naturally the data apply with greater accuracy the more nearly the range coincides with that on which the calculation was based.*

The data of the table have reference, as stated, to the deviation of the separate points of explosion from the *mean* point of explosion. It is therefore necessary to determine the position of this point with reference to the target. Evidently it is dependent on the actual range as well as on the range given or ordered, and finally also on the behavior of the fuse. In case of *normal* behavior of the fuse the mean point of explosion lies 50 metres in front of the target, when the range given or ordered and the actual target distance are one and the same. Any difference between the two naturally enlarges or reduces the distance of the mean point of explosion from the target. The height of explosion is taken from the firing table, but only in entire metres.

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* Whoever carefully tests the data under *D*, *E* and *F* will find that the dispersion of the points of explosion, in comparison with the heights, exceeds the data of the firing table by a not inconsiderable amount. This is true for instance for the ranges 2000 and 3000 metres. The probable deviation of the points of explosion in height, calculated according to the data of the table at 2000 metres is about 2.15 metres, for 3000 metres as much as 4.9 metres, whereas the firing table gives for the probable deviations in height 1.55 and 2.7 metres respectively. I consider the latter as too favorable; the probable deviation in height of the points of explosion must, according to my view, be *at least* equal to the product of the probable longitudinal deviation by the tangent of the angle of fall, *i. e.* for shrapnel at 3000 metres, 20 times tangent 12° 8′ = 4.3 metres. The proof of the correctness of my view would lead me too far into detail.

EXAMPLES.

Target distance 2000 m., range ordered 2000 m., point of explosion $\frac{-50}{6}$.

Target distance 2020 m., range ordered 2000 m., point of explosion $\frac{-70}{6}$.

Target distance 2020 m., range ordered 2050 m., point of explosion $\frac{-20}{6}$.

Target distance 2020 m., range ordered 2100 m., point of explosion $\frac{+30}{6}$.

The deviations given in the separate columns and corresponding to the different lottery numbers, are referred to this position of the mean point of explosion. By adding algebraically the numbers expressing the deviations to those designating the position of the mean point of explosion, we obtain the position of every particular point of explosion,

Suppose for example that the range ordered is 2000 metres, that the mean point of explosion is given as $\frac{-70}{6}$, and that the lottery number 25 is drawn, then adding the deviation under *E*, $\frac{-15}{4}$, to the figures for the mean point of explosion gives $\frac{-85}{10}$. With lottery number 85—deviation $\frac{+25}{-4}$—the point of explosion would have been at $\frac{-45}{2}$.

In case the fuses do not burn normally, but too short or too long a time, the position of the mean point of explosion is naturally changed too, and in such wise that the distance of the point of explosion in front of the target becomes as much shorter or longer as the fuses burn too long or too short a time (estimated in distance of course). In the same way the mean height of explosion becomes less or greater, so that since the normal height of explosion corresponds to a distance of the point of explosion in front of the target equal to 50 metres, it will, for every 5 metres that the fuse burns too long or too short, be $\frac{1}{10}$ the normal height less or greater.

If we assume for the actual target distance 2020 and for the range ordered 2000 metres, and then suppose that the fuses burn 30 metres too long, the distance of the mean point of explosion in front of the target is not —70 but —40; the mean height of explosion will be $0.6 \times 6 = 3.6$[*] metres less than the normal which was 6 metres, therefore 2.4; the mean point of explosion lies therefore at $\frac{-40}{2.4}$, or in whole numbers, $\frac{-40}{2}$. Had the fuse burned 80 metres too long, the point of explosion would have been at $\frac{-70+80}{6-6\times 0.6} = \frac{+10}{-3.6}$, or in whole numbers at $\frac{+10}{-4}$. On the other hand, had the fuse burned 30 or 80 metres too short, the mean point of explosion would have been at $\frac{-110}{+10}$ and $\frac{-150}{16}$, respectively.[†]

In firing with fuses that burn too long innumerable ground hits (with or without subsequent explosion) are naturally obtained; these are recognized by a negative value for the height of explosion. Suppose for instance, that with the position of the mean point of explosion at $\frac{-10}{1}$[‡] (the fuses burning 40 metres too long with a range of 2000 metres), the lottery number 81 (deviation $\frac{+20}{-4}$ is drawn, then we have for the point of explosion $\frac{+10}{-3}$. The shot strikes short before explosion, not at —10 metres but somewhat farther in front of the target. To determine the position of the point of striking on the ground is seldom necessary in the firing game, yet it may be, as

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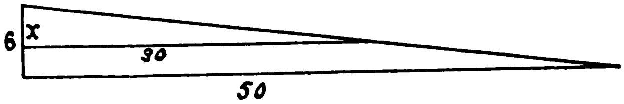
[*] From the figure it is evident that the tangent of the angle of fall is $\frac{6}{50}$, consequently, if the fuse burn 30 metres (horizontally) too long, the point of explosion will be 3.6 m. lower:

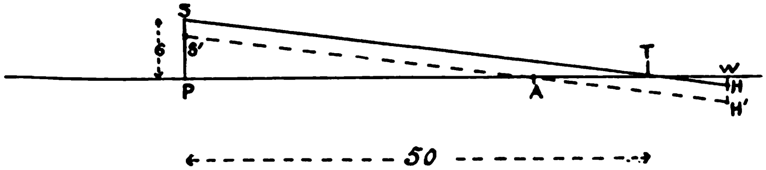
$x = \frac{6}{50} \times 30 = 3.6$m. J. P. W.



[†] The normal height of explosion, which, according to the firing table amounts to from 5.5 to 6 metres is here assumed; exact computation gives the point of explosion as situated at $\frac{-150}{14.3}$. The difference of 1.7 metres in the height of the point of explosion is without effect in practice.

[‡] $\frac{6}{50} \times 40 = 4.8$; $6 - 4.8 = 1.2$, or in entire numbers 1 metre; $-50 + 40 = -10$; therefor $\frac{-10}{1}$. J. P. W.

for instance in case of shots, the points of explosion of which, with a negative height of explosion, lie *behind* the target, while the actual striking point on the ground may still lie in front of the target. The point of striking may be found as follows:



In the preceding figure let S be the normal point of explosion (50 metres in front of the target), SP the normal explosion height (6 metres for a range of 2000 metres), T the target and STH the normal trajectory; now let TW be the distance of the point of explosion of any shot from the target and WH' its known (negative) height of explosion (both given by the table), A being the point where it strikes the ground, $S'AH'$ (parallel to STH) will be its trajectory. The following relation then, results directly from the figure:

$$\frac{AT + TW}{WH'} = \frac{50}{SP}, \text{ from which we find:}$$

$$AT = \frac{50 \times WH'}{SP} - TW.$$

In the example above in which $TW = 10$, $WH' = 3$, $SP = 6$ (or more exactly 5.5) metres, AT becomes $\frac{50 \times 3}{6} - 10$ or 15 metres; that is, the point where the shot, the point of explosion of which was found to be $\frac{+10}{-3}$, strikes the ground lies 15 metres in front of the target.

Finally let us see what effect the use of a plate* will have on

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* Sight plates (*Ausfatz-platten*)—Small plates of steel placed on the socket of the tangent-scale fitting around the latter to diminish the reading on the scale; for example, if the scale be set at 2100 metres and a "plate" be placed in position, it will then (read from the upper surface of the plate) mark about 2050 metres, now, if the scale be run up until it again reads 2100 metres, it is evident that that individual gun, though normally laid at 2100 metres, is really laid at 2150 metres. Similarly by taking away a plate, a gun may be made to fire with an elevation less than used by another, though setting its tangent scale at the same range. This expedient is intended to make it possible to work guns, which differ in their shooting by one command; and it is customary to use with common shell one plate at the commencement of the ranging, in order to have a margin in both directions. The plates are also used to give a slight increase or decrease of elevation throughout the battery, and to make sure that such variation is regular. (Taken from the note-book of 1st Lieutenant A. B. Dyer, 4th Artillery)

the position of the mean point of explosion. By the insertion or removal of a plate the trajectory will be turned $\frac{3}{16}^{\circ}$ upward or downward; the explosion distance (from the target) remains therefore nearly the same; and only the height of explosion becomes greater or less. By the aid of the firing table for shells (Column 6) the amount of this can be accurately determined, and it is of course recorded in entire metres only. But in order not to multiply slight errors, it is best first to compute the position of the mean point of explosion to one decimal place, and then pass to whole numbers. For instance, if for 2000 metres the mean height of explosion is $+5.5$ metres, it would become by the use of a plate $+12.1$, by the removal of a plate -1.1 metres. Had we worked with whole numbers to begin with, the mean height of explosion would have been taken as 6, the effect due to the plate as 7 ($2000 \times \tan \frac{3}{16}^{\circ} = 2000 \times 0.0033 = 6.6$). and we would have obtained for the height of explosion 13 (or, in case of removal of the plate -1) metres. However, even if we work with entire metres from the beginning, no *grave* errors can be made.

C. OBSERVATION.

However much the deviation of a shot may influence the accuracy of fire, a false observation of it much oftener leads to complete failure to strike the object, or at least interferes more with successful firing. Only by constant practice can the number of false observations made be gradually reduced, and perfection in the art of observation be acquired. The important point is however, under any circumstances to be able from the results of the firing, to recognize the fact that a false observation has been made, to see where it has been made and to know how to remedy the mistake. For this reason, after it has been determined where a given shot actually struck, it is still necessary to consider whether its striking was correctly or incorrectly observed.

As the result of experience it is found that about $\frac{2}{3}$ (67 per cent.) of the shots are correctly observed, $\frac{1}{4}$ (25 per cent.) not at all (*i. e. doubtfully*), the rest (8 per cent.) falsely. The probability therefore that a shot will be correctly, doubtfully or falsely observed is, consequently, the same exactly as that out of 100 lottery numbers, *one* out of 67, 25 or 8 (respectively) numbers *previously* designated will be drawn. We may therefore assume that an observation is correct in case the number drawn is between 1 and 67, that it is doubtful in case the number is between 67 and 92 and that it is false when the number is between 93 and 100. As a matter of fact the conditions in every firing practice are different from those of any other. It is therefore best to decide before beginning the game, and for every particular target, what shall be the relation of correct, doubtful and false observations to one another. It should be noted however, that the relation of the number of false to the number of correct observations is the most important point,—the number of doubtful observations has less influence. A slight change in the number of false observations may raise or lower the *ratio* to the correct ones considerably.

The observation of shrapnel and torpedo-shell with time fuses is far more uncertain than that of shell with percussion fuses. This is partly due to the small volume of the explosion cloud of the two former and its rapid dissipation, but much more to the position of this cloud in the air, often far above the target. It may be taken for granted that all shrapnel, which have a height of explosion of over 3 metres, will, under *ordinary* circumstances be observed doubtfully, because the position of the cloud of explosion with reference to the target in such a case cannot be determined, and also because it will not be possible, except under specially favorable circumstances, to so determine the position of the point of explosion, from the observation of the pieces of the projectile which strike near the target and the little clouds of dust thrown up by them, as to the permit of putting another shot in the same point. If, in case of points of explosion 3 metres or less in height, we consider the same observation relations to hold for shrapnel as we did for percussion shell, the results will certainly not be too unfavorable for the former. Since the explosion cloud of torpedo-shell is larger and the innumerable fragments strike nearly vertically downward, the points of explosion in their case may be regarded as observable up to and including four metres in height.

As long as old powder was used in firing, the conditions of observation for shrapnel, and more especially for torpedo-shell were not unfavorable. It could be assumed that every explosion which covered the target with smoke and stood out *distinctly* from it lay in front of it. But this aid to observation no longer holds, and for that reason the observation of high points of explosion has become more difficult.

TABLE SHOWING FOR EACH LOTTERY NUMBER THE AMOUNT OF DEVIATION OF THE SHOTS FROM THE CENTRE OF IMPACT.

Lottery numbers.	SHELL.		
	DEVIATION FROM THE CENTRE OF IMPACT IN CASE OF		
	small	medium	large
	DISPERSIONS.		
	A.	B.	C.
1	—60	—100	—140
2	—50	—85	—120
3	—45	—75	—105
4	—40	—70	—100
5	—40	—65	—90
6	—35	—60	—85
7	—35	—55	—80
8	—30	—55	—75
9	—30	—50	—70
10	—30	—50	—70
11	—30	—45	—65
12	—25	—45	—65
13	—25	—45	—60
14	—25	—40	—60
15	—25	—40	—55
16	—25	—40	—55
17	—20	—35	—50
18	—20	—35	—50
19	—20	—35	—45
20	—20	—30	—45
21	—20	—30	—40
22	—20	—30	—40
23	—15	—30	—40
24	—15	—25	—35
25	—15	—25	—35
26	—15	—25	—35
27	—15	—25	—30
28	—15	—20	—30
29	—15	—20	—30
30	—10	—20	—25
31	—10	—20	—25
32	—10	—20	—25
33	—10	—15	—25
34	—10	—15	—20
35	—10	—15	—20
36	—10	—15	—20
37	—10	—15	—20
38	— 5	—10	—15
39	— 5	—10	—15
40	— 5	—10	—15
41	— 5	—10	—15
42	— 5	—10	—10
43	— 5	— 5	—10
44	— 5	— 5	—10
45	— 5	— 5	— 5
46	— 5	— 5	— 5
47	± 0	— 5	— 5
48	± 0	± 0	— 5
49	± 0	± 0	± 0
50	± 0	± 0	± 0

TABLE SHOWING DEVIATIONS

Lottery Numbers.	SHRAPNEL or TORPEDO SHELL.			Lottery Numbers.	SHRAPNEL or TORPEDO SHELL.		
	Deviation from the mean point of explosion				Deviation from the mean point of explosion		
	as regards	DISTANCE OF EXPLOSION / HEIGHT OF EXPLOSION	from target in case of		as regards	DISTANCE OF EXPLOSION / HEIGHT OF EXPLOSION	from target in case of
	short	medium	long		short	medium	long
	RANGES				RANGES		
	D.	E.	F.		D.	E.	F.
1	− 45 + 2	− 65 + 7	− 75 + 16	26	− 10 + 1	− 15 + 3	− 20 + 3
2	− 40 + 2	− 55 + 7	− 65 + 13	27	− 10 + 1	− 15 + 2	− 20 + 1
3	− 40 + 1	− 50 + 6	− 60 + 15	28	− 10 + 1	− 15 + 2	− 15 + 7
4	− 35 + 2	− 45 + 6	− 55 + 11	29	− 10 + 1	− 15 + 1	− 15 + 5
5	− 35 + 1	− 45 + 5	− 50 + 10	30	− 10 + 1	− 15 + 1	− 15 + 4
6	− 30 + 1	− 40 + 5	− 45 + 10	31	− 10 ± 0	− 15 − 1	− 15 + 3
7	− 30 ± 0	− 40 + 3	− 45 + 7	32	− 10 ± 0	− 10 + 4	− 15 + 2
8	− 25 + 3	− 35 + 6	− 40 + 12	33	− 10 ± 0	− 10 + 2	− 15 ± 0
9	− 25 + 2	− 35 + 4	− 40 + 8	34	− 10 − 1	− 10 + 2	− 10 + 5
10	− 25 + 1	− 35 + 2	− 40 + 3	35	− 5 + 1	− 10 + 1	− 10 + 4
11	− 25 ± 0	− 30 + 5	− 35 + 12	36	− 5 + 1	− 10 + 1	− 10 + 3
12	− 20 + 3	− 30 + 4	− 35 + 7	37	− 5 + 1	− 10 ± 0	− 10 + 2
13	− 20 + 2	− 30 + 4	− 35 + 5	38	− 5 ± 0	− 10 − 1	− 10 + 1
14	− 20 + 1	− 30 + 1	− 35 + 3	39	− 5 ± 0	− 5 + 3	− 10 − 1
15	− 20 + 1	− 25 + 5	− 30 + 9	40	− 5 ± 0	− 5 + 1	− 5 + 4
16	− 20 + 1	− 25 + 4	− 30 + 7	41	− 5 ± 0	− 5 + 1	− 5 + 3
17	− 20 ± 0	− 25 + 3	− 30 + 6	42	− 5 ± 0	+ 5 + 1	− 5 + 2
18	− 15 + 2	− 25 + 2	− 30 + 3	43	− 5 − 1	− 5 ± 0	− 5 + 1
19	− 15 + 1	− 25 ± 0	− 25 + 8	44	± 0 + 1	− 5 ± 0	− 5 ± 0
20	− 15 + 1	− 20 + 4	− 25 + 6	45	± 0 + 1	− 5 ± 0	− 5 − 1
21	− 15 + 1	− 20 + 3	− 25 + 3	46	± 0 + 1	− 5 − 1	− 5 − 3
22	− 15 ± 0	− 20 + 2	− 25 + 1	47	± 0 + 1	± 0 + 2	± 0 + 3
23	− 15 ± 0	− 20 + 2	− 20 + 9	48	± 0 0	± 0 + 1	± 0 + 2
24	− 15 − 1	− 20 + 1	− 20 + 7	49	± 0 0	± 0 ± 0	± 0 + 1
25	− 10 + 2	− 15 + 4	− 20 + 4	50	± 0 0	± 0 ± 0	± 0 ± 0

FROM MEAN POINT OF EXPLOSION.

Lottery Numbers.	SHRAPNEL or TORPEDO SHELL. Deviation from the mean point of explosion as regards $\frac{\text{DISTANCE OF EXPLOSION}}{\text{HEIGHT OF EXPLOSION}}$ from target in case of short RANGES D.	medium RANGES E.	long RANGES F.
51	±0 ±0	±0 ±0	±0 ±0
52	±0 ±0	±0 ±0	±0 −1
53	±0 ±0	±0 −1	±0 −2
54	±0 −1	±0 −2	±0 −3
55	±0 −1	+5 +1	+5 +3
56	±0 −1	+5 ±0	+5 +1
57	±0 −1	+5 ±0	+5 ±0
58	+5 +1	+5 ±0	+5 −1
59	+5 ±0	+5 −1	+5 −2
60	+5 ±0	+5 −1	+5 −3
61	+5 ±0	+5 −1	+5 −4
62	+5 ±0	+5 −3	+10 +1
63	+5 ±0	+10 +1	+10 −1
64	+5 −1	+10 ±0	+10 −2
65	+5 −1	+10 −1	+10 −3
66	+5 −1	+10 −1	+10 −4
67	+10 +1	+10 −2	+10 −5
68	+10 ±0	+10 −2	+15 +0
69	+10 ±0	+10 −4	+15 −2
70	+10 ±0	+15 +1	+15 −3
71	+10 −1	+15 −1	+15 −4
72	+10 −1	+15 −1	+15 −5
73	+10 −1	+15 −2	+15 −7
74	+10 −1	+15 −2	+20 −1
75	+10 −1	+15 −3	+20 −3
76	+10 −2	+15 −4	+20 −4
77	+15 +1	+20 −1	+20 −7
78	+15 ±0	+20 −2	+20 −9
79	+15 ±0	+20 −2	+25 −1
80	+15 −1	+20 −3	+25 −3
81	+15 −1	+20 −4	+25 −5
82	+15 −1	+25 ±0	+25 −8
83	+15 −2	+25 −2	+30 −3
84	+20 ±0	+25 −3	+30 −6
85	+20 −1	+25 −4	+30 −7
86	+20 −1	+25 −5	+30 −9
87	+20 −1	+30 −1	+35 −3
88	+20 −2	+30 −4	+35 −5
89	+20 −3	+30 −4	+35 −7
90	+25 ±0	+30 −5	+35 −12
91	+25 −1	+35 −2	+40 −3
92	+25 −2	+35 −4	+40 −8
93	+25 −3	+35 −6	+40 −12
94	+30 0	+40 −3	+45 −7
95	+30 −1	+40 −5	+45 −10
96	+35 −1	+45 −5	+50 −10
97	+35 −2	+45 −6	+55 −11
98	+40 −1	+50 −6	+60 −15
99	+40 −2	+55 −7	+65 −13
100	+45 −2	+65 −7	+75 −16

TABLE SHOWING FOR EACH LOTTERY NUMBER THE AMOUNT OF DEVIATION OF THE SHOTS FROM THE CENTRE OF IMPACT.

Lottery numbers.	SHELL. DEVIATION FROM THE CENTRE OF IMPACT IN CASE OF			Lottery numbers.	SHELL. DEVIATION FROM THE CENTRE OF IMPACT IN CASE OF		
	small	medium	large		small	medium	large
	DISPERSIONS.				DISPERSIONS.		
	A.	B.	C.		A.	B.	C.
51	± 0	± 0	± 0	76	+15	+25	+35
52	± 0	± 0	± 0	77	+15	+25	+35
53	± 0	± 0	+ 5	78	+15	+30	+40
54	± 0	+ 5	+ 5	79	+20	+30	+40
55	+ 5	+ 5	+ 5	80	+20	+30	+40
56	+ 5	+ 5	+ 5				
57	+ 5	+ 5	+10	81	+20	+30	+45
58	+ 5	+ 5	+10	82	+20	+35	+45
59	+ 5	+10	+10	83	+20	+35	+50
60	+ 5	+10	+15	84	+20	+35	+50
				85	+25	+40	+55
61	+ 5	+10	+15	86	+25	+40	+55
62	+ 5	+10	+15	87	+25	+40	+60
63	+ 5	+10	+15	88	+25	+45	+60
64	+10	+15	+20	89	+25	+45	+65
65	+10	+15	+20	90	+30	+45	+65
66	+10	+15	+20				
67	+10	+15	+20	91	+30	+50	+70
68	+10	+15	+25	92	+30	+50	+70
69	+10	+20	+25	93	+30	+55	+75
70	+10	+20	+25	94	+35	+55	+80
				95	+35	+60	+85
71	+10	+20	+25	96	+40	+65	+90
72	+15	+20	+30	97	+40	+70	+100
73	+15	+20	+30	98	+45	+75	+105
74	+15	+25	+30	99	+50	+85	+120
75	+15	+25	+35	100	+60	+100	+140

The numbered squares are to be cut out as separate lottery numbers.—Those without numbers are extra and can be used in place of any that may be lost.

1	2	3	4	5	6	7	8	9	10
11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30
31	32	33	34	35	36	37	38	39	40
41	42	43	44	45	46	47	48	49	50

51	52	53	54	55	56	57	58	59	60
61	62	63	64	65	66	67	68	69	70
71	72	73	74	75	76	77	78	79	80
81	82	83	84	85	86	87	88	89	90
91	92	93	94	95	96	97	98	99	100

COMMENT AND CRITICISM.

General Willcox's History of the Mexican War.

I am truly sorry that the criticisms in my review of General Wilcox's History of the Mexican War should have excited discussion. The opinions I advanced were modestly enough conceived, but probably the language carried too much presumption in questioning the wisdom with which success was gained. One of Major Lane's positions is unquestionable; and as honest confession is a good thing to start with I will say that I was "clear off" in saying General Taylor fell back from Buena Vista the day after the battle. My error was due to forgetfulness more than to ignorance. I had naturally forgotten that before falling back on Monterey any forward movement had been made, since it was not a pursuit and was resultless.

I also erred in criticising the book's orthography of Santa Anna's name. I have since seen some of his autograph letters in which he spells his name with two n's, *à l'antique*. Wilcox is correct. The President preserved the ancient spelling; *now* there is no double n in Spanish, and the Mexicans pronounce his name in three syllables, San-táh-nah, and as one word.

And now let us pass to the Major's criticisms. General Taylor *would* appear to have misjudged his enemy at Point Isabel. It is hard to believe that he hurried forward to fortify in front of Matamoros with any fear of his communications being cut off. They were threatened and he posted back to fortify his supply base with all his force except a few light guns in Fort Brown, and certainly without a knowledge of the enemy's available artillery.

Certainly the battle of Resaca *had to be* fought in order to save Fort Brown. I simply mentioned what Wilcox said, that many of his officers advised against it, in order to show to what a strait Taylor had been reduced by his ignorance of his enemy. Success under such circumstances was due to the indomitable individualism of the American Soldier, rather than to the skilled foresight of the leader.

Nobody ever questioned Taylor's pluck or dogged perseverance. Was it a part of General Taylor's plan, "knowing his enemy," to leave his base of supplies in the air, for the mere purpose of planting a few light guns against Matamoros and risk them there, besieged, with a minimum of service, while he should go back to Point Isabel with all available troops to fortify and then to return to crush the possible Mexican Army that might intercept him? He did it all, but was it generalship? Wasn't it done at a big sacrifice of bone muscle and blood, avoidable in a great measure? Wasn't it in the opinion of many of his officers, after their taste of the enemy at Palo Alto—at the risk of a complete defeat?

The Major objects to my holding Buena Vista to have been a drawn battle. I cannot well define a "drawn battle." It may well be claimed that if the party taking the initiative is repulsed—he is defeated; certainly he is defeated in his plans. But if he be not followed and disorganized the defense cannot well claim a victory. Lundy's Lane, Buena Vista and Antietam may be called drawn battles, though the plans of British, Mexicans and Confederates were defeated. Yes, I think, whether General Taylor "knew it" or not, that at Wool's speaking we were whipped. It may have been the magnetism of Taylor's coming presence, it may have been the arrival with him of comparatively fresh troops (a large percentage of a total of "4800" about 700 of whom were *hors du combat*, and a larger proportion still of probably but 3500 effectives), or it may have been both that saved disastrous defeat.

I quote from page 55, *Congressional Reports on Mexican War*, 1847. Letter dated Buena Vista, February 24th, 1847, General Taylor says "An obstinate and sanguinary conflict was maintained with short intervals during the day, the result being that the enemy was completely repulsed from our lines. An attack of cavalry upon the rancho of Buena Vista, and a demonstration upon the city of Saltilio itself were likewise handsomely repelled. Early in the night the enemy withdrew from his camp [unmolested—J. H.] "and fell back upon Agua Nueva a distance of eleven miles." No word of any advantage taken of the enemy's defeat.

On March 1st Taylor reports, page 57, from Agua Nueva that he had arrived there on the 27th, three days after the battle and that on said 27th the last of the Mexicans left there in the morning, and added that he was to despatch a command that day, March 1st, four days after, to harass the enemy's rear and to secure whatever military supplies should be found, up to Encarnacion.

General Taylor here continues "I have no doubt that the defeat of the *main army* [italics mine—J. H.] at Buena Vista will secure our line of communications [what line of communications?—J. H.] from further interruption, but I still propose in a few days to change my headquarters to Monterey with a view to make such further arrangements as may be necessary in that quarter.

The dispositions made to harass our rear *vindicate the policy and necessity* of defending a position in front of Saltillo, where a defeat has thrown the enemy far back into the interior. No result so decisive could have been obtained by holding Monterey, and our communications would have been constantly in jeopardy."

It will be seen that the General is very modest in claiming a *victory*. He says "the enemy were handsomely repulsed from our lines." Why did he *pursue* the enemy on the *fourth day* after their falling back on Agua Nueva? Did he go there before retracing his steps to Monterey, in order to pick up the trash abandoned by the last remnant of a Mexican Army on the way to Encarnacion and "harass" them four days after they left?

General Taylor's last quoted sentence will strike the reader,—knowing that the government and General Scott expected him to stay at Monterey— as giving an *excuse* for his original forward movement, viz: to secure his "line of communication from furthur interruption." That is, he had extended his line to make it need protection, had passed on without preparing the necessary defense, and without knowing that Santa Anna was gathering an army to overwhelm him if possible.

Four strategic plans may be divined of General Taylor's movements. 1. A brilliant, bold, attempt to reach the City of Mexico from the north before Scott, depending on the country for his supplies. If this was his plan. Buena Vista was a defeat. 2. Simply to carry out "*l'audace toujours l'audace*" to go as far as he could without any defined objective. 3. To make a diversion in favor of Scott's campaign; or 4. To extend a line of communication in order to defend it.

Can it possibly be assumed that he pushed forward from Monterey to Agua Nueva to find a main army to conquer in order to defend his line of communication behind Monterey?

Let us pass on to the San Pascual affair. I have not time to hunt up General Kearny's report, and I doubt its bearing on the case even. It has none without he claims a victory, absolute. If he does it would make old Californians smile.

I give the following extract from Fayette Robinson's *History of the Army of the United States*, page 142, as complementary to Wilcox's account.

"It was now evident that Pico intended to harass the American troops by making an attack in every pass that afforded him an advantage. He was enabled by his superior horses to occupy them [the passes] before General Kearny; and as his wounded men were suffering severely and required rest, and this position [on San Bernardo] was a strong one, Kearny determined to hold it until he should receive a reinforcement from Commodore Stockton, to whom an express had been sent by a trusty indian. He remained there four days and was closely surrounded by the enemy, who had received an addition to their forces and now numbered over two hundred men, so that he could procure no more provisions [nor water], and had to subsist entirely on mule flesh. Seventy-five marines and a hundred seamen under command of Captain Zeilin of the Marine Corps, came from the ships *Congress* and *Portsmouth* to his assistance: and with this efficient force he marched into San Diego without molestation. The distance was thirty miles and was marched in two days without difficulty * * * arrived in San Diego on the 12th of December."

As Robinson was an old Dragoon officer, it is not probable that he would derogate anything from his old arm. The whole tone shows tenderness to our troops. The brackets in the quotation are mine. I shall call attention to four points here. 1. "*Had been sent*, *i. e.* the trusty indian had been sent for the navy support before Kearny determined to hold the strong point which he could not leave. 2. *A trusty indian* was the express sent to Stockton; what would have happened if the indian had not proved trusty or had been intercepted? 3. The addition to the enemy's force were the neighboring rancheros: there were no organized Californian troops to call on. 4. With seventy-five marines and one hundred seamen and Kearny's victorious command (as Major Lane would have us consider it), he marches without molestation into San Diego, despite the formidable force of two hundred mounted rancheros—men with scarcely anything but the lance!

To revert to the first charge of our dragoons, the scattered nature of it was so unlike what American soldiers can do, that it lends much proximate credibility to Juan Largo's (Warner's) charge that Davidson had taken his horses to replace their broken down ones. It can't be called a successful charge of trained troops that will leave their leader to be lanced, and only saved from death by Lieutenant Emory's (not of the ranks) pistol. If the horses are broken down the more it behooves the commander to recollect that the movement of the mass is governed by the slowest horse. If none are fit, don't charge. Davidson's howitzer mules ran away. His men must have been weakened by the march and couldn't hold the mules, or was it because they were playing artillery and hadn't got the run of their mules yet? Davidson should have taken oxen. It looks, Major, as if Kearny didn't know when he was whip't, no?

Poor old Don Juan, I shouldn't wonder if he did try to reimburse himself from Lawrence Graham's command for what he charged Davidson with stealing from him? It was his only chance in those days, of making things square. Then, the strong arm was law.

Lastly, I am sorry my criticisms have impressed the Major with a want of patriotism in me. There were plenty of bad moves in the Mexican War. The charges on Molino del Rey were bad, very bad. I think the Major will admit that there were some mistakes made in the rebellion. Should he point them out I would not think him unpatriotic. Again, little glory attaches to our successes if we belittle our enemy. The poltroonery of the fellah adds nothing to the glory of Wolseley. So far as my review went I tried to show that we had not a despicable foe to encounter, and that for Texas, California, etc., good American blood had been paid.

If the Major desires to learn what a good fight the Mexicans made under their circumstances and handicapping, I suggest that Colonel Balbotin's "La Invasion Americana" be read. With all allowances our conquest was glorious enough for our arms personelle and morale.

I am sure I intended nothing that would show that I did not admire the tone and temper of Wilcox's work as history. If I hinted at a peculiarity it was not to brand it as a blemish. The book heightened the general in my estimation, and I had known him since '43. Altogether he is eminently moderate and fair; if anything, he leans to the avoidance of all blame, but a military review is useless without it seeks for the lesson that history conveys.

JOHN HAMILTON,
Colonel, U. S. A.

Our Field Gun.

Captain Moch of the French Artillery, in his "Notes on the Field Gun of the Future," recently published in the *Revue d'Artillerie*, gives some very interesting and suggestive data in regard to foreign field guns. An inspection of his tables shows that our own field gun does not bear comparison well, in some important respects, with one or two foreign guns of recent type.

The standard fire to which field guns are held up for comparison is shrapnel fire; it is *par excellence* the fire that will be used on the next battle fields; no other fire can approach it in man-killing power at long ranges. Below will be found a few statistical facts, some taken from Captain Moch's tables, and others computed by the writer, which serve to compare along this line the Spanish 7.85 cm. (3.09-inch) gun of the Sotomayor system with our own 3.2-inch field gun.

	Sotomayor.	U. S. Field Gun.
Calibre	3.09 in.	3.20 in.
Weight of gun	770 lbs.	829 lbs.
Weight of projectile	14.33 lbs.	13.5 lbs.
Number of bullets in shrapnel . . .	231	170
Muzzle velocity	1509 f. s.	1700 f. s.
Muzzle energy	226 f. tn's	271 f. tn's
Range at which final velocity will be 600 f. s.	6430 yds.	5930 yds.
Number of rounds in limber chest . .	36	42
Weight behind horses with piece limbered up	3608 lbs.	3789 lbs.

It is to be noted that the smaller caliber and lighter Sotomayor gun give decidedly better shrapnel effects than our larger caliber and heavier gun. The Spanish gun fires a shrapnel which contains more than 30 per cent. more bullets than the American gun and this projectile carries these bullets with a man-killing velocity, up to a range 500 yards greater than that at which our gun gives the same remaining velocity to its projectile. This is done with a less strain upon the carriage by 55 ft. tons, than that caused by the recoil of the United States' gun, and with less weight behind the horses by about two hundred pounds. Our gun carries six more projectiles in the limber than the Sotomayor gun, but adding this number to the load of the Spanish limber, the weights behind the horses would still be 90 lbs. less in the Sotomayor system.

Lieutenant Schenck's proposition in the October number of the Journal to increase the weight of our projectile to 18 lbs., using a muzzle velocity of about 1400 f. s., would, without doubt, restore the ballistic supremacy of our gun, even though it would place additional weight behind the horses; it would give us 278 bullets in each shrapnel, and would increase the range at which there would be sufficient remaining velocity to give man-killing power to the shrapnel bullets, to a limit beyond which there is no need of going, and it would reduce the strain on the carriage due to recoil by 26 ft. tons.

It is believed that this is a question well worthy the serious consideration of the Ordnance Department.

E. M. Weaver,
1st Lieutenant and R. Q. M., 2nd Artillery.

BOOK NOTICES.

Felddienst-Ordnung. Ernst Siegfried Mittler und Sohn. Berlin, 1890. Official. Pp. 218, with Appendices.

This little volume is supplemental to the "Drill Regulations" in the German army. Its aim is to lay down the rules and principles applicable to every variety of field service both in war and during the Autumn Manœuvres. Essentially intended as a book of reference, it is arranged with this end in view and is quite characteristic of German methods. The first one hundred and fifty-five pages are devoted to questions of field service in war, while the remaining pages are devoted more particularly to the Autumn Manœuvres.

Even the casual reader will be struck by the clearness and conciseness with which rules and principles are enunciated, a feature often wanting in German text-books. The book is entirely free from confusing details and does not attempt to lay down rules of conduct for individual cases that may arise in the field, but rather seeks to state clearly the objects to be accomplished by the different field duties and the general means of their attainment, leaving to officers of all ranks, the selection of the details. The governing idea seems to be to secure to all officers within their own spheres of action the opportunity of initiative and thus to teach them self reliance, independence, and freedom from fear of responsibility. The complexity of modern military operations forbids rigid and fixed methods and this fact seems clearly recognized in the volume under consideration. As pertinent to this fact, a paragraph of the Emperor's order, promulgating the "Instructions" may be of interest. It reads as follows: "The liberty permitted herein in the practice of field service, is intentional and should be to the advantage of leaders of all ranks in independent determination." The contents of the volume are conveniently divided into subjects and the separate items numbered consecutively, thus securing a systematic arrangement.

To indicate more clearly the manner in which a subject is treated, the following translation of "Protection on the March," is given:

INTRODUCTION.

68. Marching troops, for the most part confined to the roads in great depth of formation, require a certain time to get into battle formation. It is the problem of the troops appointed for protection to assure this time and to brush aside slight disturbances so that the march of the whole may not be hindered.

69. A good orientation is the first step in security. To complete the same, immediate protective measures are not to be neglected.

70. The main body of an advance has for its protection an advanced guard in front, and the main body on a retreat has behind it a rear guard. The security of the flanks is effected through flank guards.

ADVANCED GUARD.

71. Cavalry divisions, or parts of the same in front of an army, are not generally in a condition to assure the protection of the following masses, by virtue of their other duties. Therefore the latter, even when there are advanced cavalry divisions, must always push out an advanced guard. It is a problem of the advanced guard to take up and maintain connection with the advanced cavalry divisions.

72. The consideration that an effective orientation forms an essential means of security, leads to sending out beyond the advanced guard, the attached cavalry troops. They may for this purpose as well be under the immediate orders of the commander-in-chief (independent cavalry) as assigned to the advanced guard (advanced guard cavalry).

In this way the cavalry procures more rest and steadier advance for the whole, than if it be advanced only in cases of necessity.

Its movements are so appointed, that, while fulfilling all the requirements of orientation, connection with the following infantry is never lost, and that it is always at hand in the deployment for battle.

Circumstances may also make it desirable to send the greater part of the cavalry in some other direction or to hold it back at times.

So soon as close contact is established with the enemy, the tactical conduct of the cavalry comes to the front; but even then orientation must not cease.

73. The distance between the advanced guard and the main body depends on one's object, strength, considerations with respect to the enemy, and nature of the ground. The lead of the advanced guard on the one hand, must be great enough to prevent delay or interruption to the march of the main body and, on the other hand, not so far as to debar the timely attack of the main body.

In an advance to attack the distance may be lessened in order to hasten the development to the front.

74. The strength and organization of the advanced guard varies according to the ground and strength of the whole; in larger groups according to the strength of the foremost masses. It comprises from $\frac{1}{6}$ to $\frac{1}{3}$ the infantry.

If the mass of the cavalry is not assigned to the advanced guard, at least a detachment sufficient for the purpose must be attached.

Artillery and pioneers, as much as possible by tactical groups, are assigned according to necessity.

The presence of a bridge train and part of a sanitary detachment may be necessary.

75. The advanced guard consists of the main body, advanced body and, finally, the advanced-guard cavalry (compare 72).

76. The main body comprises the mass of the infantry and, as a rule, the artillery.

77. The advanced body consists, preserving units as much as possible, of ¼ to ⅓ the infantry and the necessary cavalry and pioneers.

The advanced body marches at such a distance before the main body as to secure for it the time necessary for deployment, on coming in contact with the enemy, usually ½ to 1 kilometre; small advanced guards, so far that the main body cannot be surprised by an effective rifle fire.

A strong advanced body may, if it promises a better security, send forward a detachment (company, platoon) 300 to 400 metres.

78. At about the same distance in advance of the advanced body is the infantry point, beyond this the cavalry point, or the cavalry of the advanced body with its point.

The infantry point consists of one officer and at least a section, so that it may have a certain degree of resistance and may be able to search a broader front without having to take the advanced body into consideration. The point generally marches in dispersed order, two men as a rule serving as connecting files, half way back to the advanced body.

The cavalry point consists of one officer and four to six troopers. As one or two troopers are left on the road in the rear, the point utilizes the neighboring heights for observation.

79. Infantry marching alone divides its advanced guard in a similar manner.

80. A cavalry division and other independent cavalry choose a division of the advanced guard, and means of orientation and security commensurate with the problems presented.

81. All measures of an advanced guard must have for their object to *prevent the steady and uniform march of the whole from being unnecessarily interrupted.* It is of essential importance to protect the troops from a serious surprise. Smaller hostile detachments are themselves compromised by the fact that the leader of the advanced guard is justified in assuming a bold attitude from the knowledge that he is followed by the main body.

With regard to advancing, the smaller divisions are always dependent on the larger. It devolves on these to maintain the connection to the front.

The foregoing translation is a fair sample of the manner in which different subjects are treated, and, as will be observed, nothing but general principles are touched upon. A subject so presented will always lead to a more comprehensive understanding than one burdened with a mass of unimportant details which often serve to bury from view the main principles.

In a nine page introduction some general observations are made on discipline and military training. The latter, it is stated, can be acquired by practice in a comparatively short time: but the former is a thing of gradual growth and can be acquired only after a sufficient period. Athletics are put down as a valuable factor in military training, both for officers and men, as increasing their bodily strength and dexterity. The various elements that make up an officer's training are gone over briefly and the observations concluded with the significant remark that "delay and neglect of accomplishing results are far more serious than a failure to grasp the proper methods."

Following the introduction, Army Organization and Command are touched upon. Next comes the Preparation and Transmission of Orders, Reports, and Military Sketches. The rules and principles present nothing unusual except, perhaps, the organization of mounted relays and their conduct, in cases where the field telegraph or signaling is not available.

Orientation by the advanced cavalry troops follows next in order. Some of the more important observations read as follows:

"For purposes of orientation all suitable means are to be set in motion.

"For observation, single soldiers and small parties are most suitable.

"An officer should possess in a marked degree the powers of drawing correct conclusions from short moments of observation. Well mounted, provided with reliable field glasses and maps, skilled in judging ground and map-reading, sufficiently well acquainted with the object of the movement and the enemy's circumstances, he is the most important organ of orientation.

"All independent cavalry leaders down to the chiefs of squadrons and of officer's patrols are responsible that contact with the enemy once established should not be lost."

The different duties for security of the troops, on the march, at a halt, or in siege operations are then taken up and concisely treated.

Under the subject of marching some points of interest are to be noted. The greatest enemy to marching troops is stated to be the heat. To quench the thirst of the men, mounted officers ride ahead and have the inhabitants of towns and villages place vessels of water along the line of march so that the soldiers may drink and fill their canteens without delaying the march unnecessarily.

The order of march in sets of fours is put down as requiring the following extent of road:

A battalion with small baggage	400 metres.
A battalion with large baggage	500 metres.

A foot battery requires 500 metres, a squadron 150 metres, and a division bridge train 310 metres.

To allow for the elongation of the units the following distances are to be maintained between the various divisions:

After a company	8 metres.
After a battalion, squadron, battery	16 metres.
After a regiment	30 metres.
After a brigade	60 metres.
After a division	250 metres.

Commanders are authorized to permit loosening of clothing and any other reliefs deemed advisable.

Night marches are to be avoided as much as possible as being harassing and fatiguing to the men.

After marching, the subject of cantonments with the interior regulations for the same is taken up, followed by bivouacking. The order of bivouac for the units of the different arms of the service is graphically presented.

Fifteen pages are devoted to the subject of baggage, ammunition columns and trains.

The small baggage outfit of a battalion is:

7 spare horses.
1 2-horse medicine wagon.
4 2-horse cartridge wagons.

The large baggage outfit adds:

1 2-horse staff pack wagon.
4 2-horse company wagons.
4 2-horse supply wagons.

Single companies have as a small baggage allowance:

1 spare horse.
1 2-horse cartridge wagon.

The additional for the large baggage outfit is:

1 2-horse company pack wagon.
1 2-horse supply wagon.

The baggage allowance of units of the other arms of the service is also given.

Under the subject of the supply of troops, the principles governing contributions and requisitions are laid down. The iron ration is to be used only in case of absolute necessity and by order of the commanding officer, and is to be replaced as soon as possible.

The medical service is also briefly touched upon. A sanitary detachment goes with each division and consists of 7 surgeons, 1 field apothecary, 8 hospital assistants, 8 military nurses, 176 ambulance bearers.

The supply of ammunition to troops on the firing line is secured by causing the cartridge wagons to take up a covered position 800 m. from the line and in pressing cases, near the line, regardless of loss. The supply to the foremost firing line is regulated by the battalion commander. For this purpose, some men of the reserve companies are to be utilized and no men on the firing line sent back. The cartridge wagons are to supply ammunition on demand, regardless of source, whether their own organization or not. All fresh troops sent to the firing line are to carry a supply to those already engaged. The cartridges of the dead and wounded are to be removed wherever possible. It is not a question of keeping up the prescribed supply of cartridges in a fight, but wherever ammunition is to be had, it is to be divided up and carried in the breadsack, trousers or coat pockets, &c. In defensive positions a previous supply of ammunition must be laid down in the firing line. The replacing of empty cartridge wagons devolves on the battalion commander.

The construction, preservation and destruction of telegraph lines and railroads is touched upon in a few pointed observations.

The remaining 64 pages of the volume are devoted to the regulations governing the autumn manœuvres and prescribing the method and time for the exercise of the various divisions of the troops, individually and collectively, beginning with brigade drills and manœuvres and leading up to the final grand manœuvres.

The appendix contains descriptions and well executed plates of the different headquarter flags of the German service.

A time programme of the autumn manœuvres and the formation for the parade of an army corps conclude the subject matter of the book.

The typography is above criticism but the binding is far from what it should be for a book that would be referred to as much as the one under consideration.

The little volume is a veritable mine of information on all matters pertaining to field service and the only regret is that a lack of knowledge of German should debar the great body of our officers from perusing it.

Joseph E. Kuhn,
1st Lieutenant Corps of Engineers.

Interior Ballistics. Part I, Theoretical. Part II, Experimental. By Colonel Pashkievitsch, Professor in the Michael Artillery Academy, St. Petersburg. Translated from the Russian by Lieutenant Tasker H. Bliss, First Artillery, Aide-de-Camp. Adjutant General's Office, 1892.

This is the second of the series of monographs on subjects relating to the science of artillery which have been issued from the Adjutant General's office during the present year. The first of the series, also by Colonel Pashkievitsch and translated by Lieutenant Bliss, treats of the resistance of guns to tangential rupture, and forms with the work under notice, a connected and rather complete treatise on the variable pressures produced in the bore of a gun by the expansion of the powder gas, and the best means of controlling these pressures by a properly built up gun. These monographs contain the substance of lectures delivered by Colonel Pashkievitsch during the years 1888 and 1889, to the senior classes at the Russian Artillery school.

After a few paragraphs on the well known phenomena of ignition, inflammation and combustion of single grains and charges of gunpowder, the author gives a condensed account of the experiments made by Nobel and Abel in 1875 (so well known to our artillery officers through the republication of their memoirs, unabridged, by the Artillery School press), with a description of the apparatus employed—illustrated with plates—and a resumé of the most important of the deductions made by these experimenters from their labors. Though these experiments relate to the phenomena accompanying the explosion of gunpowder in a *closed vessel*, they have an important bearing upon the subject of interior ballistics, since they help to determine the temperature of combustion of fired gunpowder, the mean specific heat of the products of combustion, the ratio of solid to gaseous products, and what is technically called the "force of the powder"—all of which are factors in computing the work done by the expansion of the gases.

The author next takes up the important subject of the motion of a projectile in the bore of a gun; and within the compass of twenty-seven pages gives the substance of M. Sarrau's classic "*Recherches sur les effets de la poudre dans les armes*" and "*Formules pratiques des vitesses et des pressions dans les armes*," memoirs originally published in the *Mémorial de l'Artillerie de la Marine* during the years 1874 to 1878.[*] Colonel Pashkievitsch, like all recent writers on interior ballistics, has followed Sarrau's methods very closely from the elegant deduction of the fundamental equations of thermodynamics—equations which "contain all the thermodynamic laws of gases"—through their application to the establishment of the differential equation of motion of a projectile in the gun, and the approximate solution of this somewhat intractable equation so as to take into account the gradual combustion of the powder grains under the variable pressure to which they are subjected. The practical results of this analysis are Sarrau's well known binomial and monomial formulas for muzzle velocity and his formulas for the maximum pressure upon the base of the projectile and the breech of the gun. The binomial formula for muzzle velocity is illustrated by a single example with data taken from the results of firing brown prismatic powder, at the Ochta factory, in 1885, in 28 cm. and 22.9 cm. guns. The constants thus obtained are made use of in an elegant discussion of the characteristics of a powder suitable for these guns, which is a model for such investigations.

Colonel Pashkievitsch—following Sarrau—assumes that the relation between the maximum pressure on the breech and the maximum pressure on the base of the projectile is expressed by the equation

$$P^1_{\max} = P_{\max}\left(1 + \tfrac{3}{2}\frac{\tilde{\omega}}{w}\right)$$

in which P^1 and P refer, respectively, to the breech and base of the projectile, $\tilde{\omega}$ is the weight of the powder charge, and w the weight of the projectile. It is believed that, for the relatively large charges employed in the latest types of guns, the following expresses more nearly the ratio between these maximum pressures:—

$$P^1_{\max} = P_{\max}\left(1 + \tfrac{1}{4}\frac{\tilde{\omega}}{w}\right)$$

The next section is on "Formulæ for the designing of guns," and is a short, but fairly complete, resumé of Sarrau's memoir entitled "*Recherches théoriques sur le chargement des bouches à feu*," published in the *Mémorial des Poudres et Salpêtres*. Vol. 1, page 35.[†]

The fourth, and last, section of Part I consists of an original and extremely interesting discussion of that part of the work of expansion of the powder gases which was not introduced into the differential equation of motion. In deducing this equation it was assumed that the entire work done by the gases at any instant was expressed in the corresponding velocity of translation of

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[*] These memoirs have been translated into English by Lieutenants Meigs and Ingersoll, and are published in Vol. X of the Proceedings U. S. Naval Institute, 1884.

[†] This memoir may be found in "Notes on the Construction of Ordnance." No. 42. Translated by Lieutenant D. A. Howard, Ordnance Department, U. S. Army.

the projectile, thus neglecting the heat communicated to the walls of the gun—the work expressed in the rotation of the projectile—in forcing the base ring into the grooves and in overcoming the subsequent friction—in communicating motion to the gun and carriage and to the powder charge—in overcoming the resistance of the air to the acceleration of the projectile—and, finally, the loss of gas through the vent and by windage. The author remarks: "The united influence of the above causes of loss of the store of work of the powder gases was partly taken into account in the preceding discussion by the fact that the coefficients in the expressions for the initial velocity of the projectile and for the pressure on the breech were so determined that these data should have the values actually observed in the experiments. But, in order to judge of the influence which each of these causes separately has on the initial velocity and on the pressure, it is necessary to consider them separately."

The author takes up these various losses of energy *seriatim*, and arrives at the following conclusions:

The loss of heat communicated to the gun, as determined by experiment varies from one-fourth part in a rifled musket barrel to one-tenth part in a 12-pounder gun, and rapidly diminishes as the calibre increases.

The rifling, rotation and recoil exercise but a small influence either on the initial velocity of the projectile or of the pressures in the bore.

In the communication of motion to the products of combustion there is employed approximately not more than ten per cent. of the living force communicated to the projectile.

The object of the second or experimental part of the work, as stated by the author, is "The discussion of the various methods of determining the pressure of the products of decomposition, developed on firing, in the different sections of the bore of a gun; the velocities of the projectile at these different sections; and the times required for its passage through different lengths of the bore." Under the head of "The Statical Measurement of Pressure" the author gives a very complete discussion of Rodman's knife and of Noble's crusher guages, with methods of constructing tables for their use. The dynamical determination of pressure is quite fully discussed, and among the apparatus described are the accelerometer and accelerograph of Marcel-Deprez, the Noble chronoscope, the Schultz chronograph and the Sebert velocimeter.

The work appears to be well translated and but few typographical errors have been noticed. "Initial velocity" is used throughout for muzzle velocity. In interior ballistics the initial velocity is zero. Some changes of Sarrau's notation are noticed, without apparent reason.

James M. Ingalls,
Captain 1st U. S. Artillery.

Alloys of Iron and Chromium. By R. A. Hadfield. Including a Report by F. Osmond, on the Chromium Steels of Mr. R. A. Hadfield: Reprinted from the Proceedings of the *Iron and Steel Institute*. Received through courtesy of Captain E. L. Zalinski, 5th U. S. Artillery.

This is a most interesting presentation of the subject of chromium steel. Beginning with an historical account of the discovery of chromium by Vanquelin, the author proceeds to treat the subject with considerable detail up to include the latest application of chromium steel in the manufacture of armor piercing projectiles by his own firm. He refers to the labors and contributions of Berthier, Frémy, Bouissangault, Brustlein, Baur, and others.

Of Baur, he writes: "After considerable investigation the writer is led to the conclusion that it is to Mr. Julius Baur, of New York, to whom credit must be given of first introducing on a practical scale the manufacture of chromium steel." M. Brustlein, the metallurgist of the Holtzer Company of Unieux, France, has frankly admitted that he was, in 1875, led to make his own experiments from seeing an account of Baur's work in America.

Here, then, is one more American invention of greatest importance to military science, which was permitted to go to Europe for development because of neglect or oversight at home. The principle of initial tension, the slotted screw breech fermeture, the Broadwell gas check, the perforated powder grain, breech-loading arms, metallic ammunition, magazine small-arms were, respectively, placed before us very early in their histories, but they were all in succession pushed aside, and only accepted after they had received the stamp of European approval. It would be a very interesting contribution to our professional literature if the history of these acts of mistaken judgment could be written.

Mr. Hadfield discusses his subject under the following headings: Early History, Description of the Metal, Early Experiments, Production of Ferro-Chromium by Crucible and Blast Furnace, Magnetic Properties of Ferro-Chromium, Use of Ferro-Chromium in Cast-iron, Manufacture of Chromium Steel, General Application of Chromium to Steel Manufacture.

Mr. Osmond's report on the Hadfield chromium steels is exhaustive. From his experiments he finds that chromium may exist in steel in three states, at least, either separately or simultaneously: 1. In the state of *dissolved* chromium, 2. In the state of a *compound* of chromium, iron and carbon in the form of *isolated globules*, 3. Same as "2," in the form of a *solidified solution*. The data connected with the physical and chemical characteristics of the specimens and with the various tests and experiments made, are fully set forth in tables, and, graphically, by charts.

It will be interesting to give some of Mr. Hadfield's conclusions:

"It is noteworthy that whilst chromium, so far as we imperfectly know its properties, is a hard metal, yet its addition, in the absence of carbon, does not produce any greater hardness, at any rate up to three or four per cent., than steels of similar silicon and aluminum percentages. Chromium, therefore, in its effects upon iron *as regards hardness*, may appropriately be classed along with most of the other non-hardening elements alloyed with that metal. Probably carbon must still be considered to be the only true hardener of iron." Page 36.

"We may imagine that hardened steel (that is, water or oil hardened) is a material in which the molecules are in a state of intense strain, often relieved, in the case of hardened steel projectiles, by the material spontaneously rupturing itself. It appears, therefore, that any material to be used, where subjected to sudden and intense strains [stresses] should not be in the condition of having a high elastic limit. If heavy guns were made of a grade of steel having medium tensility, but with a disregard to high elastic limit, it is probable that less failures would occur. In other words, it might be found better to have a harder grade of steel with a lower and natural elastic limit than a milder steel in which a higher elastic limit is obtained by means of sudden cooling, and which is probably a 'strained' elastic limit." Page 41.

"It hardly seems probable that this steel [chromium] will, at any rate for some time, come into general use or displace ordinary carbon steel except in special work." Page 45.

At present the use of chromium steel is confined to armor piercing projectiles, certain special classes of armor, and tools.

Mr. Hadfield's firm has supplied armor piercing projectiles to the English Government since 1882. He gives a short resumé of some of the latest tests of his projectiles supported by excellent reproductions of the plates and projectiles employed. The results of these tests are given in condensed form in the following table:

PROJECTILE.		PLATE.		Striking Velocity.	Penetration	REMARKS.
Cal.	Wt.	Kind.	Thickness.			
in.	℔s.		in.	f. s.	in.	
13.5	1120	Compound	18	1950	Complete.	Also penetrated a 6-in. wrought-iron plate, 20 feet of oak backing, a second 10½-in. wrought-iron plate, a third 2-in. wrought-iron plate; total penetration of armor 36½ inches. Projectile broken after passing through last plate.
6	100	"	9	1825	"	Reception test. Projectile whole. Only slightly altered in shape. Face of plate 1.25 per cent. carbon.
"	"	"	"	"	"	Same as last.
"	"	"	"	"	"	Projectile whole, very slightly altered; was fired a second time through another 9-inch plate, was still entire and was fired a third time at a special plate which broke it up.
"	"	"	6	"	"	A "bursting" shell with thin walls and double the capacity of core of a. p. shell. Found entire 2000 yards beyond target.
"	"	"	10½	1830	26½	Four projectiles. All entire and uninjured.

The percentage of chromium used in armor pirercing projectiles varies from 1.25 per cent. to 2 per cent., and the percentage of carbon varies according to the special requirements in each case.

M. Brustlein observed that the effect of chromium is to increase the tensile strength of steel and also its elastic limit without diminishing the elongation. Mr. Hadfield considers that the hardening effect of chromium is confined to the higher carbon steels, the effect increasing, in a measure, directly with the per cent. of carbon present. The great hardness of high carbon chromium steels is due, according to M. Osmond, to the formation of an iron-chromium carbide, which is itself very hard, and which, at high temperatures (1200° C. and higher), is dissolved and held in solution in molten steel, the cooled mass yielding a solidified solution of the carbide in carbon steel, and producing chromium steel.

The entire paper is very interesting and instructive. It is to be hoped we may soon have an equally thorough treatment of the iron-nickel-carbon steel which has so recently appeared on the scene to the undoing of chromium-steel projectiles. E. M. W.

The Annual of the Office of Naval Intelligence. General Information Series No. XI, July, 1892.

Again it becomes our pleasant duty to notice the Annual of Naval Intelligence in the *Journal*. The product of 1892 is similar in appearance, arrangement, and value, to those of previous years and as usual furnishes the reader with a vast amount of naval and military information which cannot be found elsewhere except in disconnected fragments scattered here and there throughout the world. The general subjects treated are arranged in chapters and, as several of these contain valuable information for the artillerist's profession, it may be well to consider each with sufficient detail to give him an idea of each chapter and the contents of the book as a whole.

I. NOTES ON SHIPS AND TORPEDO BOATS.—Begins with facts relating to the U. S. Navy, such as appropriations, vessels proposed or laid down, launched or dropped during the year. An object of interest under the head of torpedo boats is a brief description of the Baker submarine boat. Following in the same order, similar information is furnished with respect to England, France, Italy, Russia, Germany, Spain and less important countries of Europe and South America.

Considerable interest attaches to submarine boat experiments in France and Italy, which, taken in connection with those of our own navy, indicate an approaching solution of this problem. Therefore the next naval war, it is probable, will see this unknown but important element introduced amongst many others yet untried. Russia is introducing electrical launches as picket boats.

II. NOTES ON MACHINERY.—This part relates principally to ship machinery. Although not dealing directly with artillery matters, it is believed that officers of this arm will find much information which will aid them in their preparation for the new artillery problems and conditions. Several discussions of scientific interest are presented, the more important of which are, extracts from the report of the Chief of the Bureau of Steam Engineering for 1891 on "Steel Castings," "Deterioration of condenser tubes in the U. S. S. Baltimore" and "Vibration of Vessels." The last subject is set forth to considerable extent in the words of Mr. A. F. Yarrow, a most careful investigator. He points out causes of vibration and suggests means of removing them. He has proved by experiment that they are independent of the screw. The subject is illustrated by photographs.

III. NOTES ON ORDNANCE.

High Power Guns.—In the notes relating to high power guns abundant evidence appears, showing a rapid tendency towards the abandonment of all calibers larger than 13''.5 and this size is becoming rare. During the year no new 110-ton guns have been ordered in England, the manufacture being restricted to 67-ton 13''.5 guns. Italy is confining her orders to 68-ton, and Germany to 28-cm. 35-caliber guns. The record of the English 110-ton gun is by no means encouraging. Out of a contract for twelve, ten have been delivered. Five of these are now mounted on ships and are *assumed* to be in serviceable condition, one is to be repaired, one failed on trial and is now reserved for experimental purposes, one was strengthened to replace another, a fourth was condemned and the remaining one has just been accepted. Those now mounted are not considered safe with full charges and in some cases are said to be defective. The 13''.5 67-ton guns have a record little better, and the same may be said of most of the other guns in the English service.

In France there is a reaction towards smaller calibers and higher initial velocities. The largest gun of the future is to be the 30-cm. 50-caliber gun, projectile 625 pounds, initial velocity 2625 f. s. This type is to replace that of the 42-cm., whose record is little better than that of the 110-ton guns. Two Krupp 119-ton 40-cm. guns have been mounted in a Gruson Cupola and the system was found to work well, but it does not appear as having been thoroughly tested.

It would appear from the facts here given that very large guns in Europe have had their day. Expensive but valuable lessons have been learned by England, France and probably Germany, in regard to these "obsolete masses of iron," and these and other foreign nations are showing a strong disposition "to have done with them." Their experience now comes to the rest of the world free of charge, and to us very opportunely. In view of this and much other experimental information obtained in foreign countries, we are especially fortunate in being somewhat backward in our new armament, since we may now profit by all their experience and avoid all their recognized mistakes.

The first three 24-cm. Canet guns for the *Capitan Prat* have passed their trial successfully. The guaranteed velocity of 2400 f. s. was obtained with smokeless powder. The last two of the Canet 32-cm. guns for the Japanese navy passed their trials. One gave a veloctty of 2386 f. s. with a pressure of 16.15 tons. All the mounts and mechanism worked satisfactorily.

Rapid Fire Guns.—The principal systems which have been prominent during the year are the Armstrong, Canet, Krupp, Schneider, Hotchkiss and Driggs-Schroeder. The use of cordite in the Armstrong guns gave 2660 f. s. The great length and resulting high velocities of Canet guns, the bursting of a Hotchkiss gun at the battle of Vina del Mar, Chili, 1891, and interesting mechanical details in the various breech mechanisms are the special features relative to this class of ordnance during the year. France has been adopting rapid fire guns in her armament and is now converting her 10, 14, and 16 cm. guns into rapid fire guns. Future conditions will exact rapid fire guns of large caliber and this step seems merely to anticipate the future armament which, in all probability, will consist almost if not entirely of rapid fire guns. The Dashiell mechanism for quick firing guns of large caliber, have been adopted in the U. S. navy. A description is given. It is not unlike that of Canet.

Machine Guns.—The Maxim automatic, and Koda 8-mm. machine guns are considered and described.

Gun Mounts.—The Vavasseur housing apparatus has for its object the withdrawal of the gun inboard from the firing position when desirable. The Schneider and Krupp mounts and hoists are fully described and illustrated. The Fletcher mount adopted for 4″ rapid firing guns in the U. S. navy deserves study.

Small Arms.—The small arms of all nations are carefully discussed and tables and data relative to the latest models, interesting experiments with smokeless powders, and statistics in regard to the re-arming of Europe given.

Torpedoes.—Sims-Edison dirigible torpedo underwent experiments which showed methods of launching and clearing the ship and, with one or two exceptions, controllability. The Whitehead, notwithstanding its great number of failures during the year, and previous years, still holds its own, and is being manufactured after larger models and is being more generally adopted. The motive actuating European nations seems to be that it is absolutely necessary to possess this torpedo regardless of its record, until a better one can be secured. Successful experiments with the Howell torpedo led to an order for a number for use in our own navy. The Ericsson submarine gun and *Destroyer* are explained and experiments made by the U. S. navy given. The tabulated results indicate a range of 500 ft. A comparison of these with the results which will soon be obtained from trial of the guns of the *Vesuvius* will be interesting. Torpedo booms, net cutting attachments and discharging apparatus come in for notice.

High Explosives.—The Justin and Snyder high explosive shells are shown, with results of experiments during the year. Very little interest however is attached to either of these make-shifts.

In France experiments were made (1) *Firing against protective decks.* The target represented as nearly as possible a ship's deck and side. A splinter screen was placed behind the protective deck. 32-cm. common fuzed cast-iron shells, containing 55 pounds of melinite, were fired with velocities of about 1635 f. s. The trial showed that a 0''.315 sheet iron splinter screen caused the shells to explode before striking the deck. The effect on the deck depended on the distance of explosion therefrom. The details are too numerous to be given here, but merit careful study.

(2) *Firing against light armored upper works.* The target was made up to represent the light upper works of the *Brennus*, and was attacked with projectiles in a manner similar to that described above, and also with 16-cm. projectiles containing 8.8 pounds of melinite and black powder. Again the details are too numerous to present here, but the conclusion was that armor is worsted when attacked with powder charged shells which perforate before explosion, or with large melinite charged cast-iron shells, striking normally with velocities from 1968-2132 f. s. In April, 1892, 10 melinite shells fired from a mortar destroyed a target at a range of 1970 yards.

Armor face hardening.—Patent specifications of the Harvey and Tresidder processes given showing means and methods used in hardening plates.

The remainder of the chapter is devoted to cellulose, coffer-dam tests, etc., ordnance instruments, particularly Fiske's position-finder, illuminated sights and projectiles.

IV. NOTES ON NAVAL ADMINISTRATION AND PERSONNEL.—Here we find a continuation of the subject touched upon in earlier numbers. These notes are based mainly on foreign official publications and relate principally to England, France, Italy and Germany. They constitute a valuable contribution to naval studies, but possess only general interest for the artillery.

V. ELECTRICITY ON BOARD NAVAL VESSELS.—The electrical paper this year differs materially from those of previous years. The development and introduction of arts and sciences are generally accompanied by a great variety of kinds and forms of apparatus, without any necessary relation to one another. They are usually the products of different minds working along different and independent lines toward the same end, but with wholly different kinds of devices and units. The transition from this condition of affairs to one of simplicity and uniformity marks an epoch in such development. The application of electricity to naval warfare has been no exception to this rule, and we find the navy now passing through this change. It appears from the paper now before us that the efforts of the navy during the year in regard to its electrical problems have been in the direction of standardizing all apparatus and of producing such correlation of parts in future equipments as will secure well devised and uniform systems, fulfilling certain conditions evolved from experience. Such efforts always mark an advanced stage in adoption of machinery and shows how early and well our naval friends have perceived the value of electricity for modern conditions of war. The standardizing movement is proof of the hold which this agent has upon naval problems.

The subject is treated carefully and progressively, and the principles—

based upon experience—which all standard apparatus should fulfill are given. Following this method the writer considers generating sets, number and size of dynamos and location of rooms, accumulators, batteries, switch-boards, wiring lamps, etc., with respect to unformity of equipment and operation.

The question of search lights on shipboard is discussed in a thorough manner and the different methods of arranging and controlling them are presented. The development of a German lamp with horizontal carbons and results obtained from it are of special interest. The introduction of electric motors is given considerable space and their superiority in many cases, over all other forms of motors is recognized, not only in regard to weight, convenience, cleanliness, and efficiency, but also in cases where no other motor will accomplish the desired result. The contrast in favor of power transmission through means of wires as against pipes and similar devices, is well brought out. The conclusions here laid down are interesting when compared to those of an English officer recently discussing the same subject, in which it is concluded that pipes should be much simpler and safer than wires. The means and importance of internal communication are dwelt upon.

While none of the electrical problems on shipboard can ever be quite the same as those in a fort, still the majority of them must be essentially the same, and abundance of information may be obtained from ship problems already solved. In reading this chapter and reflecting on its contents, the question naturally arises in the mind as to how long it will be after we have begun to solve our "electrical problems" before the "standardizing" period is reached. With all this experience similar to what our own must be, we should be able to commence practically where the navy stands to-day. Here again the army can find much experience and resulting information free of cost and trouble and should profit by it.

VI. The Naval Manœuvres of 1891.— The naval exercises embraced in this subject relate to England, France, Germany, Austria and Russia. The manœuvres are principally valuable in showing the plans of operations in each case, the rules laid down for governing umpires, and the mass of details with reference to attack and defense by torpedo boats. Owing to the imperfect or double nature of the evidence the decisions of the umpires were not always conclusive. The failure of torpedoes in the English fleets were pronounced and torpedo boats showed up in very poor light. Fewer casualties resulted than in former years.

VII. Armor in 1892.—After giving a brief statement as to the necessity for equal conditions in comparing armor plates, the writer divides the subject into I. French trials at Gâvres. II. English trials. III. Indian Head trials. IV. Conclusions deduced from the year. He then proceeds to discuss the results in each particular series. In each case ballistic and firing details are given, with illustrations of the results. These form a collection of great value. In part IV the writer concludes that the U. S. Bethlehem plate tested at Indian Head November 14, 1891, stands higher in order of merit than either English or French plates tried during the year. The appearance of this

Harveyized high-carbon nickel-steel plate after trial is clearly reproduced. Additional tests at Indian Head have demonstrated beyond question the value of nickel-steel, which used in connection with the Harvey process has developed armor to an efficiency never realized before. The most remarkable results in the history of armor were obtained with the 10″½ Harveyized nickel-steel plate of the Bethlehem Company tested at Indian Head July 23, 1892, and with a similar plate tested at the grounds of the Bethlehem Company July 30, 1892. In each case the navy 8″, 250-pound projectile, 1700 f. s. was used and five shots were fired. Each blow being delivered with 5008 foot-tons, or a total of 25040 foot-tons was spent on the plate. Neither plate was essentially injured and, to all appearances, were nearly as strong as before.

VIII. SOME STANDARD BOOKS ON PROFESSIONAL SUBJECTS.

In closing these remarks it may be well to emphasize some of the characteristics of the work under consideration.

1. It is a professional book the compilation of which is performed by officers of the navy who are especially detailed for this purpose.

2. It is an *annual* and therefore represents systematic organized effort with well defined objects in view.

The Bureau of Information is established and run according to business principles. Officers of the navy alternate between ship and shore duty. While on shore they are assigned to various duties as, collecting information, work in shops, at proving grounds, etc., where they are enabled to study theoretically the results of such practical experience as they may have obtained at sea, or to construct and test any theoretical apparatus which they may have devised during the same period. The results of this rotation in duty by which theory can be reduced to practice and experimental data brought within the mellowing influence of scientific light, need no comment. Some construct guns and carriages, while others use them. Then comes a time when the constructors go out and operate the machines which they have made and soon learn whether or not their designs are ideally perfect. In the same manner some collect information and others, while using it, come directly in contact with subjects and problems in regard to which information is deficient and are sent in their turn to make up the deficiency.

The collection of such a book may seem a small matter, and in itself it is, but when considered in connection with the work of preparation, organization, and above all the acumen of its founders to perceive the ultimate benefits which the bureau of information would return, it must be regarded as a great undertaking. Keeping in mind the live and liberal policy which originated and continues *this necessary department in a progressive profession*, we need not wonder that emergency finds them ready. J. W. R.

BOOKS RECEIVED.

Report of Adjutant General of Pennsylvania, 1891.

Report of Adjutant General of Massachusetts, 1891.

List of Foreign Correspondents of the Smithsonian Institution, by GEORGE H. BŒMER.

A Catalogue of Scientific and Technical Periodicals (1665 to 1882), by HENRY CARRINGTON BOLTON.

Alloys of Iron and Chromium, by R. A. HADFIELD, including a report by F. OSMOND.

Smithsonian Report, 1889.

Smithsonian Report, U. S. National Museum, 1889.

Annual of the Office of Naval Intelligence, 1892.

Annual Report Bureau of Ethnology, 1885-86.

Descriptive Map of Army Posts, by *Lieutenant* H. C. HALE, U. S. A.

SERVICE PERIODICALS.

Revue d'Artillerie.

SEPTEMBER.—75-mm. field materiél, Schneider system, constructed for Brazil. Artillery in the United States in 1892. Metallurgical industries in the United States. Rules of fire for the German foot artillery. The materiél of the Russian field mortar.

OCTOBER.—Notes on the Austrian artillery.

Subdivisions of the year of instruction into periods.

First Period.- (*a*) Instruction of recruits. 1st October, 1st July.
(*b*) " " veterans. All battery exercises

Second Period.-1st July to August 9 includes manœuvres of groups, regiment and fire.

Third Period.-August 10—31, manœuvres with other arms.

Fourth Period.-Manœuvres with division of infantry and cavalry; general manœuvres.

Fifth Period.-General rest, preparation of personnel for instruction of recruits and transfers to reserve.

Notes on Italian fortress artillery [continued].

NOVEMBER.—Artillery of the future and the new powders [continued]. Fire manœuvres of masses of artillery and their teachings.

Under this title the author [Cohadon, Lieutenant Colonel 2nd Regiment of Artillery,] discusses the operations of the artillery collected at Camp Chalons, 1st—14th August, 1892, and gives suggestions and conclusions which are the results of his observation.

DECEMBER.—Notes on the Austrian artillery. Methods and formulas of experimental ballistics.

First Part: Exterior Ballistics. Chapter I. Law accepted for the resistance of the air. Chapter II. (1) Rectilinear movement. Table of Ballistic functions. (2) Fire with elevation under 5°.

Fuses and detonators of the German artillery. J. W. R.

Revue Militaire de l'Etranger.

SEPTEMBER.—Military organization of railroad service in Austria-Hungary.

History of the subject. Organization of the service in peace. Organization of the service in war.

The military forces of Denmark (continued in October). The Danish army. II. General organization of the army upon a peace footing. Military news.

OCTOBER.—Field magazines in the German army. Military utilization of the navigable rivers in Italy (continued in November and December).

NOVEMBER.—Officers of the Reserve and "Landwehr" in Germany.

DECEMBER.—The new regulations of manœuvre for the German field artillery. The Italian budget for the exercises of 1893-94 and projects of reform of the Minister of War.

J. W. R.

Revue du Génie Militaire.

MAY-JUNE.—Notes upon the organization of the Corps of Engineers in the 18th Century. Note upon the trace and measure of the carapace in Béton cement.

An analytical discussion of the subject with several examples.

The Italian fortifications; from a course at the Turin school of application for the artillery and engineers. J. W. R,

Revue Maritime et Coloniale.

OCTOBER.—New Caldonia and its inhabitants. Balloons and exploration of Africa. The origin of French India. Four contributions to the geometry of naval tactics. Shipwreck statistics. Study upon the mechanical theory of heat.

J. W. R.

Revue du Cercle Militaire.

SEPTEMBER 11.—The Russian naval manœuvres of 1892. The technical corps (troops) of Austro-Hungary.

SEPTEMBER 18.—The Military Club of Vienna (continued). The new regulations of instruction and internal service for the Italian infantry (continued). The first combats of the Army of the Rhine (continued).

SEPTEMBER 25.—The Chinese army of the green flag (continued).

OCTOBER 16.—The reserve divisions in the manœuvres of 1892 (continued).

November 6.—Impressions of manœuvres. The Italian mobilization. The new war formations.

November 13.—Letters of an English officer on our grand manœuvres (continued).

November 27.— Medical statistics of the French army in 1890 (continued).

December 4.—The Souchier prism Telemeter (continued). Pacification tactics in Tonquin.

December 11.—Electrical transmission through space without any intermediate conductor.

December 18.—The new Chalais-Meudon dirigible balloon.

J. W. R.

La Marine Française.

November 27.—The Coloniale army. The Russian naval manœuvres.

December 4.—Mathematical pointing. Preface to the discussion of the Washington conference upon moderate speed.

December 11.—The Franco-Russian and English fleets compared.

December 18.—Auxiliary dispatch boat cruisers. The marine budget.

J. W. R.

Journal de la Marine, Le Yacht.

No. 765.—The national marine.

No. 766.—The cruiser *Olympia*, U. S. Navy. The navies of the world (from Broad Arrow).

No. 767.—The marine budget. The navies of the world.

No. 768.—The use of heavy oils for fuel in the Navy. Electrical launches.

No. 769.—The national marine work in the marine arsenals.

No. 770.—The English navy. Ideas on the electric propulsion of boats. The navies of the world. English torpedo vessels.

No. 771.—English cruisers.

No. 772.—The new constructions in the Arsenals at the end of 1892.

No. 773.—Trials of the *Capitan Prat* (artillery and speed).

J. W. R.

Revue d'Infanterie.

DECEMBER.—Treatise on the exercises and manœuvres of infantry. History of infantry in France. The Russian army. Chapter VII (artillery). Our cavalry. J. W. R.

Revue Militaire Universelle.

Tactics applied to the terrain. Explosives. Information upon small arm cartridges. The Dahomeyan Expedition of 1890. The Chaplain of St. Cyr. In Algiers. J. W. R.

Mémoires de la Société des Ingénieurs Civils.

Revue Militaire Suisse.

JUNE.—A reform in the instruction of our cavalry. Supplement—Report for 1891 on the administration of the federal military department.

AUGUST.—Fortification of the passage of Luzienstieg. The French manœuvres.

OCTOBER.—General organization of the army corps.

DECEMBER.—Military budget for 1893. J. W. R.

Memorial de Artilleria.

SEPTEMBER.—Applications of electricity to artillery, by D. Severo Gómez Nuñez, Captain of Artillery (continuation).

The author in this article treats principally of the collection of electrical apparatus exhibited at the Moscow exposition by Messrs. Sautter Harlé and Co. He mentions a continuous current lamp for light-house work which embodies steadiness of light and freedom from oscillations inherent in alternating currents.

Motors and dynamos were divided into three groups.

1. Those of highest potential coupled direct to a fifteen H. P. engine used for illuminating warships.

2. Those in which the dynamo is coupled direct to a compound vertical engine, and intended for use in torpedo boats.

3. Those of smaller size for smaller class of torpedo boats. All these different models light lamps within and projectors from 30 to 40 cm. without and are also used for signaling.

The writer further considers the present necessity for electric light in the proper equipment of a fortified place, not only for the purposes of war but for the thorough drill and preparation for the same. His argument is to the effect that the electric current is essential for signaling, illumination and searching by night, and for pointing the guns and working the range-finders by day. He maintains that it is not judicious on account of expense, to curtail these auxiliaries, that the pieces must be pointed and handled so as to elicit the greatest possible return, that he who has to direct the guns, receive the hostile fire and repel it, must avail himself of all possible auxiliaries, and that he who does not have light in his magazines and over the field of fire at night will not be equal to the emergency.

Coast artillery. Warships (continuation).

A review and comparison of English, French and United States vessels, and their relation to coast artillery.

Modern small arms and their ammunition (continued). Our arm in the East Indies (continuation). Note on the energy absorbed by friction in the bore of a gun.

Translation of Captain Noble's paper.

OCTOBER.—Scheme for the assimilation of classes of guns for the service of modern siege and fortress artillery.

In the paper the author brings forth a plan for simplification in the nomenclature and a general correlation of the corresponding parts in different classes of artillery. He holds that in all cases where the corresponding parts can be made alike and of the same material they should be made so.

NOVEMBER.—The most suitable period for practical instruction and exercises. Study upon a single fuze for our artillery. A target with an electric bell. A few thoughts relative to the probable perturbating causes in the determination of initial velocities with the Bréger chronograph. J. W. R.

Revista Cientifico Militar [Barcelona].

NOVEMBER 15.—The Spanish American Military Congress. The health of the soldier. The manœuvres of 1892 (continued).

DECEMBER 1.—The 6-mm. gun. The initiative in tactics Metallic bridges. Abridged ballistics (continued).

DECEMBER 15.—The manœuvres of 1892. J. W. R.

Boletin del Centro Naval. Vol. IX.

MARCH AND APRIL.—*Nautilus,* of the Spanish Royal navy. Plan for a swift cruiser.

An analytical discussion of the problem to construct a vessel that will have a speed of 22 knots with forced draught and 18 knots with natural draught (continued in June).

JUNE.—The national dynamite factory. Trials of a 75-mm. gun manufactured by shops of Creusot. Cruiser *Patagonia.* H. M. S. *Resolution.* Torpedo despatch-boats (continued in July).

JULY.—Material of the 15-cm. R. F. gun, 45 calibers, Schneider system.

AUGUST AND SEPTEMBER.—Comparative study of the material of 15-cm. rapid fire guns.

Consists in a comparative description of the four systems of rapid fire guns. Canet, Armstrong, Krupp and Schneider, translated from *Le Génie Civil*, also appeared in *Engineering*.

Squadron Evolutions, 1892.

Treats of the orders given for the instruction of the squadron, consisting of manœuvre and use of torpedoes.

Reports of chiefs of squadron and torpedo divisions. Tactics of torpedo vessels. J. W. R.

Circulo Naval, Revista de Marina [Valparaiso].

NOVEMBER 30.—Our last squadron of manœuvre and questions pertaining to it (second part). European navies. General instruction for officers in charge of the electrical and torpedo branches. Organization of the naval personnel of the principal maritime powers of the globe. A vocabulary of powders and explosives. The great war of 1892, a prophecy (by Lord Salisbury).

Revista Militar [Lisbon].

Revista Maritima Brazileira.

NOVEMBER.—The warship and naval war. Powders and explosives. The construction of forts.

Archiv fuer die Artillerie-und Ingenieur-Offiziere des Deutschen Reichsheeres.

SEPTEMBER.—Laws regarding twist; an illustration as to how to obtain the kind of twist, including an essay in regard to the use of variable twist, by Lieutenant Colonel Von Scheve. Inspector of the 2nd Artillery Inspection Depot.

In relation to the velocity of rotation of oblong projectiles and the determination of the most advantageous length of twist. from an essay by N. Zaboudski, Professor at Michael Artillery Academy, St. Petersburg, and Captain of the Russian Artillery Guard. H. C. S.

Mittheilungen ueber Gegenstaende des Artillerie-und Genie-Wesens. 9th and 10th Number.

The behavior of steel and iron when subjected to low temperatures, with special reference to the construction of steel "laffetten." An essay on the Electrical Exhibition at Frankfort A. M., 1891.

A full description is given, among many others, as to the methods employed in transmitting electric power from Laufen to Frankfort, a distance of 108.74 miles.

Experiments carried on with different kinds of armor plates, at Annapolis. Horse shoes made out of aluminum, in Russia. A full description of the Souchier range-finder (with plates).

H. C. S.

Jahrbuecher fuer die deutsche Armee und Marine.

OCTOBER.—A composition giving the details of the siege of Thionville in November, 1870, from the diary of one of the German officers present. Work to be done by torpedoes when attacking and when defending bodies of water. The Russian Empire on the Pontus and the oriental question, by Otto Wachs. The theory in regard to military riding instructions.

H. C. S.

Internationale Revue ueber die Gesammten Armeen und Flotten.

Allgemeine Schweizerische Militaerzeitung.

SEPTEMBER 3.—Austrian regulations in regard to target practice. About the practicability of using the absolutely best form for projectiles and the results to be attained thereby.

The writer demonstrates the practicability and points out the importance of having the projectiles ogival "based" as well as ogival "headed."

SEPTEMBER 10.—Extracts from Dragomirow's report of his inspection of the field exercises in July and August, 1891.

SEPTEMBER 17.—A study of army corps, chiefly as regards their composition (continued). Cavalry swimming across rivers.

A translation from the "Revue de Cavalerie," February number, 1892 (continued).

SEPTEMBER 24.—Use of cavalry in future wars. H. C. S.

Marine Rundschau.

Mittheilungen aus dem Gebiete des Seewesens.

Militaer Wochenblatt.

Militort Tidsskrift.

The Journal of the Royal United Service Institution.

SEPTEMBER. Magazine rifles, their latest developments and effects. Saddles. Color blindness. Torpedo-net defenses. The military situation in upper Egypt. Cavalry swimming. Comparison of the most important regulations of the four continental powers, as regards the attack and defense.

OCTOBER. Annual reports upon the changes and progress in military matters during 1891. The French Naval Manœuvres (1892). The field-gun of the future.

NOVEMBER. German Divisional Cavalry. General Jarras. The Russian Navy. A long distance ride. Regulations for mobilization for home defense regular force.

DECEMBER. The strategic positions in the Mediterranean. The magazine rifle question. A field firing exercise with all arms, in the XIV German Army Corps. Recent works by Captain Holnig. A short account of the French Marine Infantry.

J. W. R.

Journal of the United Service Institution of India.

Aldershot Military Society.

Proceedings of the Royal Artillery Institution.

SEPTEMBER. Fire discipline, its necessity in a battery of horse or field artillery and the best means of securing it. Skill at arms. Mountain artillery progress. Achievements of field artillery.

OCTOBER. The United States Military Academy. "I" Troop Royal Horse Artillery at the Battle of Fuentes D'Onore. Fire discipline, its necessity in a horse or field battery and the best means of securing it. Achievements of field artillery.

NOVEMBER. Fire discipline, its necessity, etc. Mounting hydro-pneumatic disappearing guns. Achievements of field artillery.

DECEMBER. The Sudan, past and present. Fire discipline and skill at arms. Achievements of field artillery.

Engineering.

SEPTEMBER 23. Modern United States Artillery No. XXV (continued). The national gun factory (Figs. 504 to 511).

Under this head is given a brief description of the gun shops, and in detail the manufacture of an 8-inch breech-loading steel rifle under—1. Operations before shrinkage, (*a*) the tube; (*b*) boring; (*c*) assembltng of the tube and jacket; (*d*) assembling the hoops. 2. Operations after assembling. 3. Table XLIII, presented and actual shrinkage in assembling guns. (*a*) First shrinkage. (*b*) Second shrinkage.

H. M. Battle-ship *Ramillies* in course of construction.

OCTOBER 21. Canet quick firing guns.

NOVEMBER 11. The cost of electric supply. Two new British battle-ships.

NOVEMBER 18. H. M. S. *Vulcan*. J. W. R.

The Engineer.

NOVEMBER 4. The Vickers-Harvey nickel plate at Portsmouth.

NOVEMBER 11. The Brown segmental wire-wound gun. Her Majesty's first class battle-ship *Howe*.

NOVEMBER 18. The Vickers-Harvey armor plate.

This article shows a half tone photograph of the effect of five 6″ Holtzer projectiles upon the plate. The plate apparently stood the test well. In the word of the text "it looks practically nearly as strong and stiff as before the attack."

The Argentina twin screw armor clad *Libertad*. H. M. S. *Revenge*.

NOVEMBER 25. Factory driving by electricity.

DECEMBER 9. Breech-loading rifled mortars for the United States Government.

DECEMBER 16. Notes on the recent Russian plate trials.

Data and description of experiments given. Illustrated by ten cuts showing the development and results of the trial.

J, W. R.

The United Service Gazette.

SEPTEMBER 17. The late naval manœuvres (mining and countermining at Belfast).

September 24. Artillery fire discipline. Our position in the Mediterranean and our navy.

October 1. The next naval war.

October 8. Continental methods of attack. The lessons of the Chilian War.

October 15. The French Fleet in the Mediterranean. Naval supremacy.

October 22. Professor Hebler on the best possible form of bullet. Continental methods of defense.

October 29. The Russian Navy. The torpedo net.

November 5. Mobilization for home defense. Torpedoes and torpedo craft.

November 12. Our naval deficiencies.

November 26. The *Militär-Wochenblatt* on public opinion and the coming war I (continued).

December 31. Progress in French shipbuilding.

J. W. R.

The Army and Navy Gazette.

September 17. Field artillery practice. Torpedo boat catchers.

September 24. The study of naval war.

October 1. The French Naval Manoeuvres.

October 15. Lord Roberts and the Royal Artillery.

October 22. The Russian Naval Manoeuvres.

October 29. The staff college. The next naval programme.

November 5. British and foreign ordnance.

A reply to the recent articles in *Engineering* which treated of the Schneider system of R. F. guns and comparisons with other systems. The article is devoted to consideration of statements made by Schneider & Co., and correction of erroneous statements made by them in reference to Armstrong guns.

November 12. The Harveyized armor plate.

November 19. Specialists in the Royal Artillery.

J. W. R.

Journal of the American Society of Naval Engineers.

November. An analysis of the results of the experiments made on the paddle-wheel Steamer *Ville de Douvres*. Speed trials.

Influence of shock on propeller efficiency. Tests of riveted joints at the Watertown Arsenal. Coal endurance and machinery of the new cruisers. Boilers and their determination. The marine engine. The elimination of sulphur from iron. Bending tests of steel. Notes.

Proceedings of U. S. Naval Institute.

No. 63. First aid to the injured and transportation of the wounded.

Journal of the U. S. Military Service Institution.

NOVEMBER. Guns and forts. Queries on the cavalry equipment. Artillery service in the rebellion. The field gun of the future. Abstract of lectures on explosives.

Journal of the U. S. Cavalry Association.

The Army and Navy Journal.

OCTOBER 8. The evolution of the naval officer. The new army gun.

OCTOBER 15. The detachable ram. Sail power for our new navy.

NOVEMBER 5. Whale-backs as monitors. Army ordnance work.

NOVEMBER 26. The Woodbridge wire wound guns. The Naval Bureau of Ordnance.

DECEMBER 17. Small arm projectiles, past and present. Report of the Secretary of the Navy.

DECEMBER 24. The state troops at Buffalo. Smokeless powder and magazine rifles.

The Army and Navy Register.

NOVEMBER 19. The lance for the cavalry.

NOVEMBER 26. Commodore Folger's report.

DECEMBER 3. Testing an armor plate.

DECEMBER 10. The lake naval question again. Bureau of steam engineering.

DECEMBER 24. Proposed scheme for test of the pneumatic guns of the *Vesuvius*.

Cassier's Magazine.

JULY. Ship building in America.

A highly interesting and valuable article, with description and many illustrations of the ship-yard and machinery at Newport News, Virginia.

Direct connected engines (continued).

Fully illustrated article showing different types of engines connecting directly with dynamos.

Electrical equipment of modern war-ships II.

An article by Lieutenant Hamilton Hutchins, U. S. Navy, in which he shows the numerous advantages of electricity over other sources of power for many purposes on warships.

SEPTEMBER. Modern methods of quarrying.

This is an article devoted principally to modern methods of drilling with view of producing the least waste in the stone when blasted.

Hammersley's United Service.

OCTOBER. I Methods of marching.

In the author's mind (Captain H. R. Brinkerhoff, 15th Infantry) there are two methods of marching; the one in which officers and men know nothing of their destination or the object in view, the other in which all as far as possible possess such information. The former is bad the latter is good. While admitting the absolute necessity for forced marches with infantry under heavy burdens, he presents a strong sensible argument for making them no oftener than necessary, and for lightening the burden whenever possible.

III Europe in 1890-91 (continued). The coming revolution in tactics and strategy (from the *Contemporary Review*).

An argument tending to show that the adoption of smokeless powder marks an epoch in tactics and strategy, and that the first week's fighting in the next great European War will show that a new departure must be made. The weight of the argument inclines to the defensive, claiming that all recent changes in weapons and material will be to the advantage of the defense. It is further maintained that there is nothing in either the offensive or defensive which gives the one or the other a moral advantage, but that this consideration shifts from one to the other as experience establishes superiority in war.

NOVEMBER. I Wanted a defensive policy.

A paper giving an argument in favor of a large and efficient navy, and a more liberal policy in regard to the acquisition of coaling stations and possessions, especially in the West Indies and Sandwich Islands. The value to the United States of the South American and China trade are brought out in a clear and interesting manner.

December. I A plea for seamanship. II A cavalry raid.

The Iron Age.

October 6.—Making great guns. Test of an Ellis-Tresidder compound armor plate. Torpedo boat No. 2 nearly completed.

October 20.—Electric motors in a machine shop.

Treats of the introduction of electric motors into the new shops of De La Vergne Refrigerating Machine Co., at the foot of 138th Street, New York. This interesting article is fully illustrated and treated under the following heads:—Erection of the shop building; heating; fire protection; equipment; appliances; machines driven by electric motors; wiring; the motors; the power required; general advantages; tests.

Elimination of S. from iron.

November 24.—The Morgan mortar mounting.

December 15.—The turrets of battle ships.

December 29.—A French steamship mobilization trials.

Scientific American.

September 17.—A submarine search light.

October 1.—German military balloon apparatus.

October 29.—Improved armor plates.

November 12.—A remarkable warship.

A description of the English battle-ship *Ramillies*, with armament, dimensions, and other important data.

Engines of a modern battle-ship. Data of battle-ships given in tabular form.

November 19.—Fast torpedo boats. The Gathman torpedo.

November 26.—A recent projectile trial. Large dynamo for direct driving.

December 3.—Loss of a great ship of war (Howe).

December 10.—Improved armor plate planing and slotting machine.

December 17.—The astounding military force of Europe.

December 24.—Progress of our navy.

December 31.—Smokeless powder. The new army magazine rifle.

The Engineering Magazine.

October.—How electricity is measured.

November.—Relative cost of electricity and gas.

The Railroad and Engineering Journal.

OCTOBER.—The dynamite cruiser *Vesuvius*. A new English battle-ship *Barfleur*.

NOVEMBER.—Electricity in welding and metal working. Cruiser *Olympia*.

DECEMBER.—The first light ships with electric light. The new breech-loading mortars.

The Engineer (N. Y.).

DECEMBER 10.—The position of naval engineers. Abstract of report of Bureau of Ordnance.

DECEMBER 24.—The Sims-Edison torpedo. Machinists in the navy.

Electrical Review.

NOVEMBER 12.—Electric torpedo boats.

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DECEMBER 10.—The Baker submarine boat.

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THEORETICAL DISCUSSION OF THE BROWN SEGMENTAL SYSTEM OF WIRE GUN CONSTRUCTION.

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For the convenience of the general reader, as well as the artillery expert, this discussion will be divided into two parts: First, what will be termed the *General Discussion*, avoiding, as far as possible, mathematics. The system will be described in detail, and the principles involved will be thoroughly discussed. Second, what will be termed the *Mathematical Discussion*, in which the claims made in the general discussion will be verified by mathematical formulæ.

The first part will be complete in itself, and the general reader will lose nothing by omitting the second part.

GENERAL DISCUSSION.

The Brown Wire Gun consists essentially of a segmental core wound with wire under such tension that the compression between the longitudinal segments of the core induced thereby will be more than sufficient to resist all ordinary powder pressure.

The longitudinal segments are primarily held together by a breech and muzzle nut, screwed on hot, with the proper degree of shrinkage, so that the tension of the nut and adjoining wire will be the same after winding.

The wire is wound between the nuts under a high degree of tension and anchored by a special device.

The trunnions are not attached to the core or body of the gun, but to an outer trunnion jacket, which jacket is attached to the gun proper by means of the breech nut. The breech block engages in a bushing which is screwed into the trunnion jacket. By this means the recoil is transmitted to the trunnions through the bushing, and jacket; and the core or body of the gun is thus relieved from the major part of the longitudinal thrust due to powder pressure upon the bottom of the bore. The gun itself is free to expand longitudinally within this jacket, which is attached only to the breech nut.

Plate I shows a longitudinal section of the gun, and also a cross-section through the powder chamber. The general contour of the gun is shown in the several plates.

The *modern system* of gun construction consists essentially of a core or body which is placed under a condition of "*initial compression*," by means of outer jackets of some kind; which are either shrunk on, as in the case of "*built up guns*" or wound on under tension, as in the case of "*wire guns*."

This "initial compression" produces in the core or body a circumferential compression, which is a maximum at the surface of the bore.

The action of the gunpowder is first to overcome the circumferential compression at the surface of the bore, and then to stretch the inner core or tube.

The action of the gunpowder is first to stretch the outer jacket, and compress the metal of the core, and after the initial compression has been overcome to stretch the core or inner tube, at the same time increasing the compression.

If the powder pressure is of such magnitude, that either the outer jacket, or core, is stretched beyond its elastic limit of extension, or the inner tube compressed beyond its elastic limit of compression at the surface of the bore, a permanent set will be given to the metal, at some point; and on being released from the powder pressure, the gun *will not* return to its original condition and dimension. If neither of these limits are exceeded, the gun will return to its condition before firing, when relieved of pressure.

In this paper the term *elastic strength*, will include both of these limits. The elastic strength of any part of the system is its power under the particular conditions to resist, being either stretched or compressed, beyond its elastic limit. It is manifest that neither of these limits can be exceeded in action.

A gun constructed under the modern system will stand the powder pressure which will produce at the surface of the bore a circumferential stress equal to the "initial compression" at that surface, plus the elastic strength of the inner tube, provided that the radial pressure is not greater than the elastic limit for compression, or more properly a certain function of that limit depending upon the dimensions of the gun. And further provided that the stress upon the outer jacket does not exceed its elastic strength.

The *circumferential stress* produced by powder pressure at the surface of the bore, is a function of the radial pressure, the radius of the bore, and the exterior radius of the gun, at the point considered (see mathematical discussion).

It is evident that three conditions are essential in such system of construction:

First.—The *outer jacket* must be strong enough to stand the circumferential strain produced by the powder pressure.

Second.—The core or body of the gun must have sufficient elastic strength to stand the tension of winding.

Third.—The entire system must have sufficient longitudinal strength to resist not only rupture but also any permanent elongation.

The enormous elastic strength of steel wire naturally drew the attention of gun constructors to its value as a material for the outer jacket. As steel wire can be manufactured that will have an elastic strength of 200,000 lbs. per inch, an outer jacket could not be stretched beyond its limit of elasticity by powder pressure.

Many attempts have been made to use wire for the outer jacket of guns. In this connection, however, there is one serious difficulty to be overcome. A solid outer jacket has longitudinal strength; whereas, a wire jacket of itself has none. Now the area of cross-section of the core or body of a properly constructed wire gun, is about one-half of that of a solid "built up gun" of the same dimension; and about two-thirds of the thickness of the metal of a large "built up gun," can be utilized for longitudinal strength. The entire core of a wire gun, being in one piece, can be so utilized. Therefore, where the metal of the core or body of a wire gun has the same elastic strength as the metal of the "built up gun," the longitudinal strength of the wire gun is but three-fourths of that of the "built up gun."

Longridge proposed to meet the difficulty by using longitudinal ribbons or bars either between the wire and the core or between the layers of wire. This will, of course, give some longitudinal strength to the outer jacket. There is, however a practical difficulty in the way of its value as a satisfactory solution of the problem, viz.: the mechanical impossibility of giving to each ribbon the same tension; the result being that during action they will be stretched one by one beyond their elastic limit.

Longridge has lately devised and patented a most admirable system, by means of which the greater part of the longitudinal thrust is taken up by an outer jacket, which is attached to the gun at but one point.*

Doctor Woodbridge endeavored to solve the problem by brazing the wire into a solid mass. As this system proved a failure, it need not be discussed here.

In Doctor Woodbridge's latest patent he proposes to place longitudinal bars about his inner solid core, and then wind with wire. Exactly how these bars differ from Longridge's ribbons

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* Mr. Longridge has taken exception to the statement that the use of longitudinal ribbons or bars was his device, affirming that the idea was suggested by others. Finding this plan set forth in the description of his patents I assumed that it was his own idea. I am aware that Mr. Longridge has not used this method, and I have spoken of it on several occasions merely to show that Dr. Woodbridge's system of longitudinal bars was not novel, and is in fact practically the same idea.

Mr. Longridge also takes exception to certain statements which originally came from me, that would seem to imply that I considered his wire guns longitudinally weak.

I have never intended to convey any such idea. Mr. Longridge's system has in my opinion ample longitudinal strength. This however is due to the arrangement of the several parts, and the distributions of the strains. The *wire wound tube* has not of itself sufficient longitudinal strength.

Whereas, I claim that the *segmental tube* of a Brown gun, has ample longitudinal strength *per se*, regardless of the distribution of stress and strain. G. N. W.

or bars between the wire and core, except as to size, is not perceptible. There is a theoretical and mechanical principle involved in this method of construction, where the segments form a tube; which renders the system unsound and unsafe. As, however, one of the most valuable principles of the Brown system would be involved in the discussion, we will defer it for future consideration.

Mr. Brown undertakes to solve the problem of longitudinal strength by increasing the elastic strength of the *core itself.* He *sub-divides the core or body* of his gun into *longitudinal segments* of such a size that a high condition of *special elasticity* may be set up therein and the requisite longitudinal strength be thus obtained.

By this process he can, without difficulty, *double* the elastic strength of the metal used in the core of his gun, still retaining sufficient ductility: and, therefore, although the area of cross-section of the core of his gun is but one half of that of a solid "built up gun," the gun will have one and one-half times the longitudinal strength, as the metal has double the elastic strength of that used in the "built up gun."

But in order to do this does he not sacrifice the circumferential elastic limit for extension of his core? True, but as at the same time he can double the elastic limit for compression of the metal he can wind with twice the tension; and, therefore, double the initial compression at the surface of the bore.

The system will, therefore, stand a greater powder pressure; as twice the compression is more than the compression plus the elastic strength of the inner tube of a "built up gun," constructed of a metal having one-half the elastic strength.

In order to demonstrate the truth of this statement let us compare the elastic strength of a "built up" cylinder of one caliber thickness of metal; elastic limit of metal twenty-five tons per square inch; with a wire wound segmental cylinder of the same dimensions: elastic limit of segmental core fifty tons per square inch; and "initial compression" at surface of bore fifty tons per square inch.

BY BIRNIE'S FORMULÆ.

Built up Cylinder.

Powder pressure which will exceed elastic limit for extension . . . . = 31.5 tons per sq. in.
Powder pressure which will exceed elastic limit for compression . . . . = 23.5 tons per sq. in.
Maximum safe powder pressure . . . . . . = 23.5 tons per sq. in.

Segmental Wire Cylinder.

Powder pressure which will reduce compression to zero . . . . = 31.5 tons per sq. in.
Powder pressure which will exceed elastic limit for compression . . . . = 47.0 tons per sq. in.
Maximum safe powder pressure . . . . . . = 31.5 tons per sq. in.

This marked difference in the two systems is due to the fact, that in the "built up" system you cannot carry the powder pressure to the point where the elastic limit for extension is passed; as, before reaching this point, you will have compressed the inner tube beyond its elastic limit for compression. Whereas in the segmental wire system the pressure required to reduce the compression at the surface of the bore to zero is always less than that required to overcome the elastic limit for compression (see mathematical discussion).

In any gun the maximum safe value of the powder pressure must not exceed about sixty-three per cent. of the compression plus the elastic limit for extension, nor ninety-four per cent. of the elastic limit for compression. In order to determine the maximum safe powder pressure, we must determine which is the least of these two values. The above figures are for a gun in which the minimum thickness of metal over the maximum powder pressure is one caliber.

For steel we may consider the two elastic limits as equal. In all guns the compression is made equal to the elastic limit.

In built up guns, therefore, the two values are sixty-three per cent. of twice the compression and ninety-four per cent. of the compression. Of course, the latter is the smaller, and therefore the maximum safe value of powder pressure.

In the Brown segmental wire gun the core has no elastic strength for circumferential extension; the two values are sixty-three per cent. of the compression and ninety-four per cent. of compression: the former is, of course, the smaller value. If, however, we can double the elastic limit, we can use double the compression, and therefore the maximum safe value of the powder pressure for Brown segmental wire gun will be to that of the built up gun as one hundred and twenty-six is to ninety-four.

I will now show that the claim that the segmental tube can be constructed of a steel having twice the elastic limit of that used in built up guns, is entirely within the actual results obtained.

The physical conditions demanded by the government for sea-coast guns is shown by the following tables, taken from the report of the Chief of Ordnance of 1889, page 254, being a part of the specifications for steel forgings for 8, 10 and 12-inch guns, under Act of September 22, 1888.

These tables undoubtedly show the best conditions obtainable in large forgings from O. H. steel. Table I gives dimensions of specimens.

TABLE II.

"Each of the test specimens should show physical qualities given in the following table No. II, which the manufacturer should aim to obtain."

Caliber of Cannon.	Designation of pieces.	Elastic limit. Lbs. per sq. in.	Tensile strength Lbs. per sq. in.	Elongation after rupture.
Sea-coast, 8-in. . .	Tube,	46,000	86,000	19 per cent.
	Jacket,	50,000	93,000	17 per cent.
Sea-coast, 10-in. and over	Tube,	46,000	86,000	19 per cent.
	Jacket,	48,000	90,000	17 per cent.

TABLE NO. III.

"The forgings shall, however, be accepted as to physical qualities provided no one of the specimens shows results in any particular below the figures given in the following table No. III."

Caliber of Cannon.	Designation of pieces.	Elastic limit. Lbs. per sq. in.	Tensile strength. Lbs. per sq. in.	Elongation after rupture.
Sea-coast, 8-in. . .	Tube,	42,000	78,000	17 per cent.
	Jacket,	46,000	85,000	16 per cent.
Sea-coast, 10-in. and over	Tube,	42,000	78,000	17 per cent.
	Jacket,	44,000	83,000	16 per cent.

TABLE NO. IV.

"Except that one, and only one specimen, from each end may be in any one particular lower in its qualities than the figures given in Table No. III, but must not be, in that particular, lower than the figures given in the following table No. IV."

Caliber of Cannon.	Designation of pieces.	Elastic limit. Lbs. per sq. in.	Tensile strength. Lbs. per sq. in.	Elongation after rupture.
Sea-coast, 8-in. . .	Jacket,	44,000	83,000	14 per cent.
Sea-coast, 10-in. and over	Tube,	40,000	75,000	15 per cent.
	Jacket,	42,000	80,000	13½ per cent.

All the specimens considered in the above tables were to be 0".564 in diameter and three inches between shoulders.

Now compare the physical conditions as above required by the government, with those actually obtained in the twelve segments of the experimental 5-inch Brown wire gun, now being constructed.

Number of segment.	Position of Specimen.	Elastic limit. Lbs. per sq. in.	Tensile strength. Lbs. per sq. in.	Elongation after rupture.	Ratio of E. L. to T. S.
1.	Breech,	106,892	174,317	14 per cent.	61 per cent.
1.	Muzzle,	105,000	178,468	15 per cent.	56 per cent.
2.	Breech,	115,115	185,993	13 per cent.	62 per cent.
2.	Muzzle,	100,985	177,139	14 per cent.	57 per cent.
3.	Breech,	111,486	180,673	15 per cent.	62 per cent.
3.	Muzzle,	102.300	160,875	18 per cent.	64 per cent.
4.	Breech,	108,207	172,475	14 per cent.	64 per cent.
4.	Muzzle,	100,000	173,408	12 per cent.	58 per cent.
5.	Breech,	104,000	167,200	15 per cent.	62 per cent.
5.	Muzzle,	106,713	164,542	16 per cent.	65 per cent.
6.	Breech,	103,596	169,021	14 per cent.	61 per cent.
6.	Muzzle,	117,950	191,450	11 per cent.	62 per cent.
7.	Breech,	101,649	181,656	13 per cent.	56 per cent.
7.	Muzzle,	113,995	190,535	13 per cent.	60 per cent.
8.	Breech,	116,878	184,092	12 per cent.	63 per cent.
8.	Muzzle,	107,392	184,580	14 per cent.	58 per cent.
9.	Breech,	113,470	192,735	12 per cent.	59 per cent.
9.	Muzzle,	116,100	178,849	14 per cent.	65 per cent.
10.	Breech,	114,878	180,975	13 per cent.	63 per cent.
10.	Muzzle,	109,626	166,100	14 per cent.	66 per cent.
11.	Breech,	115,885	195,349	14 per cent.	59 per cent.
11.	Muzzle,	105,000	179,000	14 per cent.	59 per cent.
12.	Breech,	105,248	178,921	14 per cent.	59 per cent.
12.	Muzzle,	100,000	160,891	12 per cent.	62 per cent.

Specimens taken from breech and muzzle end.

Length between shoulders two inches,

Diameter 0".618.

The conditions adopted as a standard are as follows:

Tensile strength not less than 160,000 lbs. per sq. in.
Elastic limit not less than 100,000 lbs. per sq. in.
Elongation not less than 12 per cent.
Elastic limit not to exceed 63 per cent. of tensile strength.

In consequence of the crude method of hardening and annealing, which we were obliged to use, the following tolerances were adopted:

First.—A segment would be accepted when the ratio of the elastic limit to tensile strength exceeded 63 per cent. in any one specimen, provided the elongation was 14 per cent. or over.

Second.—An elongation as low as 10 per cent would be accepted provided the elastic limit exceeded 115,000 lbs. per sq. in. and the ratio did not exceed 63 per cent.

The above conditions we found to be well suited to chrome steel, giving us a very tough and elastic material.

By the above comparison it will be seen that Mr. Brown will use in his 5-inch gun a steel which has more than double the tensile strength and elastic limit of that used in "built up guns," at the same time obtaining sufficient ductility to ensure ample toughness.

As the minimum elastic limit is 100,000 lbs. per sq., in. we can wind so as to produce a compression at the surface of the bore of 100,000 lbs. per sq. in.

Considering the case of a gun in which the minimum thickness of metal over maximum powder pressure is one caliber, we have—

63 per cent. of 100,000 = 63,000.
94 per cent. of 100,000 = 94,000.

Therefore the maximum safe powder pressure for such a gun would be 63,000 lbs per sq. in.

The two cylinders which have been tested had a thickness of metal of one caliber, they stood the following pressures without injury:

No. 1, 57,220 lbs. per sq. in.
No. 2, 68,000 lbs. per sq. in.

In the 5-inch gun the minimum thickness of metal over the maximum powder pressure is somewhat less than one caliber; the factor being 60 per cent. instead of 63 per cent., therefore the maximum safe powder pressure is 60,000 lbs. per sq. in. We do not, however, expect ever to exceed 53,000 lbs. per sq. in. in practice. This will give a muzzle velocity of about 2600 ft. sec. with brown prismatic powder.

Attention is called to the reports of trials of the test cylinder, appended hereto.

The 5-inch Brown gun is one caliber thick, about eighteen inches from the bottom of the bore, i. e. from the face of the De Bange gas check.

A "built up gun" one caliber thick at any point over the maximum pressure would be one caliber thick over the entire maximum pressure. Constructed of steel, having for the tube an elastic limit of 46,000 lbs. per sq. in., which is the maximum government requirement for high pressure guns; it would be compressed to 46,000 lbs. per sq. in. at the surface of the bore.

63 per cent. of $2 \times 46{,}000 = 57{,}960$.

94 per cent. of $46{,}000 = 43{,}240$.

Maximum safe powder pressure equals 43,240 lbs. per sq. in. Using Clavarino's method of calculation, the elastic strength of such a gun would be 52,000 lbs. per sq. in.

Captain Birnie claims 56,000 lbs., per sq. in. as the elastic strength of the 8-inch B. L. Rifle No. 1, this is by Clavarino's method of calculation; by his own method it would be about 48,000 lbs. per sq. in.; the thickness of metal over powder chamber being about 1.1 calibers. This gun has been tested to 46,300 lbs. per sq. in.

It should be remembered, however, that there is a vast difference between the elastic strength of a "built up gun" and the maximum safe powder pressure of a Brown segmental wire gun. In the former case if you exceed the elastic strength of the gun you give the metal a permanent enlargement. In the Brown gun you merely reduce the compression at the surface of the bore to zero. The pressure which should reduce the compression to zero at the surface of the bore in Test Cylinder No. 2, is 63,654 lbs. per sq. in., the cylinder has sustained a pressure of 68,000 lbs. per sq. in., without showing the slightest enlargement.

To distort the segmental tube of the 5-in. Brown gun would require a pressure of 94,000 lbs. per sq. in., being beyond the possibilities of gunpowder. To distort the lining tube, will require a pressure equal to 94 per cent. of its elastic limit. The probable elastic limit obtainable in lining tubes will be discussed further on. However as it is hardly probable that a breech mechanism will ever be devised, a carriage ever constructed, or a projectile ever be forged, which will stand 60,000 lbs. pressure per sq. in., it is waste of time to discuss these excessive theoretical pressures.

We will now consider the point suggested in connection with Dr. Woodbridge's later system. Longitudinal stress in a gun may be divided into two parts: that which is due to the pressure upon the bottom of the bore, and that which is due to the radial compression of the inner tube between the powder gas and the outer jacket.

In the Brown system the former is transmitted to the trunnion jacket through the breech nut, the trunnions being in no way attached to the segmental tube (see Plate I). The segmental tube being required to take up only that longitudinal thrust due to compression between the powder gas and wire jacket plus that due to friction of the shot in the bore. Furthermore, as the trunnion jacket does not touch the segmental tube nor even the wire, and as there is a slip joint between it and the chase jacket, none of the thrust taken up by the jacket is transmitted to the segmental tube by friction. It must be remembered that as the liner in the Brown gun is in two or more pieces and is not attached in any manner to the breech mechanism it can do but little towards resisting longitudinal thrust. In calculating longitudinal strength the value of the liner has been practically ignored.

Now in Dr. Woodbridge's system it is manifest that the initial compression at the surface of the bore can never exceed the elastic strength of his inner solid tube, whatever may be the elastic strength of his segmental bars. Therefore the bars cannot in any way add circumferential strength to the gun, and must be looked upon as a device merely to give longitudinal strength. If the bars are of the same modulus and elastic strength as his solid tube, the same longitudinal strength could have been obtained by simply thickening the inner tube. He must, and probably has, constructed his bars of a much higher grade of steel, in which case they merely become a part of the outer jacket. The inner tube must sustain the longitudinal thrust due to the pressure between the gas and the segmental jacket precisely as though the wire had been wound directly upon the solid tube; and therefore they do not relieve the inner tube in any way from this character of longitudinal thrust. Their chief function is therefore due to the fact that the trunnions are attached to these bars. In other words Mr. Brown puts his trunnion jacket on the outside of the wire, and Dr. Woodbridge puts his between the wire and the inner tube. But in this manner of construction there is an enormous condition of friction between this segmental jacket and the inner tube; and therefore the inner tube will necessarily take up some of the thrust upon the breech block; in fact its due proportion depending upon the relative area of cross-section of inner tube aud segmental jacket. The inner tube of a Woodbridge gun will therefore be called upon to sustain a much greater longitudinal thrust than the segmental tube of a Brown gun, when it cannot possibly have as great an elastic strength and must necessarily be made thinner for a given sized gun. The inner tube of the Woodbridge 10-inch gun is understood to be two inches thick throughout its entire length. The segmental tube of a Brown 10-inch gun would be six inches thick at the breech, tapering to two inches at the muzzle.

There is a very important mechanical objection to the Woodbridge system. It is practically impossible to obtain a number of segments with exactly the same physical conditions. When such segments are formed into a cylinder and wound under tension some of them will be distorted more than others; the bore will be unevenly contracted and will not be anywhere near a true cylinder. Now Dr. Woodbridge is attempting to place a segmental cylinder over a solid cylinder and to wind *both together*, the result will be that the normal pressure on the surface of the inner tube will be far from uniform and, in fact, there may be places where the surface compression is zero.

Mr. Brown also uses an inner solid liner, but he first winds his segmental core and after the winding is complete, he bores it out on a taper, and inserts the liner by hydraulic pressure, thus ensuring a true fit and uniform compression. The proposed method will probably be interesting. The gun having been wound, will be bored to caliber, and the breech action fitted. The gun will then be *fired* in its unlined condition several shots. The firing will jar the segments into position, and even up the tension throughout the entire system. The gun will then be bored on a taper, and the liners inserted by hydraulic pressure. The lined gun will then be bored to a diameter slightly less than the caliber, and in this smooth bore condition will be fired up to, and beyond the *maximum pressure* which the system is expected to stand during action. Heavy projectiles will be used so as to obtain high pressures. This will not only set the liner in position, but will determine its elastic condition for compression; therefore it can not thereafter take a permanent set, under a less compression. The gun will then be bored to caliber and rifled. It is manifest that by this process a condition of compression, and fit between the various elements will be obtained, as perfect as it is possible to produce by mechanical operations.

Such a process is, of course, utterly impossible under the Woodbridge system of construction.

It should be remembered that as the compression between the segments will not be reduced to zero during action, and as the segmental tube acts precisely as a solid tube until this compression is reduced to zero, the Brown segmental wire gun can be used without a liner. This was clearly demonstrated by the two cylinder tests, in their unlined condition. In neither case was there any radial or longitudinal displacement of the segments; nor was there any increase in the diameter of the powder chamber under high pressure. The only question which can arise, is whether there will be any tendency for scoring to follow the line of the joints between the segments. This can only be determined by actual test.

5-INCH B. L. RIFLE.

The theoretical circumferential strength of the 5-inch experimental gun is shown in plate 1. The method of calculating the curves will be discussed in the *Mathematical Discussion.* Curve C gives the *compression at the surface of the bore from breech to muzzle.*

It was desired to make this compression constant; but it can be shown mathematically that a constant rate of compression from breech to muzzle is not possible with a straight tapered core, and a straight tapered exterior of wire jacket. The constant compression was therefore sacrificed to ease of mechanical construction.

It will be noted, however, that the variation is comparatively slight. Being a maximum at the breech of 100,000 lbs. per sq. in. and a minimum fifty inches from the muzzle of 96,000 lbs. per sq. in. The minimum compression at the surface of the bore affected by the maximum powder pressure is about 99,800 lbs. per sq. in.

This *Curve C* also gives the circumferential stress at the surface of the bore necessary to reduce the initial compression to zero, at that surface.

The *Curve P* gives the maximum powder pressure which will ever be used in the gun (battering pressures), and the broken line shows the corresponding circumferential stress at the *surface of the bore.*

The *Curve Po* gives the powder pressure necessary to reduce the *initial compression* to zero at the surface of the bore.

It is manifest that theoretically the gun is amply strong circumferentially to meet these pressures. The maximum pressure is given at 52,700 lbs. per sq. in., whereas in modern high powered guns 40,000 lbs. per sq. in. is rarely exceeded.

The *Curve V* gives the velocities corresponding to the pressures of *Curve P.*

The Curve P and V were calculated by Sarrau's method, and the remaining curves by Birnie's method.

The verification of these curves will be found in the mathematical discussion.

LONGITUDINAL STRENGTH.

The theoretical longitudinal strength of the gun is shown in plate 3.

Curve L gives the longitudinal thrust upon the segments from breech to muzzle; unlined gun. Curve L′ gives the longitudinal thrust upon the segments for a lined gun, the longitudinal strength of the liner being ignored. The thrust is given in lbs. per sq. in. of area of cross-section of the segmental tube.

Curves A and B give the tensile and elastic strength of the metal of the segments.

Curve L″ gives the longitudinal thrust per sq. in. upon the trunnion jacket. Curves C and D show the tensile and elastic strength of the jacket.

The verification of these curves will be found in the mathematical discussion.

TENSION OF WINDING.

There is no one point upon which we have received so much kind advice from the friends of the system, as upon that of *tension of winding.* There seems to be a widespread belief among artillerists that winding with a uniform tension is a decided mistake; and that the varying shrinkages used in the "built up gun" system is the fundamental and essential principle in that system of construction, and consequently as a wire gun is a built up gun, of a large number of very thin cylinders, that the tension should vary in each layer from the inner to the outer layer of wire. A reference to the opinion of Captain Crozier upon this subject does not seem to satisfy them: they admit that "he ought to know," but they are without doubt of the same opinion still, viz: that we are ignoring the most essential principle in gun construction.

Now primarily the principle of varying shrinkage so adjusted that under powder pressure each cylinder will work to its elastic limit at the same time, is not an *essential principle* of "built up" gun construction; but is rendered necessary in consequence of elastic weakness of the metal used.

The question is a difficult one to discuss without the aid of mathematics. We will endeavor, however, to make it clear. (A full discussion will be found in the mathematical discussion.)

If it were possible to obtain an outer solid jacket, which in its natural state was sufficiently strong to stand the maximum circumferential stress produced by the gunpowder, without taking a permanent set, it is manifest that the simplest and most inexpensive method of construction would be to build a gun of only of two cylinders: in which case the principle of varying shrinkages would not be used. As it is, however, impracticable to obtain such a jacket, gun constructors are forced to resort to a number of cylinders, and the principle of varying shrinkages.

Let us assume that we desire to construct a gun one caliber thick, which will stand a powder pressure of 45,000 lbs. per sq. in. This pressure would produce a circumferential stress at the surface of the bore of about 72,000 lbs. per sq. in.

Now if we could obtain a simple cylinder of a metal in which the elastic limit exceeded 72,000 lbs. per sq. in., it is manifest we would not have to resort to the "built up" principle at all: as our simple cylinder would have ample elastic strength to resist the pressure. Now let us assume the elastic limit of all the metal used in this gun to be but 52,000 lbs. per sq. in. In order to enable the gun to stand 72,000 lbs. per sq. in. we must produce an initial compression at the surface of the bore of at least 20,000 lbs. per sq. in. Practically we divide the gun into two cylinders and produce such a shrinkage that the initial compression at the surface of the bore shall be 52,000 lbs. per sq. in. Now of course if the outer jacket does not give away the inner cylinder will stand a powder pressure of 45,000 lbs. per sq. in. But this pressure will produce a circumferential stress at the *inner surface* of the *outer jacket* of say 62,000 lbs. per sq. in. It is manifest the outer jacket will not stand it, as its elastic limit is only 52,000 lbs. per sq. in. We must therefore produce an initial compression at the inner surface of the outer jacket of at least 10,000 lbs. per sq. in. We therefore divide in three parts, producing the proper compression, and so on until we get a system in which the circumferential stress at the inner surface of the outer jackets will be less than 52,000 lbs. per sq. in. The best possible condition, which is rarely if ever reached in practice, is to so arrange the shrinkage so that all the cylinders would under the maximum pressure reach their elastic limit at the same instant.

Now in a wire gun, if the wire be wound with a uniform tension, it corresponds *somewhat* to a single jacket: whereas when wound with varying tensions it would correspond to a "built up" system. It is not meant by this that the stresses set up in a wire jacket wound with uniform tension, are the same as those set up in a single cylinder shrunk on, but simply that the principle involved in determining which method to use is the same as in the case of a built up gun, viz:—if the wire has sufficient elastic strength a uniform tension may be used; if not a system of varying tension must be resorted to.

Plate II calculated for a uniform tension clearly shows that the wire has ample strength, and that the simpler method may be used with entire safety.

The Curves T_1 and T_2 show the tension on the inner and outer layer of wire *system at rest.* The tension on the outer layer being the tension of winding, the curve is a straight line, extending from breech to muzzle. The Curve T_1 shows how much the inner layer or wire has been slackened by winding on the outer layers of wire. The tension on all other wires, *system at rest,* of course lies between T_1 and T_2. The Curves T'_1 and T'_2 show the tensions on the inner and outer layer of wire during maximum action. The lines A and B indicate the tensile and elastic strength of the wire, as determined by actual test. It is manifest that under the maximum stress *75 per cent. of the elastic strength will not be reached.* Therefore the simplest method of winding may be used.

THE TRUNNION JACKET.

The trunnion jacket for the 5-inch B. L. rifle was made by the Bethlehem Iron Company. Tensile strength 92,409 lbs. per sq. in. Elastic limit for extension 49,916 lbs. per sq. in. Elongation after rupture in 2-inch specimen 24 per cent. Minimum area of cross-section is 55.26 sq. in. The jacket will therefore stand without taking a permanent set, a thrust of 2,758,238 lbs., and without rupture 5,160,337 lbs. The area of the breech-blook is 21.65 sq. in. A powder pressure of 53,000 lbs. per sq. in. will give a longitudinal thrust of $53,000 \times 21.65 = 1,169,100$ lbs. We therefore have an ample margin of safety, with a factor of safety for rupture of 4.4.

THE RIFLING.

It was originally intended to use an *increasing twist*; curve, a semi-cubical parabola. The late experiments in England seem so clearly to demonstrate the advantage of the *uniform twist*, that the original idea has been abandoned. A polygroove system will be used: *uniform twist*, twenty-four (24) grooves and lands. Twist, one turn in twenty-five (25) calibers. Depth of groove, 0''.05. Shape of groove similar to that of U. S. Army 10-inch rifle.

THE LINING TUBES.

The liner is not an essential feature of this system of gun construction, but is introduced for the purpose of increasing the life of the gun. The *bete noir* of modern gun constructors is scoring; and the insertion of a thin lining tube furnishes a simple method of renewing the surface of the bore of a gun, by removing a scored liner and inserting a new one; thus materially increasing the life of the gun.

In connection with the segmental system a question has arisen in which there is a difference of opinion. That is whether a segmental gun should be lined throughout its entire length or only partially. It is contended that inasmuch as scoring in modern guns does not extend more than three or four calibers in advance of the seat of the shot, that a liner extending from the bottom of the bore to about five calibers in advance of the powder chamber will be sufficient. On the other hand it is contended that a segmental tube is more likely to score than a solid tube, there being a tendency to follow the lines of juncture: and therefore that it would be wise to line from breech to muzzle. It is further contended that the tendency to score will be increased by rifling the segmental core.

The one-inch model gun was unlined and rifled—was fired under very high pressures, and no scoring was noticed, save at the *seat of the shot.* The gun, however, was not fired a great number of times.

Cylinder No. 2 when fired in its unlined condition showed a tendency to score along the lines of juncture after a pressure of 43,000 lbs. per sq. in. was reached. The reply to this fact is, that the unlined portion of the gun would never be subjected to such pressures. The problem can only be solved by actual test. At the present writing it is Mr. Brown's intention to line partially and to test the gun under high pressures; if scoring begins in the unlined bore, then to line from breech to muzzle.

While it is impracticable to obtain large cylinders of much over 50,000 lbs. per sq. in. elastic limit, it is entirely practicable to obtain thin liners not over one inch thick, with very much higher elastic conditions.

The Bethlehem Iron Company have agreed to furnish a liner for the five-inch experimental gun, with the following conditions:

Tensile strength 105,000 lbs. per square inch.
Elastic limit 60,000 lbs. per square inch.
Elongation in two inch specimens 15 per cent.

Such a liner inserted with a maximum tension will readily sustain a pressure of more than 50,000 lbs. per square inch without being over strained.

We are thoroughly satisfied that a crucible chrome steel liner can be made for any medium sized gun with an elastic limit of 100,000 lbs. per square inch, and an elongation of 14 per cent. in two inches.

If the liner be divided into two parts the breech liner could be made of crucible chrome steel, and the chase liner of O. H. steel, which would give ample elastic strength for the entire length of liner.

If a liner of 60,000 lbs. per square inch is used, it will, of course, be necessary to utilize the elastic strength for extension of the liner; if however a liner can be constructed of crucible chrome steele having an elastic strength of 100,000 lbs, per square inch, the stresses in the liner will not pass through zero during the maximum action.

CONCLUSION.

The advantages claimed for the system are as follows :

First.—By the longitudinal sub-division of the core, crucible steel can be used economically. Chrome steel can be used. A more perfect tempering is possible than in large solid tubes. A more careful and accurate inspection is possible. Small blow holes will be reduced in diameter by the forging and rolling process, and can affect only the strength of a single segment. A higher condition of special elasticity can be set up in the metal than is possible in large masses. The maximum longitudinal strength obtainable from steel can be ensured by this process of construction.

Second.—A higher initial compression can be given to the core or body of the gun, admitting of the use of higher powder pressure than is possible in the built up system.

Third.—In the Brown system the maximum strength of each portion of the gun is in the direction of the maximum stress it is called upon to bear. Neither in the core or wire jacket does the condition of stress ever pass through zero during maximum action.

Fourth.—A segmental gun can be constructed more economically than any other gun of equal power. The expense of casting, forging and rolling the segments is much less than for large solid tubes. There is practically no risk of loss, as should a segment fail after treatment to show the necessary elastic strength, it can readily be rolled into commercial steel. The amount of machining is not greater than in a built up. The expense of winding is very small as compared with that of shrinking on jackets.

Fifth.—The form, method of construction and high power of the Brown Segmental Wire Gun ensures a greater muzzle energy per ton of weight, than it is possible to obtain by any other system of gun construction now known.

Sixth.—In the case of a sudden emergency the Brown Guns can be constructed in any machine shop having a lathe of sufficient length to receive the gun.

COPY OF REPORT OF TEST OF CYLINDER NO. 2,

Trustees Brown Segmental Gun,

Gentlemen:

I have the honor to submit the following report of the trial of test cylinder No. 2, representing the chamber of the five inch B. L. Rifle now under construction.

It having been found necessary, in consequence of mechanical difficulties of construction, to reduce the number of segments of the gun from seventy-two (72) to twelve (12), it was deemed wise to construct a test cylinder and experiment with the same before assembling the gun.

In selecting the proper number of segments to be used, the principal acted upon, was to use as few segments as possible, consistent with obtaining the requisite physical conditions; thus materially decreasing the cost of construction.

The standard physical conditions adopted were as follows:

Tensile strength not less than 140,000 lbs. per square inch.
Elastic limit not less than 100,000 lbs. per square inch.
Elongation in two inches not less than 12 per cent.

The average conditions actually obtained both in the segments for the gun and cylinder were as follows:

Tensile strength, a mean of about 165,000 lbs. per sq. inch.
Elastic limit, a mean of about 105,000 lbs. per sq. inch.
Elongation in two inches about 14 per cent.

Thus showing that for a five inch gun the number of segments may be reduced to twelve.

DIMENSIONS OF CYLINDER.

Length	16.00	inches.
Diameter of bore	5.00	"
Ext. diam. of seg. tube	11.00	"
Ext. diam of wire jacket	15.34	"
Length of powder chamber	6.50	"
Volume of powder chamber	127.63	cubic inches.
Cross-section of wire, square	0".071 × 0".071.	
Tension of winding on wire	700	lbs.
Tension of winding per sq. in.	140,000	"
Tensile strength of wire	1,250	"

Tensile strength of wire per sq. in.	250,000 lbs.
Elastic limit of wire	1,000 "
Elastic limit of wire per sq. in.	200,000 "
Compression of surface of bore	100,000 lbs. per sq. in.
Thickness of lining tube	0".50 inch.

The powder pressure which would reduce the compression at the surface of the bore to zero, can be obtained as follows:

$$P, = \frac{3\,(58.83-6.25)\,100{,}000}{235.32+12.50} = 6{,}3654 \text{ lbs. per sq. in.}$$

The cylinder was fitted with an obturating plug for each end, through one of which was drilled a small vent, two-tenths of an inch in diameter. The only escape for the powder gas being through this vent.

In the first test cylinder the plugs were screwed directly into the segments. Thus the segmental tube was submitted to an enormous and long continued longitudinal stress, far greater than anything the segmental tube of the gun would ever be required to sustain. Furthermore the segments were weakened by cutting the thread to receive these plugs.

In the gun itself the breech-block will be screwed into the breech nut, and no threads will be cut in the bore of the segmental tube; and the entire longitudinal thrust upon the breech-block will be taken up by the trunnion jacket and not at all by the segmental tube. Therefore in the gun, the only longitudinal thrust which the segments will be required to sustain, is that due to compression, between the powder pressure and the wire pressure, plus that due to the friction of the shot in the bore.

In order to assimilate as near as possible to the conditions of the gun, Cylinder No. 2 was constructed as follows:

The cylinder proper is inserted into an outer jacket, and the obturating plugs are screwed into this jacket and not into the cylinder. The entire thrust upon the plugs being taken up by this jacket and not by the segments.

The only longitudinal thrust taken up by the segments, being that due to radial compression of powder and wire, plus that due to the friction of the copper gas checks, is, therefore, about the same as the maximum thrust in the gun for the same pressures.

This cylinder was fired seven times before inserting the lining tube, and has been fired fifty-seven times since.

The lining tube which is 0″.50 thick at one end and 0″.45 at the other, was constructed with four-tenths of one per cent. greater diameter than the bore and forced in. Thus producing a compression at the surface of the bore of 100,000 lbs. per sq. in. the chamber having them bored out to receive it.

It is, therefore, manifest that in order to reduce the compression at the surface of the bore to zero, a powder pressure of 63,654 lbs. per sq. in. would be required.

TEST IN UNLINED CONDITION.

Careful calibration showed the diameter of the chamber to be 5″.002 before beginning the test, the record of which is given in the following table:

No. of Discharge.	Charge of Powder. lbs. oz.	Density of Loading.	Pressure lbs. per square inch.	Remarks.
1	0.8	11 per cent.	Not taken.	Warming shot.
2	1.0	22 " "	Not taken.	Warming shot.
3	1.8	33 " "	18400	
4	2.0	44 " "	28261	Powder used.
5	2.4	49 " "	31738	Du Pont's sphero-hex.
6	2.8	55 " "	36817	Gr. 123.
7	2.12	61 " "	43133	

The most careful calibration showed a slight reduction in diameter of the bore, an apparent settling together of the segments.

The cylinder was then bored out and lined, since which the cylinder has been fired fifty-seven times. A complete record of all the firing is appended hereto.

Discharges No. 1 to 7 given above and repeated in the record constituted the test of the cylinder in its *unlined condition.*

Discharges No. 8 to 14 constituted the two private tests of the cylinder after lining.

With the exception of eight discharges, the remaining firings were public exhibits, made before parties of stockholders and others interested in this system of gun construction.

Discharges Nos. 35, 36, 37, 38 and 39 constituted a special test made with high pressures after obtaining the extraordinary result shown in discharge No. 34. Discharges Nos. 60, 61 and 62 were tests with U. S. Obturating Electric Primers.

The outer jacket into which the obturating plugs are screwed, and in which the cylinder is inserted is a steel casting. The first set of plugs were also of cast steel.

After discharge No. 26 it was noticed that these plugs were con-considerably compressed and bent. This had expanded the threaded portion of the jacket and distorted the thread. New plugs of crucible chrome steel were constructed; and the threaded portions of the jacket were reinforced by shrinking bands over them. These plugs were forged from a 10-inch Carpenter projectile and used in the annealed state; the minimum physical qualities of this steel are so far above that of the cast steel, of which the first plugs were made, and as the new plugs were an inch thicker than the original plugs, it was not deemed necessary to test them. It was afterwards ascertained that the lower plug had probably been overheated either in the annealing or forging and was "cold short" and brittle. The steel appeared tough under the tool and no defect was noticed. At Discharge No. 28 with a pressure of but 53,800 lbs. per sq. in. the lower plug split into three pieces, tearing away the threaded portion of the jacket, and sending the main body of the jacket fifty feet in the air. The cylinder itself was not injured.

A new jacket with heavier plugs was then constructed; since which time the cylinder has been fired thirty-six times with enormous pressures, and there has not been the slightest distortion of jacket or plugs.

DIMENSIONS OF CYLINDER JACKET.

Exterior diameter . .	19.25	inches.
Interior diameter . . .	15.50	inches.
Area of cross-section . .	102.35	square inches.

Physical Qualities of Metal.

Tensile strength . . .	64,101	lbs. per sq. in.
Elastic limit . . .	26,488	lbs. per sq. in.
Elongation in 2-inch sec. . .	17	per cent.
Total tensile strength of cyl. jacket	6,550,737	lbs.
Total elastic strength of cyl. jacket	2,712,371	lbs.

Area of plugs	19.64 sq. in.
Maximum thrust sustained by jacket	1,335,520 lbs.
Factor of safety 4.9.	*Factor of elastic safety* 2.1.
Diameter of threaded portion	16 inches.
Strength of threaded portion	3 inches.
Shearing surface	159.81 sq. in.
Total shearing strength of thread	6,969,071 lbs.
Total elastic shearing strength of thread	2,879,775 lbs.
Factor of safety 5.2.	*Factor of elastic safety* 2.2.

CALIBRATION.

The cylinder was carefully calibrated several times during the progress of the firing. The result of three calibrations are given below. The *first* after the cylinder was lined and before *Discharge No.* 8.

The *second* after *Discharge No.* 10; that is, after two shots had been fired in the lined cylinder. When it was shown that the bore had been reduced in size and become slightly tapered. This was undoubtedly due to the fact that the liner having been inserted on a taper, had been forced home by the first two discharges.

The *third calibration* given is that after *Discharge No.* 64, which clearly demonstrates that not the slightest enlargements of the bore had taken place from *Discharge No.* 10 to *Discharge No.* 64, notwithstanding the enormous pressures to which the cylinder had been submitted.

The slight variation in caliber is undoubtedly due to error of calibration.

The cylinder was carefully calibrated after Discharge No. 28, which destroyed the jacket; after Discharge No. 34 when a pressure of 68,000 lbs. was obtained; and after the special test which followed. Not the slightest enlargement was detected. The calibrations corresponded with the second and third given below, and with the usual slight deviation due to errors of calibration.

The calibrations are made at the top, middle and bottom of the chamber, on two diameters at right angles to each other.

	Before firing.	After No. 10.	After No. 64.
Top Diameter A . . .	5″.001	5″.001	5″.001
Top Diameter B	5″.001	5″.002	5 .002
Middle Diameter A . .	5″.000	4″.999	4″.998
Middle Diameter B . . .	5″.000	4″.998	4″.998
Bottom Diameter A . .	6″.000	4″.997	4″.996
Bottom Diameter B . . .	5″.000	4″.996	4″.996

A most careful examination demonstrates that there has not been the slightest displacement of the segments, either radially or longitudinally; nor has there been any displacement of the lining tube.

SCORING.

In the unlined condition of the cylinder a slight scoring, following the line of juncture of the segments was noticed, after a pressure of 43,133 lbs. per sq. in.

Since the cylinder has been lined, not the slightest scoring of any kind has been observed.

An interesting phenomenon developed by the tests, is that a discharge with a pressure of 60,000 lbs. per sq. in. and over, will enlarge the two-tenths of an inch vent to three-eighths of an inch in diameter; the hole through the plug being apparently perfectly round and highly polished, without any scoring marks therein.

GENERAL DEDUCTIONS.

The results of the various tests with this cylinder, pressures obtained and other measurements have beyond question demonstrated:

First.—That the *segmental core* of the Brown 5-inch B. L. rifle has an elastic strength which will enable it to resist a much higher radial pressure than will ever be used in the gun.

Second.—That there is not the slightest danger of any displacement of the segments during action.

Third.—The fact that there has not been the slightest elongation or distortion of the present jacket, demonstrates that the trunnion jacket of the gun will be amply strong to resist the longitudinal thrust.

The minimum dimensions of the trunnion jacket are as follows:

Exterior diameter	16.00	inches.
Interior diameter	13.63	inches.
Area of cross-section	55.26	sq. in.

Physical Qualities of Metal.

Tensile strength	92,409	lbs. per sq. in.
Elastic limit	49,916	lbs. per sq. in.
Elongation in two inch specimen	24	per cent.
Total tensile strength of jacket	5,160,337	lbs.
Total elastic limit of jacket	2,758,258	lbs.
Area of breech-block	21.65	sq. in.
Maximum powder pressure	53,000	lbs. per sq. in.
Max. thrust to be sustained by jacket	1,169,100	lbs.

Factor of safety 9.9. *Factor of elastic safety* 4.2.

Compare this with factors of safety of the cylinder jacket, and it is manifest that the trunnion jacket has ample strength. Particularly is this true when it is remembered that the trunnion jacket will not be called upon to sustain such a long continued strain. Also that as the trunnion jacket is four times as long as the cylinder jacket, it will have a much greater elastic elongation.

Fourth.—The obturating plugs of Cylinder No. 2 are constructed upon the same principle as the breech fermeture designed by Mr. Brown for the 5-inch gun. There never has been the slightest difficulty experienced in extracting or inserting the plugs. No jamming of the plug or distortion of the thread.

The breech-block of the gun engages into a breech recess in a bushing which is screwed into the trunnion jacket:

Diameter of breech recess	10.	inches.
Length of threaded portion	4.	inches.
Shearing surface	125,664	sq. in.

Physical Qualities of Metal.

Tensile strength	160,784	lbs. per sq. in.
Elastic limit	80,882	lbs. per sq. in.
Elongation in 2-inch spec.	10	per cent.
Total shearing strength	14,551,595	lbs.
Total elastic shearing strength	7,320,144	"
Total thrust on block	1,169,100	"

Factor of safety 12.4. *Factor of elastic safety* 6.3.

Diameter of bushing . .	16 inches.
Length of thread . . .	4 inches.
Shearing surface . .	201,064 sq. in.

Physical Qualities of Jacket Metal.

Tensile strength . . .	92,409 lbs. per sq. in.
Elastic strength . .	29,916 " " "
Elongation in 2-inch spec. . .	24 per cent.
Total shearing strength .	11,373,431 lbs.
Total elastic shearing strength .	7,231,044 "
Total thrust on bushing .	1,169,100 "

Factor of safety 9.9. *Factor of elastic safety* 4.2.

Compare this with similar conditions which the obturating plugs of cylinder jacket have sustained without distortion.

In conclusion I would simply say that the tests of Cylinder No. 2 have demonstrated the truth of all the claims made for the Brown system of gun construction, except of course, those which pertain to economy of construction.

Very respectfully,
Your obedient servant,
(signed) G. N. WHISTLER,
1st Lieutenant 5th Artillery,
Engineer for Trustees.

SUMMARY.

52	discharges	gave	pressures	exceeding	36,000	lbs.	per	sq.	in.
50	"	"	"	"	40,000	"	"	"	"
34	"	"	"	"	50,000	"	"	"	"
10	"	"	"	"	60,000	"	"	"	"
3	"	"	"	"	66,000	"	"	"	"
1	"	"	"	"	68,000	"	"	"	"

REMARKS.

The variations of pressures for same charge of powder is due to variation in the strength of different lots of powder.

The discrepancy in the pressure of No. 51, was due to the fact that visitors abstracted from the charge a number of grains for mementoes. The fact was not noticed at the time.

The pressures of Nos. 38 and 39 was above 66,000 lbs. per sq. in. This was the maximum of the table. Shot No. 34 was so far above that the pressure was estimated by differences it was somewhere in excess of 68,000 lbs. per sq. in.

RECORD OF FIRING OF CYLINDER NO. 2.

No.	Charge of Powder.		Density of Loading.	Pressure.
	lbs.	oz.	per cent.	lbs. per sq. inch.
1	0	8	11	Not taken
2	1	0	22	" "
3	1	8	33	18400
4	2	0	44	28261
5	2	4	49	31733
6	2	8	55	36817
7	2	12	61	43133
8	1	0	22	Not taken
9	2	0	44	" "
10	2	12	61	43144
11	3	4	72	52055
12	2	0	44	Not taken
13	3	4	72	52900
14	3	8	77	58266
15	1	0	22	Not taken
16	2	8	55	34570
17	2	12	61	43100
18	3	0	66	48000
19	3	4	72	54550
20	2	8	55	37135
21	2	12	61	44326
22	3	0	66	52658
23	3	0	69	57666
34	3	0	66	43490
25	3	2	69	57420
26	3	4	72	59800
27	2	8	55	40220
28	3	0	66	53800
29	3	4	49	32710
30	2	8	55	41500
31	3	0	66	48010
32	3	4	72	57610
33	3	0	61	61300
34	3	6	75	68000
35	2	8	55	41650
36	2	12	61	52500
37	3	0	66	55325
38	3	4	72	66000
39	3	4	72	66000
40	2	8	55	40960
41	3	0	66	55460
42	2	8	50	40176
43	3	0	66	56100
44	3	2	69	60600
45	2	12	61	50400
46	3	0	66	56049
47	3	2	69	59483
48	2	4	49	33604
49	3	4	72	63800
50	2	8	50	40914
51	3	0	66	45314
52	3	4	72	61616
53	3	0	66	44800
54	3	4	72	58610
55	3	4	72	58800
56	3	0	66	54775
57	8	4	72	60633
58	3	0	66	52822
59	3	4	72	60796
60	2	8	55	37970
61	3	0	66	50080
62	3	4	72	58866
63	3	0	66	51200
64	3	4	72	61590

MATHEMATICAL DISCUSSION.

Without entering into the question as to the relative merits of the various systems for calculating the resistances of "*built up guns*," it may simply be said that as Captain Birnie's method gives numerically, values which are the least favorable to the gun, that is, which give the least value for the maximum pressure which can safely be used in any given gun: it will be adopted in this paper.

If guns constructed by the Brown system have sufficient theoretical strength, when determined by Birnie's formulæ, any other system of calculation will indicate a greater strength.

NOTATION USED IN THIS PAPER.

$R_0 =$ Radius of bore.

$R_1 =$ Exterior radius of lining tube.

$R_2 =$ Exterior radius of segmental core.

$R_3 =$ Exterior radius of wire jacket.

$R_n =$ Generally exterior radius of any system of n cylinders.

$P_0, P_1, P_2, P_n =$ Normal pressures at the surfaces, the radii of which are respectively R_0, R_1, R_2, R_n, &c., *during action.*

$P =$ Powder pressure.

$p_0, p_1, p_2, p_n =$ Variation in these pressures from whatever cause produced.

$P'_1, P'_2, P'_3, P'_n =$ Normal pressures at the surfaces, the radii of which are R_1, R_2, R_3, R_n, &c., during the *state of rest.*

$p'_1, p'_2, p'_3, p'_n =$ Variations in these pressures from whatever cause produced.

$\theta_0, \theta_1, \theta_2 =$ Elastic limit under tensile stress, of the metal. of the various cylinders, from the bore outwards.

$\rho_0, \rho_1, \rho_2 =$ Elastic limit when under compression, of the metal of the various cylinders.

$E_0, E_1, E_2 =$ Modulus of elasticity of the metal of the various cylinders.

$T =$ Tension of winding in lbs. per sq. in.

$T'_2 =$ Tension on inner layer of wire, system at rest.

$T_2 =$ Tension on same wire during action.

$T'_n =$ Tension on outer layer of wire system at rest.

$T_n =$ Tension on same wire during action.

$C =$ Compression per sq. inch between the segments at the surface of the bore: the gun being completely wound.

In order to avoid long and complex equations, we will assume that $E_0 = E_1 = E_2$. That the modulus of elasticity is the same for all the metal used in the gun; a condition readily approximated to in the Brown system of gun construction.

It is the intention to construct all the Brown guns so that the *exterior surface* of the segmental core shall be a straight taper from breech to muzzle. In consequence of the method of winding and anchorage of the wire, the *exterior surface* of the wire jacket will also be a straight taper from breech to muzzle.

Therefore the *thickness of metal* of the gun proper will decrease uniformly from breech to muzzle. By the *gun proper* is meant the segmental core wound with wire exclusive of trunnion or chase jackets. The maximum powder pressure is not reached in a gun until after the projectile has begun to move. In a gun 44 calibers long (the minimum length proposed for the Brown guns), the range of maximum powder pressure will not exceed one-fourth of the length of the bore; after which the powder pressure falls off more rapidly than the thickness of metal of the Brown guns.

The maximum safe powder pressure for these guns, as will be shown hereafter, is a function of the caliber, initial compression produced at the surface of the bore by winding, elastic strength of the metal used, and the *exterior diameter of the wire jacket.*

In order therefore to determine the elastic strength of these guns, we must determine their elastic strength at the point where the maximum powder pressure ceases, that is, at the point *where the ratio between powder pressure and thickness of metal is greatest.*

If, therefore, we determine the elastic strength of a wire wound segmental cylinder of the same caliber as the gun, the thickness of metal of which shall be the same as that of the gun at a distance from the bottom of the bore equal to one-fourth of the length of the bore, the result obtained will give us the limiting value of the elastic strength of the gun. For, although the gun may have a greater elastic strength towards the breech, this limiting value cannot be exceeded in practice.

It is further the intention to construct all Brown guns of whatever caliber, of similar dimensions; thus the dimensions of a ten-inch gun will be twice that of the present five-inch gun. Therefore the ratio of exterior diameter of wire jacket to caliber of gun will be a constant for all Brown guns, for similar cross-sections. Therefore with same initial compression at surface of bore, and the same elastic strength of metal, all Brown guns will have the same *limiting value of elastic strength.*

In this paper we will first consider the case of an unlined gun or cylinder, and then a lined gun or cylinder.

SEGMENTAL WIRE CYLINDER (UNLINED).

In an unlined cylinder or gun, there are but two elements, the segmental core and the wire jacket. R_0 is the radius of bore. R_2 is the exterior radius of segmental core, and the interior radius of the wire jacket. R_3 is the exterior radius of the wire jacket. As there is no lining tube, R_1 does not apply.

θ_1 and ρ_1 are the elastic limits of the metal of the core.

θ_2 and ρ_2 the elastic limits of the wire.

For steel we may consider $\theta_1 = \rho_1$ and $\theta_2 = \rho_2$.

Captain Birnie's formulæ for the maximum, or more properly limiting values of P_0, that is the maximum safe internal pressure which can be used in a compound cylinder, can be made to apply to an unlined cylinder. They may be written as follows, using the notation of this paper. See Ordnance Construction Notes No. 35.

$$P_0^{(1)} = \frac{3(R_2^2 - R_0^2)(\theta_1 + C)}{(4R_2^2 + 2R_0^2) - 6R_2^2 l} \quad - \; - \quad \text{Eq. A.}$$

$$P_0^{(2)} = \frac{4(R_2^2 - R_0^2)\rho_1}{(4R_2^2 - 2R_0^2) - 2R_2^2 l} \quad - \; - \quad \text{Eq. B.}$$

$$P_0^{(1)} = \frac{3(R_2^2 - R_0^2)\theta_1 + 6R_2^2 P'_2}{(4R_2^2 + 2R_0^2) - 6R_2^2 l} \quad - \; - \quad \text{Eq. C.}$$

$$P_0^{(2)} = \frac{3(R_2^2 - R_0^2)\rho_1 + 2R_2^2 P'_2}{(4R_2^2 - 2R_0^2) - 2R_2^2 l} \quad - \; - \quad \text{Eq. D.}$$

Note.—The lettering of the equations differ in this paper from that used in Note 35. Eq. C becomes Eq. D and *vice versa.*

In order to avoid confusion, remember that for an unlined gun R_2, θ_1, ρ_1 and P'_2 used in this paper, correspond with R_1, θ_0, ρ_0 and P'_1 used in Captain Birnie's paper.

$P_0^{(1)}$ = The radial pressure per sq. inch, which will first reduce the compression C to zero, and then stretch the inner cylinder to its elastic limit for extension.

$P_0^{(2)}$ = The radial pressure per sq. inch which will compress the metal at the surface of the bore to its elastic limit for compression.

$l = \frac{p_2}{p_0}$ = The ratio between the variation of pressure produced at the outer and inner surfaces of the inner cylinder during action. The value of l is a function of the elastic strength of the outer jacket or jackets.

It is manifest that in order not to exceed either the elastic limit for extension or compression of the metal of the inner cylinder or core, we must not exceed the less of these two values of P_0.

It is probable however, and actual experience seems to indicate, that in consequence of the surroundings of the core during action, its resistance to compression is increased; and that we may therefore exceed a pressure of $P_0^{(2)}$ with safety.

The four equations are in terms of the elastic strength of the inner cylinder or core, which is *assumed to be solid*, and as will be shown hereafter, they must be altered to render them applicable to the Brown segmental system.

Eqs. A and B give the two values of P_0 in terms of the elastic strength of the core and of C and l. That is of the compression produced at the surface of the bore, and of the relative elastic strength of core and jacket. Eqs. C and D give the two values of P_0 in terms of the relative elastic strength of core and jacket, and of the normal pressure produced upon the exterior surface of the core by the winding under tension.

TENSION OF WINDING.

It will be shown hereafter that winding with a uniform tension will give ample elastic strength to the system.

A uniform tension of winding has been adopted for the Brown system of gun construction.

Captain Crozier's general formula for winding with a uniform tension is as follows (see Report of Chief of Ordnance for 1886, pages 414 and 415):

$$T = \frac{P'_2}{\frac{1}{\beta+1} \log_e \left\{ \frac{(\beta+1)n^2-(\beta-1)}{2} \right\}} \quad \text{- Eq. E.}$$

In which $\beta = \frac{E_2(R_2^2+R_0^2)}{E_1(R_2^2-R_0^2)} - \frac{E_2-E_1}{3E_1}$

and $n = \frac{R_3}{R_2}$.

Making $E_1 = E_2$ and reducing, we have

$$\beta = \frac{R_2^2+R_0^2}{R_2^2-R_0^2}$$

$$T = \frac{P'_2}{\frac{R_2^2-R_0^2}{2R_2^2} \log_e \frac{R_3^2-R_0^2}{R_2^2-R_0^2}} \quad - - - \quad \text{Eq. E}'$$

$$P'_2 = \frac{R_2^2-R_0^2}{2R_2^2} T \log_e \frac{R_3^2-R_0^2}{R_2^2-R_0^2} \quad - - - \quad \text{Eq. F.}$$

$$\text{Now } P'_2 = \frac{R_2^2-R_0^2}{2R_2^2} C \quad - - - \quad \text{Eq. G.}$$

For deduction of Eq. G see Birnie's formulæ, Ordnance Construction Note No. 35.

Therefore

$$T = \frac{C}{\log_e \frac{R_3^2-R_0^2}{R_2^2-R_0^2}} \quad - - - - \quad \text{Eq. H.}$$

$$\text{Let } \frac{C}{T} = \log_e \delta \text{ then } \delta = \frac{R_3^2-R_0^2}{R_2^2-R_0^2} \quad - - \quad \text{Eq. I.}$$

Eq. I is a very convenient formula for use in determining the relative thickness of core and wire jacket, for any given compression and tension of winding.

$$\text{Value of } i = \frac{p_2}{p_0}.$$

Birnie's formula for determining the relative values of p_0, p_1 and p_2, reduces to the following form when $E_0 = E_1 = E_2$ &c. See Ordnance Construction Note No. 35.

$$p_m = \frac{R_{m-1}^2 (R_n^2 - R_m^2)}{R_m^2 (R_n^2 - R_{m-1}^2)} p_{m-1}.$$

In which m = any subscript of p, and n = number of cylinders in system.

Therefore when $n = 2$

$$p_1 = \frac{R_0^2(R_2^2-R_1^2)}{R_1^2(R_2^2-R_0^2)} p_0$$

In order to make this apply to an unlined cylinder, and correspond with the notation of this paper, we must write R_3 for R_2, R_2 for R_1 and p_2 for p_1.

$$\text{Then } l = \frac{p_2}{p_0} = \frac{R_0^2(R_3^2 - R_2^2)}{R_2^2(R_3^2 - R_0^2)} \quad - \quad - \quad \text{Eq. K.}$$

Application of Eq. A, B, C and D to an unlined segmental cylinder.

A segmental core or tube has no circumferential strength for extension, therefore *considered as a tube* its elastic limit for extension is zero. Therefore in determining the value of P_0, we must make $\theta_1 = 0$.

Making this substitution in Eq. A and B, and substituting for l its value from Eq. K,

$$P_0^{(1)} = \frac{3(R_2^2 - R_0^2)C}{(4R_2^2 + 2R_0^2) - 6R_0^2 \dfrac{R_3^2 - R_2^2}{R_3^2 - R_0^2}}$$

$$P_0^{(2)} = \frac{4(R_2^2 - R_0^2)\rho_1}{(4R_2^2 - 2R_0^2) - 2R_0^2 \dfrac{R_3^2 - R_2^2}{R_3^2 - R_0^2}}$$

Reducing we obtain

$$P_0^{(1)} = \frac{3(R_3^2 - R_0^2)C}{4R_3^2 + 2R_0^2} \quad - \quad - \quad - \quad - \quad \text{Eq. A}'.$$

$$P_0^{(2)} = \frac{4(R_3^2 - R_0^2)\rho_1}{4R_3^2 - 2R_0^2} \quad - \quad - \quad - \quad - \quad \text{Eq. B}'.$$

From Eq. A′ it is manifest that the value of $P_0^{(1)}$ in terms of C is a function of the radius of the bore and the exterior radius of the wire jacket; but is entirely independent of the value of R_2, that is the thickness of the segmental core. From Eq. B′ it is manifest that the value of $P_0^{(2)}$ is also entirely independent of the thickness of the segmental core.

In order to apply Eqs. C and D to an unlined Brown segmental cylinder, make $\theta_1 = 0$. Substitute for l its value from Eq. K and substitute for P'_2 its value from Eq. F.

Making these substitutions and reducing, we have

$$P_0^{(1)} = \frac{3(R_3^2 - R_0^2)}{4R_3^2 + 2R_0^2} \log_e \frac{R_3^2 - R_0^2}{R_2^2 - R_0^2} T \quad - \quad - \quad \text{Eq. C}'.$$

$$P_0^{(2)}=\frac{3(R_3^2-R_0^2)\rho_1+(R_3^2-R_0^2)\log_e\frac{R_3^2-R_0^2}{R_2^2-R_0^2}T}{4R_3^2-2R_0^2}\quad \text{Eq. D}'.$$

Remembering from Eq. H that

$$\log_e\frac{R_3^2-R_0^2}{R_2^2-R_0^2}T=C.$$

It is manifest that when $C=\rho_1$, that is, when the segmental core is wound up to its elastic limit for compression at the surface of the bore, Eq. C′ and D′ become identical with Eq. A′ and B′.

Therefore when $C=\rho_1$ we can use Eq. A′ and B′, otherwise, we must use Eq. C′ and D′.

A LINED SEGMENTAL WIRE CYLINDER.

In the Brown system of construction the liners will always be inserted after winding, so as to produce the maximum initial compression at the surface of the bore consistent with the physical conditions of the metal of the liner, we will thus have a compound cylinder consisting of three elements, liner, segmental core and wire jacket.

To such a system we apply Birnie's formulæ for a three-cylinder gun.

Eq. A, B, C and D may therefore be written as follows:

$$P_0^{(1)}=\frac{3(R_1^2-R_0^2)(\theta_0+\rho_0)}{(4R_1^2+2R_0^2)-6R_1^2l}\quad - - - \quad \text{Eq. } A.$$

$$P_0^{(2)}=\frac{4(R_1^2-R_0^2)\rho_0}{(4R_1^2-2R_0^2)-2R_1^2l}\quad - - - \quad \text{Eq. } B.$$

$$P_0^{(1)}=\frac{3(R_1^2-R_0^2)\theta_0+6R_1^2P'_1}{(4R_1^2+2R_0^2)-6R_1^2l}\quad - - \quad \text{Eq. } C.$$

$$P_0^{(2)}=\frac{3(R_1^2-R_0^2)\rho_0+2R_1^2P'_1}{(4R_1^2-2R_0^2)-2R_1^2l}\quad - - \quad \text{Eq. } D.$$

In this case $P'_1=\frac{R_1^2-R_0^2}{2R_1^2}\rho_0$,

and $l=\frac{R_0^2(R_3^2-R_1^2)}{R_1^2(R_3^2-R_0^2)}$.

Substituting these values in Eq. *A*, *B*, *C* and *D*, we find that all four equations reduce to the following two when $C=\rho_0$:

$$P_0^{(1)}=\frac{3(R_3^2-R_0^2)(\theta_0+C)}{4R_3^2+2R_0^2}\quad - - \quad \text{Eq. A}''.$$

$$P_0^{(2)}=\frac{4(R_3^2-R_0^2)p_0}{4R_3^2-2R_0^2} \quad - \ - \ - \quad \text{Eq. B}''.$$

THE VALUE OF *C*.

It was desired in the Brown system of construction to produce a constant initial compression from breech to muzzle by a uniform tension of winding. That is, it was desired to make C constant for all points in the bore.

The system of construction mechanically requires that the exterior surface of the segmental core should be a straight taper from breech to muzzle; and the method of winding and anchoring used produces a straight tapered exterior surface of the wire jacket. Therefore in the Brown system R_2 and R_3 are both equicrescent variables from breech to muzzle.

Now $\frac{C}{T}=\log_e\delta$, therefore in order to produce a constant value for C, with a constant value of T, it is manifest that the value of δ must be constant for all distances from breech to muzzle. But

$$\delta=\frac{R_3^2-R_0^2}{R_2^2-R_0^2} \quad - \ - \ - \ - \ - \ - \quad \text{Eq. I.}$$

Now in Eq. I, if δ is constant and R_2 is an equicrescent variable, R_3 will not be equicrescent, and *vice versa*. Therefore it is impossible to maintain δ, and consequently C, constant from breech to muzzle when R_2 and R_3 are equicrescent variables; that is, when both the exterior surface of the segmental core and the wire jacket are straight tapers from breech to muzzle.

The constant compression was therefore sacrificed to ease of mechanical construction.

There are other mechanical difficulties to contend with in determining accurately the value of C. The value of $\log_e\delta$, which is the ratio of tension to initial compression, is calculated upon the assumption that the core sustaining the winding is solid. This is not so in the Brown system, and a certain amount of the tension is utilized in bringing the segments to a perfect fit, which is lost so far as producing initial compression at the surface of the bore is concerned.

How much of the tension is thus utilized can only be determined by experiment.

In Cylinder No. 2 $R_3 = 7''.67$, $R_2 = 5''.50$, $R_0 = 2''.50$. Therefore $\delta = 2.19$; $\log_e\delta = .7839$. Now the tension of winding was, 700 lbs. upon the wire $=$ 140,000 lbs. per sq. inch. Therefore the compression should have been $140{,}000 \times .7839 = 109{,}746$ lbs. per sq. inch. The mean reduction of diameter of the bore due to winding was $0''.0195$, indicating that $C = 105{,}350$ lbs. per sq. inch, or about four per cent. less than the theoretical. Therefore in winding the gun, whereas the theoretical tension should have been 125,000 lbs. per sq. inch, or 625 lbs. upon the wire, four per cent. was added, making 650 lbs. upon the wire, or 130,000 lbs. per sq. inch.

There is still another mechanical difficulty, and that is the impossibility of making the exterior diameters of the wire jacket correspond exactly with their theoretical values; due to the fact that the theoretical values are not always exact multiples of the thickness of the wire. This is aggravated by the varying compression of the several layers after winding.

In the 5-inch experimental gun, in order to make C as constant as possible from breech to muzzle, two points were taken: one at 100 inches from the bottom of the bore and one at the muzzle, just in rear of the muzzle nut, where $\log_e\delta$ was to be made the same. The desired theoretical value was $\log_e\delta = 0.80$, the actual result obtained was $\log_e\delta = 0.7975$. The appended tables for the 5-inch gun show the variation in $\log_e\delta$ and C for every ten inches from breech to muzzle.

LONGITUDINAL STRENGTH.

In the Brown system of gun construction the longitudinal traction produced by the pressure upon the breech-block is transmitted directly to the trunnion jacket. As the trunnion jacket is tapered from breech forward, the least area of cross-section is at the trunnions, this is its weakest point. As the point of application of the force is at the breech, we may properly consider that the stresses and strains are uniformly distributed throughout this particular cross-section.

Let R_b = Radius of breech-block.

R_n = Exterior radius of trunnion jacket at the point of least area of cross-section.

R_{n-1} = Interior radius for same cross-section.

L'' = Longitudinal traction per sq. inch of least area of cross-section.

P = Powder pressure per sq inch.

$$\text{Then } L'' = \frac{R_b^2 P}{R_n^2 - R_{n-1}^2} \quad - \quad - \quad - \quad \text{Eq. I}''.$$

SEGMENTAL CORE.

The segmental core is submitted to a longitudinal strain due to the exterior and interior pressures, during action, plus the friction of the shot in the bore.

Now the longitudinal stress produced by the action of the normal pressures alone, within the metal of the segmental core, may be determined from the following expression:

$$\frac{2(R_2^2 P' - R_0^2 P)}{3(R_2^2 - R_0^2)}$$

In which P = Interior pressure per sq. inch.

and P' = Exterior pressure per sq. inch.

It is difficult to determine the longitudinal traction due to friction of the shot in the bore. In order therefore to obtain a practical formula, we must assume some value for the rate of stress at the surface of the bore in lbs. per sq. inch, which we know will exceed the actual value, of the stress produced by the motion of the projectile down the bore.

If we assume that the friction of the shot produces a longitudinal traction equal to one-third of the entire pressure upon the breech-block uniformly distributed throughout the area of cross-section of the segmental core, the resulting pressure per sq. inch will undoubtedly exceed that produced *at the surface of the bore* by the friction of the projectile. See Captain Noble's experiments, Ordnance Construction Notes No. 60.

Let L = Longitudinal traction per sq. inch of area of cross-section of segmental core during action.

Then

$$L = \frac{R_0^2 P}{3(R_2^2 - R_0^2)} + \frac{2(R_2^2 P' - R_0^2 P)}{3(R_2^2 - R_0^2)}$$

Making $P = P_0$ P' becomes P_2 substituting:

$$L = \frac{R_0^2 P_0}{3(R_2^2 - R_0^2)} + \frac{2(R_0^2 P_2 - R_0^2 P_0)}{3(R_2^2 - R_0^2)} = \frac{2R_2^2 P_2 - R_0^2 P_0}{3(R_2^2 - R_0^2)} \quad \text{Eq. L.}$$

In which L is the longitudinal traction per sq. inch due to a pressure which would reduce C to zero, and is of course far beyond anything which will actually occur, or can possibly occur during action. It is not assumed that this thrust is uniformly distributed throughout the metal, but that L is a measure of the maximum value of the thrust at the surface of the bore.

For longitudinal traction on lining tube we have

$$L' = \frac{R_0^2 P_0}{3(R_2^2 - R_0^2)} + \frac{2R_1^2 P_1 - 2R_0^2 P_0}{3(R_1^2 - R_0^2)} \quad - \quad \text{Eq. L}'.$$

In the above equation

$$P_1 = P'_1 + l_1 P_0$$

$$P_2 = P'_2 + l_2 P_0$$

$$l_1 = \frac{R_0^2(R_3^2 - R_1^2)}{R_1^2(R_3^2 - R_0^2)} \qquad l_2 = \frac{R_0^2(R_3^2 - R_2^2)}{R_2^2(R_3^2 - R_0^2)}$$

STRESSES AND STRAINS IN THE WIRE JACKET.

As layer after layer of wire is wound on the core the tension is not only slacked off on the inner layers, but the inner layers are themselves compressed by the outer layers, which compression produces a circumferential extension of the wire equal to one-third of the compression.

Captain Crozier's formulæ are as follows when $E_1 = E_2$

Let t_r = remaining tension on wire at any radius r.

Then

$$t_r = T \left\{ 1 - \frac{r^2 + R_0^2}{2r^2} \log_e \frac{R_3^2 - R_0^2}{r^2 - R_0^2} \right\} \quad - \quad \text{Eq. M.}$$

For inner layer make $r = R_2$

$$t_{R_2} = T \left\{ 1 - \frac{R_2^2 + R_0^2}{2R_2^2} \log_e \delta \right\} \quad - \; - \quad \text{Eq. M}_2.$$

For outer layer make $r = R_3$

$$t_{R_3} = T, \text{ as it should be.} \quad - \; - \; - \quad \text{Eq. M}_3.$$

PRESSURE PRODUCED BY SUPER-IMPOSED WIRES.

Let $p_r =$ this pressure at radius r.

$$\text{Then } p_r = \frac{r^2 - R_0^2}{2r^2} T \log_e \frac{R_3^2 - R_0^2}{r^2 - R_0^2}$$

Adding one-third of this to the value of t_R and we obtain the total stress on the wire at any radius r during state of rest.

$$\frac{\Delta r}{r} E_2 = T \left\{ 1 - \frac{r^2 + 2R_0^2}{3r^2} \log_e \frac{R_3^2 - R_0^2}{r^2 - R_0^2} \right\} \quad \text{Eq. N.}$$

For inner layer make $r = R_2$

$$\frac{\Delta R_2}{R_2} E_2 = T \left\{ 1 - \frac{R_2^2 + 2R_0^2}{3R_2^2} \log_e \delta \right\} \quad - \quad \text{Eq. N}_2.$$

For outer layer make $r = R_3$

$$\frac{\Delta R_3}{R_3} E_2 = T, \text{ as it should be.} \quad - \; - \quad \text{Eq. N}_3.$$

TO DETERMINE THE INCREASE OF STRESS ON ANY LAYER OF WIRE DURING ACTION.

The action of an interior pressure $= P_0$ will produce an outward pressure at $R_2 = lP_0$.

This outward pressure will produce the following extension of the wire at any radius.

$$\frac{\Delta r}{r} E_2 = \left[\frac{2R_2^2}{3(R_3^2 - R_2^2)} + \frac{4R_2^2}{3(R_3^2 - R_2^2)} \times \frac{R_3^2}{r^2} \right] lP_0 \quad \text{Eq. O.}$$

Substituting for l its value $= \dfrac{R_0^2(R_3^2 - R_2^2)}{R_2^2(R_3^2 - R_0^2)}$ and we obtain

$$\frac{\Delta r}{r} E_2 = \frac{2R_0^2}{3(R_3^2 - R_0^2)} \left(1 + \frac{2R_3^2}{r^2} \right) P_0 \quad - \quad \text{Eq. O}'.$$

The total stress on any wire during action will be the stress during rest plus the extension given by Eq. O′.

Let $T_a =$ Stress on wire during maximum action.

$$T_a = T \left\{ 1 - \frac{r^2 + 2R_0^2}{3r^2} \log_e \frac{R_3^2 - R_0^2}{r^2 - R_0^2} \right\} + \frac{R_0^2}{3(R_3^2 - R_0^2)} \left(1 + \frac{2R_3^2}{r^2} \right) P_0$$

—Eq. P.

This equation gives the maximum tension on any layer of wire in terms of the tension of winding and interior pressure.*

On Outer Layer of Wire.

Make $r = R_3$

$$T_a = T + \frac{3R_0^2}{3(R_3^2 - R_0^2)} P_0 \quad - - - \quad \text{Eq. P}_3.$$

On Inner Layer of Wire.

Make $r = R_2$

$$T_a = T \left\{ 1 - \frac{R_2^2 + 2R_0^2}{3R_2^2} \log_e \delta \right\} + \frac{R_0^2(R_2^2 + 2R_3^2)}{3R_2^2(R_3^2 - R_0^2)} P_0 \quad \text{Eq. P}_2.$$

From which it is manifest that during maximum action the tension on the outer layer of wire is the greatest. The limiting value of this tension is of course θ_2, the elastic limit of the wire.

In Equation P_3 substitute for P_0 its value $\frac{3(R_3^2 - R_0^2)}{4R_3^2 + 2R_0^2} C$, and for T_a its maximum value $= \theta_2$.

Then maximum value of $T = \theta_2 - \frac{3R_0^2}{4R_3^2 + 2R_0^2} C.$ Eq. Q.

Substituting for T its value $\frac{C}{\log_e \delta}$, we obtain,

$$C = \frac{\theta_2}{\frac{1}{\log_e \delta} + \frac{3R_0^2}{4R_3^2 + 2R_0^2}} \quad - - - \quad \text{Eq. Q}'.$$

TANGENTIAL STRESS IN SEGMENTAL CORE.

System at Rest.

The formula for *compression* at any radius is as follows:

$$\frac{\Delta r}{r} E_1 = \frac{2R_2^2}{3(R_2^2 - R_0^2)} \left(1 + \frac{2R_3^2}{r^2}\right) P'_2 \quad - \quad \text{Eq. S.}$$

But $P'_2 = \frac{R_2^2 - R_0^2}{2R_2^2} C$ See Eq G.

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* The value of T_a, Eq. P, is the stress which in a free specimen would produce an extension equal to that produced during maximum action at any radius r, in lbs. per sq. inch. It must be kept in mind that all measures of tension and stress in the entire system are measures of the *rate* of tension or stress at the radius indicated, and are not the absolute stress on any particular sq. inch.

Therefore

$$\frac{\Delta r}{r}E_1=\tfrac{1}{8}\left(1+\frac{2R_3^2}{r^2}\right)C. \quad - \quad - \quad \text{Eq. S}'.$$

For surface of bore make $r=R_0$, when

$$\frac{\Delta R_0}{R_0}E_1=\tfrac{1}{3}C+\tfrac{2}{3}C=C. \quad - \quad - \quad \text{Eq. S}_0.$$

That is, the compression at surface of the bore during state of rest is C, as it should be.

For exterior surface we have

$$\frac{\Delta R_2}{R_2}E_1=\tfrac{1}{3}C+\frac{2R_0^2}{3R_2^2}C=\frac{R_2^2+2R_0^2}{3R_2^2}C \quad - \quad \text{Eq. S}_2.$$

Now by the *formula for winding* we find that the compression produced by winding, at the surface of seg. core, is $\frac{R_2^2+2R_0^2}{3R_2^2}T\log_e\delta$,

but $T=\frac{C}{\log_e\delta}$ this reduces to $\frac{R_2^2+2R_0^2}{3R_2^2}C$, as above.

FOR INCREASE OR DECREASE OF STRESS DURING ACTION.

Formula $\frac{\Delta r}{r}E_1=-\frac{2R_0^2P_0-2R_2^2p_2}{3(R_2^2-R_0^2)}{}_2-\frac{4R_2^2P_0-4R_2^2p_2}{3(R_2^2-R_0^2)}\frac{R_0^2}{r^2}$

Remembering that $p_2=lP_0$ and $l=\frac{R_0^2(R_3^2-R_2^2)}{R_2^2(R_3^2-R_0^2)}$

Substituting and reducing, we have,

$$\frac{\Delta r}{r}E_1=-\frac{2R_0^2}{3(R_3^2-R_0^2)}P_0-\frac{4R_3^2}{3(R_3^2-R_0^2)}P_0\times\frac{R_0^2}{r^2} \quad \text{Eq. S}''.$$

For powder pressure substitute P for P_0.

For surface of bore r becomes R_0, and we have

$$\frac{\Delta R_0}{R_0}E_1=-\frac{2R_0^2+4R_3^2}{3(R_3^2-R_0^2)}P_0=-C \quad \text{See Eq. A}'.$$

That is the maximum pressure P_0 produces at the surface of the bore a negative compression of C lbs. per sq. inch, that is an extension of C, which reduces the compression produced by the winding to zero.

GENERAL APPLICATION OF THE PRECEDING FORMULÆ TO THE DETERMINATION OF THE ELASTIC STRENGTH OF BROWN SEGMENTAL WIRE GUNS.

All Brown guns will be constructed with a segmental core, the exterior surface of which will be a straight taper from breech to muzzle. The exterior surface of the wire jacket will therefore also be a straight taper from breech to muzzle.

It is proposed to construct all guns of whatever caliber of *similar dimensions.*

These dimensions will be such that:

At the bottom of the bore $R_3^2 = 10R_0^2$
and $R_2^2 = 5R_0^2$

This will make $\delta = 2.25$ and $\log_e \delta = 0.8109$

At the muzzle: $R_3^2 = 2.65R_0^2$
$R_2^2 = 1.74R_0^2$

This will make $\delta = 2.23$ and $\log_e \delta = 0.8020$

It will probably be mechanically impossible to construct our guns exactly to these dimensions. Thus in the 5-inch experimental gun we have at the bottom of the bore $\log_e \delta = 0.8242$ and at the muzzle $= 0.79838$.

If we however determine the elastic strength of the system by the above dimensions, the results will approximate closely to those which will actually be obtained.

We will now proceed to determine generally the elastic strength of the Brown guns, by making calculations for five sections.

Breech section.—At bottom of bore.
Section A.—One quarter of the way to muzzle.
Section B.—One half of the way to muzzle.
Section C.—Three quarters of the way to muzzle.
Muzzle section.—At muzzle.

As *Section A* corresponds very closely to the point where the maximum powder pressure ceases, and is therefore the weakest section under the maximum powder pressure, the elastic strength of Section A may be taken as the *elastic strength of the gun.*

COMPUTATION OF ELASTIC STRENGTH.

Let $n = \frac{R_3^2}{R_0^2}$ and $n' = \frac{R_2^2}{R_0^2}$, then

$$l = \frac{n - n'}{nn' - n'} \text{ Eq. H.} \quad \delta = \frac{n - 1}{n' - 1} \text{ Eq. I.} \quad C = T \log_e \delta \text{ Eq. I'.}$$

The use of these ratios greatly simplify the work of computation.

TABLE A.

Formulæ.	Breech Section	Section A.	Section B.	Section C.	Muzzle Section.
$n = \frac{R_3^2}{R_0^2}$	10.00	7.72	5.74	4.05	2.65
$n' = \frac{R_2^2}{R_0^2}$	5.00	4.03	3.16	2.40	1.74
$l = (n - n') \div (nn' - n)$	0.11111	0.13630	0.17226	0.22541	0.31624
$\delta = (n - 1) \div (n' - 1)$	2.25	2.22	2.19	2.18	2.23
$\log_e \delta$	0.8109	0.7975	0.7839	0.7793	0.8020
T	124,000	124,000	124,000	124,000	124,000
$C = T \log_e \delta$	100,552	98,889	97,203	96,631	94,448

The values of C and T are given in lbs. per sq. inch.

The ratios are determined by method by differences, the second order being constant.

In constructing the various guns the actual values of n and n' will differ slightly from the theoretical values given in this table. See Table M for the 5-inch gun. The variations will not be material.

COMPUTATION OF LIMITING VALUES OF P_0.

There are four equations—Eq. A' and B' give the two values of P_0 in terms of the physical qualities of the segmental core. Eq. A'' and B'' give the corresponding values in terms of the physical qualities of the liner.

In these calculations we will assume that the segmental core is constructed of Brown gun steel in which θ_1 and $\rho_1 = 100{,}000$ lbs. per sq. inch, and that the liner is constructed of O. H. steel in which θ_0 and $\rho_0 = 60{,}000$ lbs. per sq. inch.

$$\text{Making } \frac{3(R_3^2 - R_0^2)}{4R_3^2 + 2R_0^2} = M$$

$$\text{and } \frac{4(R_3^2 - R_0^2)}{4R_3^2 - 2R_0^2} = M'$$

we have

P_0 Eq. $A' = MC$.
P_0 Eq. $B' = M'\rho_1$.
P_0 Eq. $A'' = M(\theta_0 + \rho_0)$.
P_0 Eq. $B'' = M'\rho_0$.

Substituting ratios, the value of M and M' may be written:

$$M = \frac{3n-3}{4n+2}, \text{ and } M' = \frac{4n-4}{4n-2}.$$

TABLE B.

COMPUTATION OF P_0.

Formulæ.	Breech Section.	Section A.	Section B.	Section C.	Muzzle Section.
Value of n.	10.00	7.72	5.74	4.05	2.65
Value of n'.	5.00	4.03	3.16	2.40	1.74
Value of C, from Table A.	100,552	98,889	97,203	96,631	99,448
$M = (3n-3) : (4n+2)$	0.643	0.613	0.569	0.503	0.393
P_0 Eq. $A' = MC$	64,655	62,619	55,309	48,605	39,062
Value of ρ_1	100,000	100,000	100,000	100,000	100,000
$M' = (4n-4) \div (4n-2)$	0.947	0.931	0.906	0.859	0.760
P_0 Eq. $B' = M'\rho_1$	94.700	93,100	90,600	85,900	76,000
$\theta_0 + \rho_0$	120,000	120,000	120,000	120,000	120,000
M	0.643	0.613	0.569	0.503	0.393
P_0 Eq. $A'' = M(\theta_0 + \rho_0)$	77,160	73,560	68,280	60,360	47,160
ρ_0	60,000	60,000	60,000	60,000	60,000
M'	0.947	0.931	0.906	0.859	0.760
P_0 Eq. $B'' = M'\rho_0$	56,820	55,860	54,360	51,540	45,600

Values of P_0 are in lbs. per sq. inch.

For guns thus constructed the limiting value of P_0 is that obtained from Eq. B″. It is however admitted by Captain Birnie and experience demonstrates that this value of P_0 may be exceeded with safety.

From the elastic strength of Section A, which gives the maximum safe value for the powder pressure which may be used in the guns, it is manifest that a pressure of 50,000 lbs. per sq. inch may be used with safety.

By Clavarino's method of calculation the value of P_0 Eq. B″ at Section A would be 65,016 lbs. per sq. inch.

If, then, guns are lined to a distance just beyond Section A. with a liner of Brown gun steel, elastic limit 75,000 lbs. per sq.

inch, we would obtain at Section A P_0 Eq. B″ $=$ 70,085 lbs. per sq. inch.

Attention is called to the enormous muzzle strength of these guns, due to the method of construction, and which is obtained without any increase of weight.

This renders them particularly adapted to the use of "smokeless powders."

If a powder could be manufactured which would give a constant pressure of 40,000 lbs. per sq. inch from breech to muzzle, it could be used in these guns with perfect safety.

LONGITUDINAL STRENGTH OF SEGMENTAL CORE.

This will be computed on the assumption that an internal pressure of P_0 Eq. B″ is used throughout the entire length of the gun; of course, no such pressure will ever be used in the guns.

Formulæ.

Let $L =$ longitudinal traction per sq. inch.

Then

$$L = \frac{2n'P_2 - P_0}{3n' - 3} \text{ Eq. L.} \quad P_2 = P'_2 + lP_0. \quad P'_2 = \frac{n' - 1}{2n'} C \text{ Eq. G.}$$

TABLE C.

Formulæ.	Breech Section.	Section A.	Section B.	Section C.	Muzzle Section.
Value of n'	5.00	4.03	3.16	2.40	1.74
Value of C	100,552	98,889	97,203	96,631	99,448
$(n'-1) \div 2n' = M$	0.400	0.376	0.342	0.292	0.213
$P'_2 = MC$	40.221	37,182	33,243	28,216	21,282
P_0 Eq. B″ Table B.	56,820	55,860	54,360	51,540	45,600
l, Table A.	0.11111	0.13630	0.17226	0.22541	0.31624
lP_0	6,313	7,614	9,364	11,608	14,421
$P_2 = P'_2 + lP_0$	46,543	44,796	42,607	40,824	35,703
$2n'P_2$	465,340	361,456	269,276	195,955	124,246
$2n'P_2 - P_0$	408,520	305,596	214,916	144,415	78,646
$3n - 3$	12.00	9.09	6.48	4.20	2.22
In lbs. per sq. inch $L = \frac{2n'P_2 - P_0}{3n' - 3}$	34,043	33,618	33,337	34,384	35,426
FACTORS OF SAFETY.					
Under pressure P_0:					
For elastic limit	2.9	2.9	3.0	2.9	2.8
For rupture	4.7	4.7	5.0	4.7	4.5
Under powder pressure:					
For elastic limit	3.5	3.5	6.2	8 7	8.4
For rupture	5.6	5.6	10.2	14.1	13.5

Powder pressure calculated by Sarrau for max. of 50,000 lbs. per sq. inch.

LONGITUDINAL STRENGTH OF LINING TUBE.

The proper thickness of liners will probably have to be determined experimentally. It will lie between one-twentieth and *one-tenth of a caliber in thickness.* In order to show the longitudinal strength of a thin liner, we will consider the liner as one-twentieth caliber thick.

Therefore $R_1 - R_0 = \frac{1}{10} R_0$. $R_1 = 1.1 R_0$

$$\text{and } n'' = \frac{R_1^2}{R_0^2} = 1.21.$$

The taper of the liner is so slight that we will consider n'' constant from breech to muzzle, using its minimum value $= 1.20$.

TABLE D.

LONGITUDINAL STRENGTH OF LINING TUBE.

Formulæ.	Breech Section.	Section A.	Section B.	Section C.	Muzzle Section.
Value of n	10.00	7.72	5.74	4.05	2.65
Value of n'	5.00	4.03	3.16	2.40	1.74
Value of n''	1.20	1.20	1.20	1.20	1.20
$(n''-1) \div 2n'' = m'$	0.083	0.083	0.083	0.083	0.083
$P'_1 = M'C$	4,980	4,980	4,980	4,980	4,980
P_0, Eq. B'', from Table B.	56,820	55,860	54,360	51,540	45,600
$l = (n-n'') \div (nn''-n'')$	0.8148	0.8085	0.7982	0.7787	0.7324
lP_0	46,297	45,163	43,390	40,134	33,397
$P_1 = P'_1 + lP_0$	51,277	50,143	48,370	45,114	38,377
$2n'' \div (3n''-3) = A$	4.00	4.00	4.00	4.00	4.00
AP_1	205,108	200,572	193,480	180,456	153,508
$2 \div (3n''-3) = B$	3.333	3,333	3.333	3.333	3.333
BP_0	189,400	186,190	181,193	171,798	151,993
$1 \div (3n'-3) = D$	0.083	0.110	0.154	0.238	0.453
DP_0	4,716	6,145	8,371	12,266	20,656
In lbs. per sq. inch					
$L' = DP_0 + AP_1 - BP_0$	20,424	20,527	20,658	20,924	22,171
FACTORS OF SAFETY.					
Under max. stress:					
For elastic limit	2.9	2.9	2.9	2.9	2.8
For rupture	5.4	5.4	5.4	5.4	4.9
Under powder pressure:					
For elastic limit	3.5	3.5	6.2	7.4	8.1
For rupture	6.4	6.4	11.4	15.6	14.7

Formulæ.

L' = Longitudinal traction per sq. inch at surface of bore.

$$L' = \frac{1}{3n'-3} P_0 + \frac{2n''}{3n''-3} P_1 - \frac{2}{3n''-3} P_0 \quad \text{- Eq. L}'$$

$$P_1 = P'_1 + lP_0 \quad P'_1 = \frac{n''-1}{2n''} C \quad l = \frac{n-n''}{nn''-n''}$$

$C = \rho_0 = 60,000$ lbs. per sq. inch.

A liner of O. H. steel can readily be obtained of not over one-tenth caliber thickness, with the following physical conditions:

Tensile strength, 110,000 lbs. per sq. inch.
Elastic limit, 60,000 lbs. per sq. inch.
Elongation in 2-inch specimen, 15 per cent.

LONGITUDINAL STRENGTH OF TRUNNION JACKET.

The physical qualities of the O. H. steel for the trunnion jacket of the 5-inch experimental gun are as follows:

Tensile strength, 92,409 lbs. per sq. inch.
Elastic limit, 49,916 lbs. per sq. inch.
Elongation in 2-inch specimens, 24 per cent.

We may take this as a fair average of what we will obtain for all of our guns.

The formula is

$$L'' = \frac{R_b^2 P_0}{R_n^2 - R_{n-1}^2}$$

For our guns the values of R_b^2, R_n^2 and R_{n-1}^2 at the section of minimum area will be about as follows:

$$R_b^2 = 1.1 R_0^2 \quad R_n^2 = 10.25 R_0^2 \quad R_{n-1}^2 = 7.43 R_0^2$$

Then

$$L'' = \frac{1.1}{10.25 - 7.43} P_0 = 0.39 P_0$$

For $P_0 = 56,440$ lbs. per sq. inch.
$L'' = 21,812$ lbs. per sq. inch.
Factor of safety for rupture $= 4.2$.
Factor of safety for elastic limit $= 2.25$.
For $P = 50,000$ lbs. per sq. inch.
$L'' = 19,500$ lbs. per sq. inch.

Factor of safety for rupture = 4.7.
Factor of safety for elastic limit = 2.5.
From all of which it is manifest that the longitudinal strength of the Brown segmental system is more than ample.

For Segmental Tube,

we have minimum factor of safety, under the maximum pressure which the gun will stand:

For elastic limit = 2.8. For rupture = 4.5

Under powder pressure:

For elastic limit = 3.5. For rupture = 5.6.

For Lining Tube,

Under maximum pressure:

For elastic limit = 2.7. For rupture = 5.6.

Under powder pressure:

For elastic limit = 3.5. For rupture = 6.4.

For Trunnion Jacket,

Under maximum pressure:

For elastic limit = 2.25. For rupture = 4.2.

Under powder pressure:

For elastic limit = 2.5. For rupture = 4.7.

Therefore for the entire system, under maximum powder pressure, we have

Factor of safety for elastic limit exceeds 2.5,
Factor of safety for rupture exceeds 4.5.

There can be, therefore, no question as to the sufficiency of the elastic strength of the system, either as to circumferential or longitudinal strength: provided it can be shown that the wire will not be stretched beyond its elastic limit during action.

TENSIONS IN THE WIRE JACKET.

To determine the *minimum elastic limit of wire* which may be used with safety in constructing a gun of given dimensions, in order to be able to produce a given initial compression at the surface of the bore, we use the following formula:

$$\theta_2 = \left\{ \frac{1}{\log_e \delta} + \frac{3R_0^2}{4R_3^2 + 2R_0^2} \right\} C \quad - \quad - \quad \text{Eq. Q.}$$

Now as δ is constant from breech to muzzle in the Brown guns, or at least approximately so, it is manifest that the value of θ_2 is greatest for the least value of R_3 and therefore it must be determined for the muzzle.

At the muzzle of all Brown guns $\log_e \delta = 0.802$ and $\frac{R_3^2}{R_0^2} = 2.65$.

Therefore

$$\theta_2 = \left\{ \frac{1}{0.802} + \frac{1}{4.20} \right\} C = 1.484978 C$$

Consequently when $C = 100{,}000$ lbs. per sq. inch, the elastic limit of the wire must be at least 148,498 lbs. per sq. inch.

The wire used in the 5-inch experimental gun had an elastic limit of 200,000 lbs. per sq. inch.

To determine the maximum tension which may be used in winding a gun, in order to insure that no wire will be stretched beyond its elastic limit during maximum action, we use the following formulæ:

$$T = \theta_2 - \frac{3R_0^2}{4R_3^2 + 2R_0^2} C. \quad - \ - \ - \quad \text{Eq. Q}'.$$

It is manifest that T must be calculated for the maximum value of R_3, or at the breech. For all Brown guns $\frac{R_3^2}{R_0^2} = 10$ at the breech.

$$T = \theta_2 - \tfrac{1}{4} C. \quad - \ - \ - \ - \quad \text{Eq. Q}'.$$

For $\theta_2 = 200{,}000$ lbs. per sq. inch and $C = 100{,}000$ lbs. per sq. inch. Max. value of $T = 192{,}857$ lbs. per sq. inch.

As already shown it only requires a tension of 124,000 lbs. per sq. inch to produce a compression of 100,000 lbs. per sq. inch at the surface of the bore of the Brown guns.

With a powder pressure of 50,000 lbs. per sq. inch the maximum tension on any wire during action will be 173,055 lbs. per sq. inch. Giving us a margin of safety on the outer wire of 26,945 lbs. per sq. inch, or 135 lbs. on each wire.

The internal pressure which will stretch the outer wire to its elastic limit is determined by the following formula, deduced from Eq. Q'.

$$P_0 = \frac{R_3^2 - R_0^2}{3R_0^2}(\theta_2 - T) = \frac{n-1}{3}(\theta_2 - T) \quad - \quad \text{Eq. Q}''.$$

FOR STRESS ON WIRE DURING REST.

On Inner Layer of Wire.

$$t_{R_2} = T \left\{ 1 - \frac{n'+1}{2n'} \log_e \delta \right\}$$

$$\frac{\Delta R_2}{R_2} E_2 = T \left\{ 1 - \frac{n'+2}{3n'} \log_e \delta \right\}$$

On Outer Layer of Wire.

$$\frac{\Delta R_3}{R_3} E_2 = t_{R_3} = T.$$

FOR STRESS ON WIRE DURING ACTION.

For Inner Layer of Wire.

$$T_s = T \left\{ 1 - \frac{n'+2}{3n'} \log_e \delta \right\} + \frac{n'+5n}{3nn'-3n} P_0.$$

For Outer Layer of Wire.

$$T_s = T + \frac{2}{n-1} P_0.$$

TABLE E.

INTERNAL PRESSURE WHICH WILL STRETCH OUTER LAYER OF WIRE TO ITS ELASTIC LIMIT.

Formulæ.	Breech Section.	Section A.	Section B.	Section C.	Muzzle Section.
Value of n	10.00	7.72	5.74	4.05	2.65
$(n-1)\div 3$	3.00	2.24	1.58	1.02	0.85
$\theta_2 - T$	76,000	76,000	76,000	76,000	76,000
P_0 in lbs. per sq. inch	228,000	170,240	120,080	77,520	64,600

TABLE F.

STRESS ON WIRE DURING STATE OF REST.

Formulæ.	Breech Section.	Section A.	Section B.	Section C.	Muzzle Section.
Value of n'	5.00	4.03	3.16	2.40	1,74
$(n'+1)\div 2n' = u$	0.600	0.624	0.658	0.708	0.787
$\log_e \delta$ from Table A.	0.8109	0.7975	0.7839	0.7793	0.8020
$1 - u \log_e \delta$	0.5135	0.5023	0.4843	0.4539	0.3688
T from Table A.	124,000	124,000	124,000	124,000	124,000
Remaining Tension	63,674	62,285	60,053	56,283	45,731
$(n'+2)\div 3n' = u'$	0.467	0.498	0.544	0.611	0.618
$1 - u' \log_e \delta$	0.621	0.603	0.574	0.524	0.504
Stress in lbs. per sq. inch:					
On inner layer	77,004	74,772	71,176	64,976	62,946
On outer layer	124,000	124,000	124,000	124,000	124,000

TABLE G.

STRESS ON WIRE DURING MAXIMUM ACTION.

Formulæ.	Breech Section.	Section A.	Section B.	Section C.	Muzzle Section.
Value of n	10.00	7.72	5.74	4.05	2.65
Value of n'	5.00	4.03	3.16	2.40	1.74
$(n'+5n) \div (3nn'-3n)$	0.458	0.607	0.857	1.130	2.549
P_0 Eq. B'', from Table B.	56,820	55,860	54,360	51,540	45,600
Increase of stress on inner layer.	26,024	33,907	46,487	58,240	116,234
$2 \div (n-1)$	0.223	0.298	0.422	0.656	1.212
Increase of stress on outer layer.	12,670	16,643	22,940	33,810	55,267
Stress in lbs. per sq. inch:					
On inner layer	103,028	108,679	117,663	123,216	179,180
On outer layer	136,670	140,643	146,940	157,810	179,267

Table G was calculated for the maximum internal pressure, from breech to muzzle, required to compress the metal of the liner to its elastic limit for compression. Such pressures can never occur along the entire bore in actual practice.

In the following table the stress on the wire during action is calculated for *powder pressures*. The powder pressures were calculated by Sarrau's formulæ, for a maximum of 52,000 lbs. per sq. inch—being 2,000 greater than will be used in practice.

TABLE H.

STRESS ON WIRE DURING ACTION CALCULATED FOR POWDER PRESSURES

	Breech Section.	Section A.	Section B.	Section C.	Muzzle Section.
Tension during rest:					
On inner layer of wire	77,004	74,772	71,176	64,976	62,946
On outer layer of wire	124,000	124,000	124,000	124,000	124,000
Powder Pressures	52,000	52,000	25,473	19,600	15,921
Coef. of increase inner layer	0.458	0.607	0.857	1,130	2.549
Coef. of increase outer layer	0.223	0.298	0.422	0.656	1.212
Increase of stress on inner layer	23,816	31,564	21,830	22,149	40,583
Increase of stress on outer layer	11,596	15,496	10,550	12,858	19,296
Total stress on inner layer	100,820	106,336	93,006	87,125	103,529
Total stress on outer layer	135,596	139,496	134,550	136,858	143,296

Stress given in lbs. per sq. inch. For coef. see Table G.

TABLE I.

TANGENTIAL STRESS IN SEGMENTAL CORE.

System at rest and during action. Calculated for a maximum pressure of 62,619 lbs. per sq. inch. Computed for Section A only. The gun assumed to be unlined.

For what radius taken.	Compression between Segments. System at Rest.	Compression between Segments. During Maximum Action.
	lbs. per sq. inch.	lbs. per sq. inch.
At surface of Bore - - - - - -	100,006	0.
At ¼ distance to exterior surface - -	75,194	16,126
At ½ " " " - -	62,025	19,896
At ¾ " " " - -	54,299	22,073
At exterior surface - - - - - -	49,250	23,587

Internal pressure required to reduce the compression between segments to zero, from surface of bore to exterior surface, 129,480 lbs. per sq. inch.

This table concludes the mathematical verification of the strength of the Brown system of gun construction, and it has been demonstrated that the elastic strength of the guns constructed under the Brown system will be more than ample to sustain the most extreme powder pressures that will ever be demanded to meet the requirements of modern warfare.

TENSION OF WINDING.

There are several ways of producing an initial compression at the surface of the bore by winding with wire. Three systems require consideration. *First:* Winding with a *uniform tension.* *Second:* Winding under a *varying tension* so regulated that at the instant of *maximum action* the stress on each layer of wire will be the same. *Third:* Winding under a *varying tension* so regulated that in the *state of rest* the stress on each layer of wire will be the same.

UNIFORM TENSION.

The advantages of this system are ease of application and the fact that for the same gun, and initial compression, it admits of the use of the minimum tension during the process of winding.

Its disadvantages are that during the *state of rest* the outer wires are under a much greater strain than the inner layers; and, also, that during maximum action the outer wires are required to sustain a much greater strain than any wire would be required to sustain under either of the other two systems.

FIRST SYSTEM OF VARYING TENSION.

The advantage claimed for this system is that at the instant of maximum action the strain upon the wire jacket is uniformly distributed over each layer of wire.

This claim however is only theoretically true. The maximum action for which the wire will be wound will either be $P_0^{(1)}$ or $P_0^{(2)}$. If it is wound for $P_0^{(1)}$ it will not be true for $P_0^{(2)}$ and *vice versa,* and in neither case will it be true for the maximum powder pressure. The best that can be said for the system is that the strains will be more nearly uniform under maximum action than they would be with a uniform tension. Its disadvantages are difficulty of application and the fact that the system requires the use of the maximum tension in winding the inner layer of wire.

The wire under the shock of discharge, when supported by the surrounding wires, will stand a much greater strain than the single strand will during the process of winding. Therefore a system which calls for the maximum tension during winding should not be adopted, unless it can be shown to be absolutely necessary to insure the elastic strength of the system.

SECOND SYSTEM OF VARYING TENSION.

The only advantage of this system is that during the state of rest the wire will be under a uniform stress. This may be of considerable importance, as the state of rest is the ordinary condition of the gun. It is possible that such a system of winding will add materially to the life of the gun.

Had it been possible to produce this condition from breech to muzzle in a straight tapered gun, it would have been used in the 5-inch experimental gun. A system of winding which would produce this condition of tension at but one cross-section, did not appear to be of sufficient importance to warrant its use under the circumstances. It is possible however that it may b deemed wise to resort to it, in the construction of the Brow guns.

An examination of Birnie's four equations, A, B, C, D, which give the limiting values of P_0 in terms of the strength of the inner cylinder under initial compression, and the following equations to which they may all be reduced,

$$P_0^{(1)}=\frac{3(R_n^2-R_0^2)(\theta_0+C)}{4R_n^2+2R_0^2} \quad - \quad - \quad \text{Eq. A}'''.$$

$$P_0^{(2)}=\frac{4(R_n^2-R_0^2)\rho_0}{4R_n^2-2R_0^2} \quad - \quad - \quad - \quad \text{Eq. B}'''.$$

clearly demonstrates that the value of P_0 is a function of θ_0, ρ_0, R_n and C, and of these only. It is entirely independent of the manner in which this compression is produced. We may therefore use any system of tension that will produce this compression C, the magnitude of the tension being such as to maintain R constant without varying the value of P_0, provided that at the instant of maximum action the elastic limit of the wire is not exceeded. We have demonstrated, that with a wire which it is perfectly practicable to obtain, a uniform tension may be used with perfect safety, giving a large margin of safety.

LINING TUBES.

Writing Eqs. C and D as follows—

$$P_0^{(1)}=\frac{3(R_1^2-R_0^2)\theta_0+6R_1^2P'_1}{(4R_1^2+2R_0^2)-6R_1^2l}$$

$$P_0^{(2)}=\frac{3(R_1^2-R_0^2)\rho_0+2R_1^2P'_1}{(4R_1^2-2R_0^2)-2R_1^2l}$$

we have formulæ for the limiting values of P_0 in terms of the elastic strength of the liner, and a normal pressure of P'_1 on the exterior surface.

When the liner is introduced with the maximum initial compression: $P'_1=\frac{R_1^2-R_0^2}{2R_1^2}C.$

The general value of l is $\frac{R_0^2(R_n^2-R_1^2)}{R_1^2(R_n^2-R_0^2)}$

Making these substitutions and reducing we obtain

$$P_0^{(1)} = \frac{3(R_n^2 - R_0^2)(\theta_0 + C)}{4R_n^2 + 2R_0^2}$$

$$P_0^{(2)} = \frac{4(R_n^2 - R_0^2)\rho_0}{4R_n^2 - 2R_0^2}$$

which are identical with Eq. A‴ and B‴. Comparing with Eq. A′ and B′ we ascertain that the value of $P_0^{(1)}$ is increased by lining a Brown gun. That the value of $P_0^{(2)}$ for a lined gun is to its value for an unlined gun as ρ_0 is to ρ_1. It is therefore important to obtain a lining tube of high physical conditions.

Now to obtain exceptionally high physical conditions in a liner the tube must be thin. An examination of these equations shows that the limiting values of P_0 are entirely independent of the thickness of the liner, as R_1 does not enter into either equation. It will be merely necessary to construct the liner sufficiently thick to sustain the longitudinal stress.

When a liner is introduced without any initial compression, as was done in the Russian guns, we have $P'_1 = 0$, and

$$P_0^{(1)} = \frac{3(R_1^2 - R_0^2)\theta_0}{(4R_1^2 + 2R_0^2) - 6R_1^2 l}$$

$$P_0^{(2)} = \frac{3(R_1^2 - R_0^2)\rho_0}{(4R_1^2 - 2R_0^2) - 2R_1^2 l}$$

Reducing we have

$$P_0^{(1)} = \frac{3(R_n^2 - R_0^2)\theta_0}{4R_n^2 + 2R_0^2}$$

$$P_0^{(2)} = \frac{3(R_n^2 - R_0^2)\rho_0}{4R_n^2 - 2R_0^2}$$

Comparing with Eq. A′ and B′ we see that the two values of $P_0^{(1)}$ for a lined and unlined gun are equal only when $\theta_0 = C$, and that $P_0^{(2)}$ is reduced one-fourth by this method of inserting the liner.

The longitudinal strength of liner one-twentieth caliber thick has been shown in Table D.

THE 5-INCH EXPERIMENTAL GUN.

The verification of the curves contained in the plates will be found in the appended Table M.

TABLE M.

VERIFICATION OF PRESSURE CURVES FOR 5-INCH EXPERIMENTAL GUN.

Distance from bottom of Bore.	Diam. of Bore.	Exterior Diam. Segmental Core.	Exterior Diam. Wire Jacket.	$\log_e \delta$	Tension on Wire.	Compression between Segments at Surface of Bore C.	Value of M	Maximum Pressure which may be used in gun, P_0.	Maximum Powder Pressure which will be used.	Remarks.
inches.	inches.	inches.	inches.			lbs. per sq. inch.		lbs. per sq. inch.	lbs. per sq. inch.	
0	5.25	11.00	15.62	0.82420	125,000 lbs. per sq. inch.	103,025	0.612	63,108	52,000	The first three values of M are for the chamber.
20	5.25	10.60	14.94	0.82194		102,424	0.603	61,750	52,000	
40	5.25	10.20	14.26	0.81384		101,730	0.591	60,152	52,000	Powder pressure computed by Sarrau's method.
60	5.00	9.80	13.58	0.80817		101,021	0.607	61,320	41,386	
80	5.00	9.40	12.90	0.80273		100,342	0.593	59,502	32,134	
100	5.00	9.00	12.22	0.79750		99,704	0.576	57,420	27,243	
120	5.00	8.60	11.54	0.79261		99,722	0.558	55,284	23,964	
140	5.00	8.20	10.86	0.78837		99,732	0.535	52,722	21,515	
160	5.00	7.80	10.18	0.78581		98,362	0.508	49,899	19,600	
180	5.00	7.40	9.50	0.78489		98,122	0.477	46,799	18,000	
200	5.00	7.00	8.82	0.78820		98,526	0.439	43,252	16,941	

TABLE M [CONTINUED].

VERIFICATION OF CURVE OF LONGITUDINAL STRESS ON SEGMENTAL CORE 5-INCH EXPERIMENTAL GUN.

Distance from bottom of Bore.	n'	P'_2	lP	P_2	$2n'$	$2n'P_2$	P	$2n'P_2 - P$	$3n' - 3$	Longitudinal Stress on Segmental Core.
		lbs. per sq. inch.	lbs. per sq. inch.	lbs. per sq. inch.			lbs. per sq. inch.			lbs. per sq. inch.
0	4.84	39,669	6,229	45,898	9.68	444,290	52,000	392,290	11.52	34,052
20	4.49	38,875	6,465	45,340	8.98	407,158	52,000	355,158	10.47	33,921
40	4.16	37,986	6,954	44,940	8.32	373,897	52,000	321,897	9.48	33,920
60	3.84	37,000	5,972	42,972	7.68	330,028	41,386	388,642	8.52	33,878
80	3.53	35,709	5,018	40,727	7.06	287,527	32,134	355,438	7.59	33,655
100	3.24	34,586	4,621	38,207	6.48	253,350	27,243	226,107	6.72	33,647
120	2.96	32,288	4,432	36,660	5.92	217,128	23,964	193,164	5.88	32,851
140	2.69	31,410	4,365	35,775	5.40	193,187	21,514	171,673	5.10	33,661
160	2.43	29,454	4,338	33,792	4.86	164,229	19,600	144,627	4.29	33,713
180	2.19	27,183	4,469	31,652	4.38	138,636	18,000	120,636	3.57	33,793
200	1.96	24,490	4,715	29,205	3.92	114,487	16,941	97,546	2.88	33,870
220	1.74	21,304	5,025	26,329	3.48	91,624	15,921	75,703	2.22	34,101

TABLE M [CONCLUDED].

VERIFICATION OF CURVES OF STRESS ON WIRE IN 5-INCH GUN.

Distance from bottom of bore.	Value of n	Value of n'	$1-\frac{n'+2}{3n'}\log_e\delta$	Tension of winding.	Stress on inner layer during Rest.	Stress on outer layer during Rest.	$\frac{n'+5n}{3n(n'-1)}$	Powder Pressure.	Increase of Stress on inner layer during Action.	Stress on inner layer during Action.	$\frac{2}{n-1}$	Increase of Stress on outer layer during Action.	Stress on outer layer during Action.	Remarks.
inch.					lbs. per sq. inch.	lbs. per sq. inch.		lbs. per sq. inch.	lbs. per sq. inch.	lbs. per sq. inch.		lbs. per sq. in.	lbs. per sq. inch.	
0	9.76	4.84	0.6115	125,000 lbs. per sq. inch.	76,434	125,000	0.468	52,000	24,318	100,752	0.228	11,856	136,856	The stress on wire is here calculated for powder pressures. To ascertain stress on wire at the instant when the compression at the surface of the bore is reduced to zero, see Tables F and G, adding one per cent. to allow for the increased tension of winding used in the 5-inch gun.
20	8.93	4.49	0.6053		75,067	125,000	0.526	52,000	27,331	102,398	0.252	13,104	138,104	
40	8.13	4.16	0.5982		74,775	125,000	0.580	52,000	30,163	104,938	0.280	14,560	139,560	
60	7.38	3.84	0.5903		73,787	125,000	0.648	41,386	26,815	100,602	0.314	12,995	137,995	
80	6.66	3.53	0.5808		72,600	125,000	0.729	32,134	24,141	96,741	0.354	11,375	136,375	
100	5.97	3.24	0.5702		71,275	125,000	0.825	27,243	22,522	93,797	0.402	10,952	135,952	
120	5.33	2.96	0.5542		69,275	125,000	0.945	23,964	22,641	91,916	0.462	11,071	136,071	
140	4.72	2.69	0.5428		67,850	125,000	1.099	21,515	23,652	91,502	0.538	11,575	136,575	
160	4.15	2.43	0.5225		65,312	125,000	1.302	19,600	25,519	90,821	0.634	12,424	137,424	
180	3.61	2.19	0.4994		62,425	125,000	1.570	18,000	28,267	90,692	0.766	13,728	138,788	
200	3.11	1.96	0.4692		58,650	125,000	1.656	16,941	33,112	91,762	0.948	16,060	141,060	

For the verification of the curve of longitudinal stress on trunnion jacket see report of test of cylinder No. 2, which forms a part of this paper.

The liner extends for eighty inches into the bore, the chase being left unlined.

The maximum longitudinal thrust can be determined as follows (for formulæ see Table D):

$n = 8.13$ $n' = 4.16$ $n'' = 1.20$ $P'_1 = 4980$

$P = 52000$ $l = 0.8100$ $lP = 42120.$

$P_1 = P'_1 + lP = 4980 + 42120 = 47100.$

$A = 4.00$ $AP_1 = 188400$ $B = 3.333$ $BP = 173334$

$D = 0.1055$ $DP = 5486$

Total longitudinal stress on lining tube during action

$= DP + AP_1 - BP = 20{,}552$ lbs. per sq. inch.

The physical condition of the metal is as follows:

Tensile strength, 80,000 lbs. per sq. inch.

Elastic limit, 140,000 lbs. per sq. inch.

Elongation in 25 mm., 18 per cent.

Factor of safety for rupture=6.8, for elasticity=3.8.

Compression at surface of bore=80,000 lbs. per sq. inch.

Value of P_0 Eq. B″ for Section A=74,420 lbs. per sq. inch.

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FIELD-ARTILLERY DRAFT.

By First Lieutenant A. D. SCHENCK, Second Artillery, U. S. A.

(CONCLUDED.)

Our old smooth bore gun was designed to meet the conditions when "it was possible to stand safely at a distance of one mile from the enemy's guns, when very little was thus demanded from the mobility of the artillery, and field-artillery required to trot only a few hundred paces, horse artillery to trot 1000 and gallop 500 paces, to do all that was necessary or possible." But even then we had a very different country, roads, &c., from European conditions, and we therefore find our loads less than those of European services. Our material was designed after thorough consideration during many years, by several boards composed of our ablest and most experienced artillery and ordnance officers, having before them the vast experience gained by the artillery during the Napoleonic wars, as well as the exhaustive experiments, charges and recommendations which followed soon after the close of these wars.

They may not in their day have known as much respecting modern ballistics and gun construction as the officers of the present day, but they certainly knew quite as much about a horse and of his capabilities under the conditions of artillery service. Powerful guns were just as ardently desired and demanded in those days as now, while the question of ammunition supply with a battery was even more urgent than now.

When the guns could and generally did come into action at point blank range with comparative safety from infantry fire, the rapidity of artillery fire was astonishing, compared with anything that can now obtain or that is permitted. Consequently we can safely assume, aside from any verification of the facts, that the maximum loads which the conditions of efficient artillery service permitted were imposed upon the teams.

Emphasis is given to this assumption when it is remembered that our old conditions, in order to assure the necessary ammunition supply with the battery, called for 12 caissons each for the light and heavy 12-pounder batteries. Had it been deemed practicable to have increased the loads and thereby reduce the number of the carriages, twelve caissons to a battery never would have obtained in the days when the artillery "*train*" was damned by the other arms of the service to an extent now unknown. During the time of our war, railroads and other methods of steam transportation rendered it possible to insure a certain and speedy supply of ammunition near to the scene of operations of an army, thus making it possible to reduce the number of caissons with a 12-pounder battery to six, giving only 128 rounds per gun with the battery. But with the advent of the rifle field guns, resulting in nearly or quite doubling the weight of the projectile, the number of caissons has again been increased to eight or nine in order to carry even a reduced number of rounds per gun with a battery.

Unquestionably the advent of the rifle gun and musket, together with the tactical methods employed, have very greatly increased the demands for a more perfect mobility, and the loads for our old guns were either less than the conditions required, or our predecessors did not know what they were about when determining them. The latter assumption would certainly be a very unsafe one to make. Our artillery horses remain practically the same from generation to generation, and the open country and in fact the roads as well. A ploughed field or cultivated land is just as hard to get over now as it ever was, despite the preponderating necessity for such vast increased mobility. It may, then, be unconditionally assumed that under no circumstances should our old loads be exceeded, and it is a matter of grave doubt whether the necessary mobility will exist for the future if we now adhere to them, especially those of the horse and light battery caissons. But let it be assumed that this can be done and meet the modern demands for greatly increased mobility. The average artilleryman with clothing, &c., weighs about 160 pounds and his knapsack 29, and with these the loads behind artillery teams for our old smooth bore field batteries were:

	CAISSONS.			GUN-CARRIAGES.		
	6-pounder horse.	12-pounder light.	12-pounder heavy.	6-pounder horse.	12-pounder light.	12-pounder heavy.
Carriages, lbs.,	3183	3865	4467	3493	3811	3856
Cannoneers, lbs..	. . .	480	480	. . .	960	960
Knapsacks, lbs.,	. . .	87	87	. . .	174	174
Totals	3183	4432	5034	3493	4945	4990

It is now in order to see what conditions exist with our new material, viewed in the light of the evident modern demand for greatly increased mobility over what the above represented. The new drill regulations gives the battery organization six guns and nine caissons. There are eighty-four cannoneers, five carried at need on each gun-carriage and six on each caisson.

In order to secure the most powerful gun and to carry the greatest possible weight of ammunition, the knapsacks are no longer carried on the carriages but on a separate wagon. This fact must be particularly noted, as we now have to deal with dead weight—save that of the cannoneers—and the latter can no longer remove the knapsacks and thus further reduce the loads when dismounted to get over exceptionally tight places and bad roads. We have:

	GUN-CARRIAGES.			CAISSONS.		
	3.20, horse.	3.20, light.	3.60, heavy.	3.20, horse.	3.20, light.	3.60, heavy.
Carriages, lbs.,	3793	3927	. . .	3848	4758	. . .
Cannoneers lbs.,	. . .	800	800	. . .	960	960
Total lbs	3793	4727	. . .	3848	5718	. . .
Old U. S. lbs.,	3183	4432	5034	3493	4955	5034
Present excess "	610	295	. . .	355	773	. . .

The dead weight of the new light battery caisson is 4758 pounds. What this means to artillery officers who served during the war will become apparent by comparing this weight with that of the old battery wagon for the park (not the lighter one for the battery), weighing 4915 pounds, which was considered the perfection of an artillery horse-killing machine even for slow marching over good roads. The new caisson has a dead weight of only 157 pounds less than for the old battery wagon, with the cannoneers mounted the *load is 1197 pounds greater,* a load of 953 pounds per horse, that for an old slow going siege gun with eight horses being only 925. Does any sane man believe that such a load is possible in a light battery in our service?

As a proper means of determining directly whether any increase of our old loads is possible, we can start with the horse artillery team and determine the work done by its horses, as compared with that done by the cavalry horse, and then compare the work done by the teams of the various batteries with each other. Not only should this work be properly related to expected conditions in war, but these conditions are such that the relations between the loads for all the batteries should compare favorably among themselves, and present a substantial agreement as to the amount of work required of the teams.

For the horse artillery serving with the cavalry in order to maintain efficiency, there must be a substantial equality of work required of the horses in the two arms of the service when marching together. The direct measure of comparison is,

Cavalry, 280 lbs. weight carried 25 miles a day at a walk.

Artillery, 125 lbs. tractive force 25 miles a day at a walk, or for a team of 6 horses, 3633 lbs. hauled 25 miles a day at a walk.

It may first be noted that, considering the fact that the near wheel horse carries 235 lbs. on his back,—one pound more than the cavalry horse carries—and the near swing and lead 226 lbs., the off horses also carrying from 96 to 101 lbs., it will be seen that the near horse for equal marches has as much work to do simply carrying his rider and equipments—234 lbs.; with doubletrees to "equalize" his work with his more fortunate mate! Put the driver on the off horse for the "relief" of the near horse, as the former has to carry the driver's kit his load will become from 256 to 261 ℔s., 22 to 27 more than for the cavalry horse, and the off horse does not appear to come in for much "relief."

Within the narrow limits here considered the work will vary as the loads or distance, and from the above the cavalry horse will carry 234 ℔s. thirty miles a day at a walk performing the same amount of work required to carry 280 ℔s. twenty-five miles a day. Reducing to the regular march there will obtain,

Cavalry 234 ℔s. 25 miles a day at a walk.
Art'y gun 3183 ℔s. 23.77 miles a day at a walk.
Art'y caisson 3493 ℔s. 21.70 miles a day at a walk.

From which it appears that, even with the otherwise apparently light loads for horse artillery, when it comes to marching as it is well known that our cavalry can and often has marched, given strict equality as to horses, condition, &c., with those for the cavalry the artillery horses will, for the regular distance of march be handicapped—the gun-teams 1.23 and the caisson teams 3.28 miles a day for each and every marching day, or relatively the same proportional handicaps for any assigned distance for a days march. Unquestionably the fact remains that the artillery is only required to make the actual march, whereas the cavalry has in addition to cover extra distance in scouting, picket duty, &c., but this will not amount to as much as from 1.23 to 3.28 miles a day extra for each trooper for every marching day, to say nothing of the fact that his horse is more or less free to pick his way while the artillery horse is laced up in harness and compelled to keep to the road. That such disparity really existed and to a much greater extent, is testified to by both Generals Hunt and Tidball, in describing the double set of horse batteries existing in the horse artillery of the Army of the Potomac, the only reason given for the necessity is the fact that one brigade attached to the reserve could recuperate and refit while the other was on active duty with the cavalry, the trying nature of the services of the horse batteries with the cavalry necessitating this alternation. Imagine a double set of horse batteries in any European army! or even in our own if we had a due proportion of horse artillery. Yet this is exactly what we would have to come to again unless we have more perfect mobility than we had during our late war, and no more convincing proof of this fact is necessary than the organization and its uses, perfected by General Barry and maintained to the end by General Hunt.

It thus appears that even a load of 3183 lbs. for horse artillery is too heavy to enable the teams to keep up with the cavalry, when it is worked up to its capabilities, and that the 3493 lbs. of load for the caisson is decidedly too heavy to insure efficiency in war, *and at the same time enable the artillery to maintain its horses in anything like equally good condition with those of the cavalry*, which it is absolutely necessary we should be able to do if we are to avoid the necessity of a double set of horse batteries for service with the cavalry. But for the present let it be supposed that 3183 lbs. load will leave us upon an equality with the cavalry, under all of the general conditions of war service, except continuous marching of twenty-five miles a day for considerable periods. If we can only keep in the running we can stand the poorer condition and extra loss of horses, though we should not be called upon to do so, as such matters will inevitably be charged to the inefficiency of artillery officers when the contrary may be the real fact. This load of 3183 lbs. can then be taken as a unit for comparison, with the teams of the other batteries to determine the amount of work they will have to do under their conditions of service as measured by this unit. The normal marches for which the loads have been calculated are—horse, 25 miles in 8 hours; light, 15 in 7½; and heavy battery 12 miles in 6¾ hours. From the *Aide Mémove*, R. E., to reduce to the same relative rate of marching, the proportionate loads for the different rates are:

For 3 miles per hour 1.
For 2 miles per hour 1.17.
For 1.8 miles per hour 1.19.

LOADS REDUCED TO THE SAME RATE AND TIME.

	GUN-CARRIAGES.			CAISSONS.		
	Horse.	Light.	Heavy.	Horse.	Light.	Heavy.
Actual loads, lbs.	3183	4432	5034	3343	4612	5034
Reduced loads, per cent.	100	111	112	104	117	112

CANNONEERS DISMOUNTED.

	GUN-CARRIAGES.			CAISSONS.		
	Horse.	Light.	Heavy.	Horse.	Light.	Heavy.
Actual loads, lbs.	3183	3632	4234	3343	3652	4274
Reduced loads, per cent.	100	73	93	104	73	93
Mean loads, per cent.	100	92	93	104	95	103

The results are what might have been expected. Going back to the measure of tractive force, it will be remembered that for horse artillery, this was taken as the full power of a good horse over good roads in the shortest time. The tractive force for the other batteries was assumed at what was supposed to be a fair limit for artillery service, at the same time indicating that the forces were probably too high, which the above comparison would indicate to be true to the extent of 11 and 12 per cent. respectively. But it must be remembered that the loads for horse artillery are permanent ones, while those for the other batteries are not so, as the cannoneers can be dismounted in order to relieve the teams whenever necessary and the gait will permit. While the former may apparently have an advantage over the latter when carrying the men, this is changed to a greater advantage the other way when they are not carried on the carriages, while the average conditions for actual service marching are much the same for all. However the fact must not be lost sight of, that the real test of efficiency as regards mobility is the ability "to get over many miles at a fast trot * * * be able in war to get over sixty miles when we are ordered to do so at whatever cost," and whenever a trot is taken the total load becomes for the time a permanent load. But the roads will favor the mounted batteries most, as being in general better than those over which the horse batteries with the cavalry will be required to march. Consequently, although the loads for the latter, light as they appear by direct comparison with those for the mounted batteries, or with those in some foreign services under much less rigorous conditions as to cavalry marching with the ponderous European loads for cavalry, as well as character of roads, &c., are really heavier than for either of these batteries. Of course the caisson appears at a disadvantage as each, except that for the heavy battery, is handicapped by the additional weight of a spare wheel, but these without the spare wheel would have the same weight as the gun carriage, except those for the heavy battery, which being this much less in weight would give a more favorable comparison.

It is now in order to go back to the consideration of the points respecting mobility raised by Prince Hohenlohe, already quoted, and it may be reiterated that our old smooth bore guns and material were designed to meet the conditions when "it was practicable to stand safely at a distance of one mile from the enemy's guns, when very little was thus demanded from the mobility of the artillery. * * * In war, many miles must often be passed over at a fast trot, * * * we shall then be able in war to get over sixty miles when we are ordered to do so at whatever cost." This latter of course means thorough training as well as proper loads behind the teams. But it is clearly evident that all of this distinguished artillerist's wise and conservative contentions involve an improvement in mobility over what already existed. In every service this vital question has received and is now receiving constant and careful consideration. As already stated the German artillery have already acted, reducing their loads from 250 lbs. in the heavy batteries, to from 420 to 460 for the gun and caisson team respectively, in the horse and light field batteries.

It has already been shown that instead of a reduction from our old measure of mobility, such as the demands for greatly increased mobility so imperatively demand, most certainly as respects the loads for the caissons if not for the gun-carriages; we have been saddled with an increase of 610 lbs. for a horse artillery gun and 295 for a light field gun, while their respective caissons have been increased in weight 355 and 773 lbs., giving loads which are clearly preposterous, especially for the light field caisson, the team for which at a trot will be required to pull more pér horse than those for our old siege gun moving at a walk.

What the results will be for the 3.60 heavy field gun remains to be seen.

PRESENT, PAST AND REQUIRED LOADS FOR FIELD ARTILLERY.

	GUN-CARRIAGES.			CAISSONS.		
	Horse.	Light.	Heavy.	Horse.	Light.	Heavy.
Present loads, lbs.	3793	4727	. . .	3848	5718	. . .
Past (old U. S.) loads, lbs.	3183	4432	5034	3493	4945	5034
Required loads, lbs.	3183	4432	5034	3343	4612	5034
Required reduction, lbs.	610	295	. . .	505	1106	. . .

The reductions from our present loads here indicated, are necessary in order to secure loads behind the caisson teams sensibly the same as for the gun teams, which are in each case the maximum which can be pulled under service conditions. It is evident that when the artillery has to maintain a fast trot in order to come promptly into position on the battle-field, and whenever practicable taking to the sides of the road in order not to interfere with the infantry, there can be little difference between the weights of the gun-carriage and the caisson. For if the heavy caisson could be hauled under such conditions, it would be conclusive evidence that the gun-carriage could be given the same weight. If the gun-carriage cannot be given this weight, neither can the caisson.

In view of the demand for perfect mobility, our present excessive loads would appear to be bad enough. But they are not the only, nor by any means the most serious impairment to mobility, though it would seem that nothing worse than these great increases in loads could be in store for our artillery horses.

It has already appeared that for artillery carriages the angle of traction is limited to 7°, which was the angle for our old carriage and harness. From measurements made with horses 15¾, 15½ and 15¼ hands high, representing the average wheel, swing and lead horses, with *well fitted collars* and hames, it appears that the points of attachments at the hames are 50, 49 and 48 inches respectively from the horizontal plane on which the horses stand. These distances, height of trace hooks, of axis of the axle and length of traces and tugs will, under the supposition that the trace hooks rise to the plane of the traces, give the following angles :

Inclination of wheel traces	9°.09′.
" " wheel tugs,	23.07.
" " swing traces	1.37.
" " swing tugs	3.20.
" " lead traces	0.06.
" " lead tugs	0.06.

As the trace hooks are below the plane of the traces, it is evident from the construction of the limber, that they can only be raised to this plane by an infinite pull, and consequently the actual angle of the trace or angle of traction is nearer 10° than 9°. But an angle of 9°.09′ is bad enough in all conscience. Entering the formulas for the load with this angle we have :

	GUN-CARRIAGES.			CAISSONS.		
	Horse.	Light.	Heavy.	Horse.	Light.	Heavy.
Present loads, lbs.	3793	4727	. . .	3848	5718	. . .
Col. Kemmis, lbs.	2428	3655	4108	2588	3835	. . .
Ratio, lbs.	2421	3440	3862	2581	3620	. . .
Increase, lbs.	{ 1365 1372	1072 1287	. . . . . .	1260 1267	1883 2098	. . . . . .

In other words, considering only the loads for the gun-carriages, after combining the actual increase of our loads with the unfavorable conditions under which our teams are now compelled to pull, we have a virtual increase of the loads of from about 1100 to 1400 lbs. ; for the light battery caisson from about 1900 to 2100 lbs. increase in the load above what it should be. Comment is unnecessary.

It is contended that the double-tree is an unnecessary instrument of torture to the overburdened near horses, and should be discarded, single-trees and all, as the latter possess no real value when the spring tug-links are used. It is claimed that the single-tree facilitates removing the teams, but a cannoneer on each side of the carriage, or the driver alone, can unhook the traces and throw them over the horse's back just as quickly as the single-trees can be unhooked and fastened on the saddles. But concede single-trees. The removal of the double-tree will lengthen the wheel traces about five inches, and the trace hooks can then be placed at the proper height. Both of these changes will reduce the present angle of traction, and it can then be further reduced to the proper angle by lengthening the pole some six inches, and also lengthening the tug somewhat. When calling attention to the weight carried by the near wheel horse, no account was taken of the pole, neck-yoke, or of the fact that a force of sixty-five pounds was extered in the direction of the traces. Determine what this force becomes in the direction of the tug when standing at an angle of 23°, and then the vertical component thereof, and some idea will be had of the real load the horse has to carry. Counting this component, weight of collar and hames, pole, neck yoke, &c., and it will become evident that the horses neck will be lacerated in short order in actual marching with loaded carriages.

This is one of the most serious aspects of the present lamentable state of affairs with our new material, and it may be well to quote Major Dwyer, *Seats and Saddles*, p. 205, *et seq.* * * * "the best disposition of the traces in draft is when they are perpendicular to the collar. * * * The rule in the *Artillerist's Manual* is therefore so far correct, but it is neither altogether so, nor does it go far enough. For the essential thing is that the trace should be perpendicular to the horse's shoulder-blade, through which the effort is made, and whose form cannot be altered, and not through the collar, and consequently the underlying shoulder-blade to which the trace should be attached, which is a matter of very great importance * * * the shoulder-blade in fact *rotates on its centre which is fixed*, whilst the upper and lower ends are movable, * * * the attachment of the trace so low down on the hames * * * to bring the pull opposite, or nearly so, to the articulation of the shoulder-blade with the arm-bone; * * * this is precisely what one sees every day, and all day long, in hundreds of instances on our roads and streets, * * * with a drawing of an off leader, showing the trace attached to the hames exactly opposite to the shoulder point. And where is it that horses most frequently get sore necks from the collar? Why, just within a few inches of this very same unlucky spot, either higher up or lower down, or on the other hand opposite the other movable end—that is, at the top of the shoulder-blade. * * * When the trace is attached to the collar very low down, the upper end of the latter will very often lose all contact with the upper part of the shoulder. * * * The fair and inevitable conclusion to be drawn from all this is, of course, that the trace should be attached as nearly as possible opposite to the immovable part of the shoulder-blade—that is to say, to its centre."

In the Ordnance Report, 1887, p. 446, will be found illustrations of our artillery harness, "showing the trace attached to the hames exactly opposite the shoulder point." Also showing even when the horse is at rest that "when the trace is attached to the collar very low down, the upper end loses all contact with the upper part of the shoulder." When the horses are in motion every collar in a battery will ride forward at top, and the want of contact with the shoulder becomes very apparent, and the reason for the "unlucky spot" where sore necks most frequently occur also becomes apparent. But the Major does not appear to point out clearly the reason why sore necks occur at the upper movable end of the shoulder-blade. He gives a front view of a horse to show that the "symmetrical oval figure (of the collar) that pleases the eye, will not fit the horse." Neither will a collar that does fit the horse exactly *when at rest* fit him when in motion. For the moment a horse is put in motion, the tops of the shoulder-blades not only move backward and forward, but they also rotate *outward*, very sensibly increasing the thickness of the shoulder at this point, and this is the chief reason why sore shoulders occur at this point with a proper fitting collar—when the horse is standing still. Any one can readily verify the motion indicated by walking a horse, with the hand over the tops of the shoulder-blades, fingers on one side, thumb on the other. To correct this evil it is necessary to give the hames a proper shape as well as the collar, otherwise they will spring a properly shaped collar out of shape and injure the shoulders. But the main contention of course is to place the point of attachment "at the centre of motion" of the shoulder-blade.

Just where this point is for a given class of horses is not readily determined, and it does not appear to be at the centre of the shoulder-blade, though the Major in his conclusion would seem to indicate this point. As nearly as can be determined thus far, at a trot this centre of motion is 83.5 per cent. of the standard height of the horse from the horizontal plane on which he stands. This will require the attachment on our hame to be moved a fraction over two and one half inches higher up on the hames. In determining the angle of traction, the length of the trace, tug, &c., the heights of attachment for wheel, swing and lead horses must be at least as great as above given, and possibly nearly or quite an inch more in each case.

Our artillery horses are quite straight shouldered, the angle generally being about 11° and 12°. The angle of tug should be the same measured from the horizon, and for the wheel horse should be as near this as possible though requiring a longer tug, as the downward pull on his collar is increased by the weight of pole, &c. For the other horses this angle cannot be approximated, nor is it very necessary that it should, provided that the attachment be at the "centre of motion." Then the collar will set properly throughout its entire length, the top having no tendency to ride forward, and the friction against the shoulders will be at a maximum and the tendency to slip,—be pulled down by the tug,—caused by an unfavorable angle of the tug will be lost. Again, *this point does not move forward and backward*, consequently the single-tree is not needed to "compensate" for such motion, but which does exist when the horse moves, for the tug when attached near the shoulder-joint. With the attachment at the centre of motion the supposed *raison d'être* for the single-tree disappears. It is contended by many that when the horses "break step" the single-tree affords no compensation, as when the shoulder of one goes back, that of the horse in front moves forward, consequently the single-tree will remain stationary. As all of our tugs are attached very low down and work against the shoulder-joint, there is a very appreciable backward and forward movement, and the single-tree does move whether the horses keep or break step. The reason for this is the very one that renders the single-tree unnecessary, contradictory as this may appear.

When all the horses are in draft the combination of traces supported by the swing and wheel tugs, virtually forms what may be called an inverted and elastic catenary, so to speak, which acts as a spring to relieve the horse's shoulders from any ordinary extra movement into the collar. As these movements are unequal, sufficient force is transmitted to the single-tree to move its ends. But if the single-tree were not there, the catenary spring will still exist, and its play is ample to afford relief to all backward and forward motion. But what it is not equal to is the sudden surge of a horse into the collar when the draft of the other horses is slack, straightening the line of trace directly back to the trace hooks; this is what bruises the shoulders so frequently, and as both shoulders act at the same time the single-tree affords no relief whatever, and is utterly useless with this elastic catenary system of traces. But what does afford a sure relief for such sudden surges into the collar, is the spring tug-link, the elasticity is certain whether the force be applied to one at a time or to both together. Fit the collar and hames properly and attach the tug at the centre of motion of the shoulder-blade, and with the spring tug-link, every imaginable virtue for either double or single-tree, or both combined, disappear, *for artillery teams hitched as in our service.*

The rigid splinter bar was not responsible for the sore shoulders of our horses, it afforded the only practicable means of equalizing the work done by the horses of a team, instead of compelling the horse carrying the driver also to pull as much of the load as his yoke-fellow with far less weight to carry, and for artillery purposes as it was for those of the old postilion coach, is far superior in every respect to the double-trees, provided always, that the collar fits properly and the traces are properly attached thereto. It is to be hoped that we will one day be able to get steel collars of proper shape and with proper attachments and at the same time get rid of a dozen or more pounds weight of collar and hames. The authorities say that a horse can pull seven times as much as he can carry; this would mean that every pound taken off in harness would enable the team to pull forty-two pounds more load. By getting rid of a dozen pounds for each collar our teams may not be able to pull 504 pounds more load, but they certainly will be able to pull a given load with greater ease and comfort, as well as with far less danger of lacerating the top of the neck.

With regard to the trace Major Dwyer says, * * * "it is altogether a mistake to suppose that a short trace of itself confers a greater mechanical advantage on the motor (horse) than a longer one, * * * shows very plainly that the angle of traction may be made more favorable with a long than with a short trace. * * * A well arranged series of experiments shows that Fehrmann's horse-savers (*i. e.* tug-links) afforded an increase of tractional power to the horse amounting to from 18 to 20 per cent.; a dimminution of the shock transmitted to the legs and breast of 22 to 33 per cent., and wear and tear of vehicle and harness of the same amount."

The reason for the increased tractive power is no doubt that every unusual effort of the horse, however slight is not lost in shock but stored up in the spring, and given off again in the work of drawing the load. It appears that these springs have especial value for use with springless carriages such as our artillery carriages. Attention has been called to the fact that our present wheel traces must be lengthened in order to secure a more favorable angle of traction. To secure a proper one the trace-hooks must be raised until they come almost into the plane of the traces when at 7°, which will probably necessitate discarding the double-tree. The question of double-tree *vs.* the splinter-bar is a mere bagatelle compared with a proper angle of traction. We have, and can continue without any tug-links to get along very well with a rigid splinter-bar and the worst fitting collars imaginable, but we can never get along with an angle of traction that handicaps our teams 1100 to 1400 or more pounds, even with the supposed aid of all the double and single-trees ever invented. If the gain in the tractive force due to the use of the tug-link is to be relied on, it would appear that we can use this gain as a "factor of safety" and adhere to our *old loads for the gun-carriages*, and still virtually secure a considerable increase of mobility without change of weight, provided always that we *secure an angle of traction not greater than 7°*. With the present angle all the gain that may possibly be due to the use of the tug-link is lost by reason of this unfavorable angle, the loss being just 20 per cent. of these old loads. If we adhere to the double-tree we compel the near horses to do 57 to 60 per cent. more work than the off horses, without either the unfortunate horse being able to prevent it by lagging, or the driver by keeping up the off horse to his work, the near horse will be broken down in short order.

So long as we must have a *brake* which gives only a dead lock, and cannot be used to hold back the carriage going down the constantly recurring little pitches in the road, which do not call for or will not permit of a dead lock, the present length of pole is too short, and should be increased whether the length of the wheel trace required it or not. With a proper brake the conditions of draft of the wheel horses,—by far the hardest worked team—,would be vastly improved; the breeching could be fastened directly to the traces, the martingale discarded and the harness made similar to that seen all over this country "every day and all day long." The brake could be applied at any time and with any degree of force, even on the drill ground, and just as readily and effectually as it is on any farm wagon in the land.

Finally, attention should be called to the article of Captain Nordstrom in a recent number of the *Cavalry Journal.* The progenitor of our bit was brought into Spain by the barbaric Moor, brought from thence to Mexico by the scarcely less barbaric *conquistador,* and from the latter country found its way into our service. Any one who knows this bit well and loves a horse upon which he has to use it, will plead guilty to being more or less a barbarian himself therefore, though he may also plead in extenuation that he is compelled to do so by the military powers that be, over whom he has no control and no influence.

APPENDIX.

Our present *brakes* are unserviceable. They are continually falling down and getting bent or broken, even when manœuvring over smooth and level turf. To lighten the gun for service with horse artillery, it is proposed to remove the seats from the gun-carriage without any provision for securing the brakes. Even with this provision they cannot be applied on the march without necessitating the dismounting of a cannoneer, and when the march is a rapid one this is impracticable. For use on the road this brake has little value at best, as it will only give a "dead lock," and cannot be used on the constantly recurring small or slight descents which will not permit of a dead lock, yet which, without the intervention of a good brake, are the very ones which continually worry the already overburdened wheel horses and lacerate their necks.

No competent engineer would for a moment think of attempting to strengthen a beam by spreading additional metal along its length, as is done with the axle of our carriage, insuring the maximum of weight for the minimum of strength, when exactly the reverse conditions are the very ends sought for in such constructions, and when secured it is always done by tying the ends of the axle to the trail by means of the ordinary tie-rods. These at once afford a support for a brake-rod, to the ends of which the ordinary brake-blocks are secured, the brake being set-up by means of a lever just such as is used on every wagon in the land. Probably the most convenient as well as by far the most powerful means of setting-up the brake being a pair of "compensating" toggle, or elbow joints—when one is at its maximum of power the other being at its minimum, affording a leverage of extraordinary power if desired, but which can be regulated at will by setting the brake-blocks more or less close to the tire. When the gun is fired with the present brake, the latter is at once sprung to its limit giving a dead lock, and the full violence of the shock of recoil must be sustained by the carriage, straining the wheels, axle and trail in the most vicious manner possible, necessitating a ponderous weight of wheel and carriage to withstand such savage treatment. But with friction brake-blocks this vicious action is avoided, for no matter how tightly set-up, at the first and most violent shock of recoil the wheels will slip on the brake-blocks, and by revolving will give relief to the entire system—wheels, axle and trail. As the violence of the recoil becomes less, a dead lock ensues at the latter and less violent end of the recoil, finally bringing the carriage to rest with but little if any greater distance of recoil than before.

With the mounted batteries such a brake can be applied by a cannoneer on the seat at any moment, and with any degree of force suited to the descent. With a horse battery a line is led from the brake-lever to the wheel team, on precisely the same principle that is in use by our army teamsters but with this difference; the teamster has a very long lever which he can readily work from his saddle, while for the artillery carriage the lever must be short and provided with a ratchet and stop, similar to those used on our locomotives for the reversing-lever, except that the rear part of the ratchet is cut away to leave the stop free to slide over it when the lever is pulled to the front. To release this stop, small thimbles are sewed to the line at short intervals, through which a stout cord is led and attached to the spring-catch, with a loop at the driver's hand, and a flexible spiral spring over the end at the catch to take up a small amount of slack, so that when grasping the line to set the brake the catch may not be pulled up and prevent the brake setting. A quick pull on the loop releases the catch and the brake-lever flies back and releases the brake. The line and cord are attached to the brake-lever and spring-catch by means of snap-hooks, which are readily removable when the gun is to be unlimbered, the end being secured to the chest handle, or in war, at the approach of danger the line can be stowed if necessary. It is a device for use on the march to enable the driver to set the brake at any movement when necessary. The brake-lever is at the hand of a cannoneer for use when firing.

A good road brake is one of the most important essentials to insure proper draft and conserve the powers of our teams with artillery carriages, and to enable a proper simplification of the harness, making it for the wheel horses similar to that in use all over this country. A martingale is sometimes used in civil prac-practice as with cotton, and stone-floats, hay-rigs, &c., with which it is entirely impracticable to use a brake, and a lock chain must be used it necessary. But for one such set of harness there are thousands of the usual pattern, moreover when the farmer replaces his hay-rig with the wagon-body to which the brake is secured, he removes the now unnecessary and useless martingale from his harness. It is a very simple matter to secure a proper and practicable brake on properly constructed artillery carriages of the usual design, that can be readily and effectually used at any and all times, whether for use on the road or when firing the gun. When the load equals a ton and a half or two tons or more. no farmer or teamster in this country would accept as a gift a wagon without the usual brake, if he were compelled to use the wagon without a brake, nor would he accept our wheel harness so long as he was at liberty to put a brake on his wagon. This harness should be similar in design and as simple as the harness for our fire engines, save only the modification necessitated by the saddle, with breeching fastened to the traces, all of which will obtain the moment we have a proper and serviceable brake, which the present one is very far from being in any respect.

CALIBER 2".90 HORSE ARTILLERY GUN-CARRIAGES.

		lbs.
2	wheels	320.00
1	axle (hollow steel), linch-pins, washers	131.00
2	trail plates (¼ inch steel)	172.00
1	shoe	21.00
2	trunnion-beds	3.46
2	cap-squares	3.34
2	axle-plates	6.77
2	axle-straps	9.38
1	transom, ¼ inch	8.00
2	transom angle-irons	6.00
2	transom brackets	2.60
2	handles	3.00
2	brackets on shoe	5.25
1	tool chest	18.00
60	rivets	3.65
2	tension-rods	46.00
1	tension-rod bolt	5.00
2	tension-rod plates	11.00
2	tension-rod brackets	2.00
1	brake-rod	36.00
2	brake-rod shoes	9.00
2	toggle-joints	6.00
2	toggle-joint transoms	3.00
2	fulcrum rods for brake-links	5 00
1	brake-lever	4.50
	brake-lever mountings	3.50
1	brake-lever arc	2.00

	lbs.
1 elevating-screw	6.00
1 elevating-screw nut and wheel	19.00
1 elevating-screw nut with trunnion	15.00
2 elevating-screw nuts with plates	11.00
1 elevating-screw fork	7.00
Handspike, implements, tools, &c.	27.00
Total	931.45
Gun	754
Total	1686

LIMBER.

1 axle, linch-pins, washers	131.00
2 hounds	26.00
1 fork	23.00
1 splinter-bar	19.50
1 pintle	29.50
1 pole-prop	7.30
4 axle-straps	16.00
1 fork-strap	1.50
2 corner-pieces	1.00
1 pintle-key and chain	6.00
1 pole, &c.	39.00
4 tug-links and eye-bolts	11.00
2 wheels	320.00
2 staples	1.00
1 chest, complete	176.00
10 bolts for axle-stays &c.	3.25
2 foot-boards, clamps, &c.	19.00
3 reinforces for straps	7.00
Rivets, &c.	8.00
Total	845.05
Paulin, equipments, &c.	76
Total	921
Ammunition &c. 36 rounds	576
Gun and limber packed for service	3183
Caisson body	484
2 wheels	320
Chest	176

	lbs.
Implements, &c.	130
Ammunition, 36 rounds	576
Total	1686
Limber, packed	1497
Caisson, packed	3183
Caisson with spare wheel	3343

With nine caissons to a battery there would be 144 rounds per gun; with six caissons 108 rounds per gun, the same as for the new English 12-pounder. With smokeless powder 40 rounds can be carried in a chest, giving 160 per gun. The German artillery in the Franco-Prussian War was used to the greatest possible extent, yet in nine of the greatest battles the average number of rounds fired per gun was only forty-five, while the average of the maximum number fired by single batteries was 137 rounds per gun. During our war the light 12-pounder batteries carried 128, and the 3-inch rifle horse batteries with two chests on the caisson 150 rounds per gun, respectively.

In the *Military Service Journal*, November, 1892, in a discussion of General Wille's Field Gun of the Future, in which it is made quite clear that the "average" of the weights of existing projectiles taken indiscriminately for horse, light and heavy field guns is as far from meeting service conditions, as would be the average of the weight of the loads for the respective batteries applied to the proper "field-gun of the future."

That the weight of the projectile should be the greatest possiblle is and always has been axiomatic and needs no demonstration. Any one can understand that the greater the weight of the shrapnel, the more bullets it will contain, and consequently the greater the chances for bagging the game. What the greatest possible weight of projectile is, is not a matter of averages or of conjecture. Every constructor must of necessity start with a definite load for the teams of the batteries he deems necessary, the number of carriages, &c., and these loads and carriages are determined by his expected conditions of service. Having constructed his carriages, limbers and caissons, he will have determined a certain amount of weight available for carrying ammunition in a given battery = W. He must adhere to a certain minimum number of rounds which must be carried with the battery to meet war conditions $= R$, $\therefore \frac{W}{R} =$ weight of one round, and this separated into the due proportional weights of service charge and projectile determines the weight of the latter, precisely as the problem was solved by Griblauval, and no doubt by others long before his time. With field-guns where light carriages are a necessity, in order to increase the weight of projectile for any particular gun, and thereby increase the "volume of fire" by a larger number of shrapnel bullets, to render these bullets effective at battle ranges the modern ballistic expert reduces the caliber of the gun to a minimum, in order to secure good sectional density and the high remaining velocities which render the bullets effective, and at the same time conserve the strength of the light carriage by reducing the necessary muzzle velocity and energy to a minimum.

THE ARTILLERY-FIRE GAME.

By H. ROHNE, Colonel, Commanding the Schleswig Field Artillery Regiment No. 9.

Translated by First Lieutenant JOHN P. WISSER, First Artillery, U. S. A., 1892.

[CONTINUED.]

I. MODE OF CONDUCTING THE GAME.

A.—FIRING WITH PERCUSSION SHELL.

The artillery-fire game has in view objects similar to those of Kriegspiel. Just as the latter is designed to make the player familiar with the mode of conducting a battle and the laws of battle tactics, so the artillery-fire game aims to furnish opportunity for the application of the firing regulations, and to lead to the acquirement of a more or less complete mastery of them. Two players at least are necessary, one of whom as instructor directs the play. In addition it is advantageous to have the director select an assistant, and it is also advisable to allow others to be present at the play and to encourage them to take part in the discussion.

For the conduct of the play are required:

1. A small box or an urn, containing lottery numbers from 1 to 100 inclusive.

2. A table indicating the value of the lottery numbers drawn (see Appendix 1).

3. The firing table of the particular gun in use.

4. A blank form for the record of the firing, which, when there are others present to witness the play, may be advantageously replaced by a black-board.

The game opens by the director giving the other player an order to fire—*i. e.* requiring him to give all the necessary commands as in action or on the firing ground—on some target (such as a battery, an open order line of infantry, the garrison of a field fortification, etc.), which is clearly designated and described by him. The director imparts to the player the character of the observation made in each case. For this purpose he assumes a fixed target distance, which, of course, is unknown to the second player, and decides, also for himself alone, whether the deviations are small, medium or large, and how the facility of observation is to be regarded.

Let us assume that the order is given to fire on a battery; the distance being 1980 m., the dispersion small. The conditions for observation the director regards as favorable, and therefore decides that the lottery numbers

1 to 75 correspond to correct observations,
76 to 95 to doubtful, and
96 to 100 to false ones.

The second player commands, after the opening range is given him in orders (or left to his judgment): "*Percussion shell! On the firing battery directly in front! 3rd piece! 1800! From the right flank fire!*"* The director meanwhile draws a lottery number which will determine the deviation of the first shot, then another, which will give the character of the observation of this shot. Let the first be the number 36. In column A of the table it is seen that this corresponds to the longitudinal deviation —10 m. The projectile therefore strikes at 1800—10 = 1790 m., therefore 190 m. in front of the target. Let the second be the number 57; it signifies a correct observation and the director therefore calls out to the player: "*Short!*" (Had the number 97, which signifies a false observation been drawn, the director would have called out: "*Over!*") The player gives the command "2000!" The director draws the lottery number 81, corresponding to a deviation of + 20 m.; the projectile, therefore, strikes at 2020 m., hence, 40 m. behind the target. For the observation

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* In case the artillery-fire game is played in a large circle of officers, there may also be three chiefs of platoon, who repeat or give (as the case may be) the commands prescribed by the drill regulations.

conditions, suppose the number 78 to be drawn; the observation is therefore doubtful, and the director so informs the player. In consequence of this the next shot is also fired at 2000 m.

If we were to continue the game in this wise, it would not only take a great deal of time but the play would also become tedious. Therefore it is advisable to have the director prepare for the game beforehand, or have his assistant prepare, by drawing a series of lottery numbers—the number depending on the number of shots allowed—and recording before the game begins the deviation in each case in turn, as well as the character of the observation (whether correct, doubtful or false). Attention is called to the fact that every lottery number drawn after its number is recorded, must be returned to the urn, so that all the numbers are in it before every drawing.

In order to determine the position of a shot with reference to the target, the amount of the deviation as determined by the lottery numbers has been added algebraically to the range ordered, and from this sum was subtracted the actual target distance. The game can be considerably simplified and accelerated and the work of the director made very much easier by subtracting algebraically the amount of deviation read off from the table, from the actual target distance and then subtracting this difference from the range ordered. The result is of course the same; but when he has prepared the game in this way, the director knows, the instant the player orders the range (elevation in terms of range), whether the shot will strike in front of or beyond the target. In case the range ordered is greater than the actual target distance minus the deviation, the shot strikes beyond, if less, in front of the target. In our example the first, with a deviation of —10 m., struck 190 m. in front of the target. Subtracting —10 from the target distance, 1980 we have 1990 m.; this subtracted from the range ordered, 1800, gives 1800—1990, or —190 m.

We will now show by an example how such preparation for a practice firing with thirty shells, to be conducted as explained above, is to be made. The director constructs a table according to the following model, on which he enters first the lottery numbers drawn and the deviation corresponding to each. In the next column is put the algebraic difference: actual target distance minus deviation. The succeeding columns contain the lottery numbers for observation together with the corresponding character of the observation:

Order of shots. 1.	Lottery number. 2.	Deviation. m. 3.	Actual target distance minus deviation. m. 4.	Lottery number. 5.	Observation. 6.	Order of shots. 1.	Lottery number. 2.	Deviation. m. 3.	Actual target distance minus deviation. m. 4.	Lottery number. 5.	Observation. 6.
1	36	—10	1990	57	c	16	20	—20	2000	48	c
2	81	+20	1960	78	?	17	59	+ 5	1975	71	c
3	20	—20	2000	53	c	18	38	— 5	1985	56	c
4	93	+30	1950	21	c	19	75	+15	1965	81	?
5	62	+ 5	1975	97	f	20	82	+20	1960	69	c
6	79	+20	1960	36	c	21	57	+ 5	1975	80	?
7	66	+10	1970	11	c	22	40	— 5	1985	47	c
8	94	+35	1945	13	c	23	89	+25	1955	18	c
9	58	+ 5	1975	25	c	24	22	—20	2000	77	?
10	13	—25	2005	74	c	25	71	+10	1970	33	c
11	22	—20	2000	18	c	26	24	—15	1995	21	c
12	81	+20	1960	45	c	27	94	+35	1945	41	c
13	30	—10	1990	7	c	28	73	+15	1965	1	c
14	64	+10	1970	100	f	29	7	—35	2015	79	?
15	74	+15	1965	83	?	30	49	± 0	1980	93	?

By a correct application of the firing regulations, the following firing-record will result from the foregoing:

No. of gun. 1.	COMMAND. 2.	No. of shot. 3.	Elevation m. (in range). 4.	OBSERVATION.	
				batt'y 5.	target 6.
VI.	P! Dir. f. batt'y 3d p.! 1800! l. fl. F.!*	1	1800	—	—190
V.	. . . .	2	2000	?	— 40
IV.	. . . .	3	2000	+	± 0
III.	. . . .	4	1900	—	— 50
II.	. . . .	5	1950	+	— 25
I.	F. w!†	6	1900	—	— 60
VI.	. . . .	7	1900	—	— 70
V.	. . . .	8	1950	+	— 5
IV.	. . . .	9	1950	—	— 25
III.	. . . .	10	1950	—	— 55
II.	. . . .	11	1950	—	— 50
I.	. . . .	12	1950	—	— 10
VI.	. . . .	13	1950	—	— 40
V.	. . . .	14	2000	—	+ 30
IV.	. . . .	15	2000	?	+ 35
III.	. . . .	16	2000	+	± 0
II.	. . . .	17	2000	+	+ 25
I.	. . . .	18	2000	+	— 15
VI.	. . . .	19	2000	?	+ 35
V.	. . . .	20	2000	+	— 40
IV.	. . . .	21	2000	?	+ 25
III.	. . . .	22	2000	+	+ 15
II.	. . . .	23	1975	+	+ 20
I.	. . . .	24	1975	?	— 25
VI.	. . . .	25	1975	+	+ 5
V.	. . . .	26	1975	—	— 20
IV.	. . . .	27	1975	+	+ 30
III.	. . . .	28	1975	+	+ 10
II.	. . . .	29	1975	?	— 40
I.	. . . .	30	1975	?	— 5

It will be observed that this firing record differs in no respect from one resulting from actual firing. The mean point of impact—calculated from shots 23 to 30—is at —3; the probable target distance is therefore 1978 m. The proper elevation of 1975 m. was not found until 22 shots had been fired. Owing to a false observation of shot No. 5, the short fork was not correctly determined; then again shot No. 8, because it happened to be an over shot (deviation + 35 m.), even with the elevation of 1950, struck beyond the target instead of in front of

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* "Percussion shell! Directly on firing battery, 3rd piece, at 1800, from the left flank, Fire!"

† "Fire at will!"

it; finally, a false observation of shot No. 14 was the cause of a considerable number of shots being fired at an elevation of 2000, before the fact was recognized that the correction applied in passing from 1950 to 2000 was too great. It may be remarked in passing, that effective shots were obtained with the elevation 1950 as well as with that of 2000 m.

Of the 30 shots fired, 21 (or 70 per cent.) were observed correctly, 7 (or 23.3 per cent) doubtfully, and 2 (or 6.7 per cent.) falsely. The results of observation were made more unfavorable by the drawing of the numbers than the director had assumed in the beginning (75 per cent. correct, 20 per cent. doubtful, 5 per cent. false).

We may remark in conclusion, that neither in directing the play nor in the course of the game is it necessary to make the calculation of the data in column six of the firing table; because the director knows at once, by comparison of the range ordered with the data contained in column four of his list, how the shot strikes with reference to the target. It is always well to have these data worked out by the assistant, however, so that a complete firing record, including the observation of the shots with reference to the target may be constructed, which will show in a convincing manner not only to the player, but also to the audience that everything has transpired and been conducted naturally and properly.

B—FIRING WITH SHRAPNEL.

Firing with shrapnel is conducted in exactly the same manner as has just been described for firing with shell. The director, preparatory to opening the game draws a series of lottery numbers, not only to fix the deviation of the separate points of explosion, but also for the character of the observation thereof, and prepares a table as in case of firing with shell. Since, as will be evident from the example given below, the observation of shrapnel, on account of their too great height of explosion, generally turns out to be doubtful, it is not absolutely necessary to draw the lottery numbers for observation beforehand, because this can be more easily done in the course of the game in case of the few shots that will occur with low points of explosion.

In addition, the director must make an assumption in regard to the behavior of the fuses, and must determine where, in consequence thereof, in the case of those heights of explosion and distances of the points of explosion in front of the target which may come under consideration, the mean point of explosion lies, and must make a note of this. The effect on the position of the point of explosion of inserting a plate is also recorded, in case he assumed for the fuses too long a time of burning.

In the following example the mode of conducting the play is clearly described.

The director gives directions to fire upon a hostile battery of six guns, weather fair; in regard to the behaviour of the fuses no data are available and nothing is known from experience.

The director makes privately the following assumptions:

Target distance, 2120 metres.
Fuses burn normally.
Deviation in case of shell, medium.

In the observation of shell and shrapnel fire, the lottery numbers 1—67 (67 per cent.) denote those correctly observed, 68—92 (25 per cent.) denote those doubtfully observed, 93—100 (8 per cent.) denote those falsely observed.

He then draws for shell and shrapnel each eighteen numbers, to determine the deviations as well as the character of the observation and constructs the following table:

The figures in column eight are inserted only in the course of the game, to facilitate the direction and conduct of the game.

The director also notes:

Position of mean point of explosion and fuse set for

$$2100 \text{ m.} : \frac{-70}{6};$$

$$2050 \text{ m.} : \frac{-120}{6};$$

$$2150 \text{ m.} : \frac{-20}{6}.$$

A plate alters the range about 60 m.;

A plate alters the height of explosion about 7 m (more exactly 6.9 m.).

PERCUSSION SHELL.						SHRAPNEL.					
Number. 1.	Lottery number. 2.	Deviation. m. 3.	Target distance minus deviation. m. 4.	Lottery number. 5.	Observation. 6.	Number. 7.	Number on the firing record of this series. 8.	Lottery number. 9.	Deviation. m. 10.	Lottery number. 11.	Observation. 12.
1	6	—60	2180	34	c	1	10	3	—50 + 6	31	c
2	61	+10	2110	65	c	2	11	80	+20 — 3	86	?
3	33	—15	2135	53	c	3	12	31	—15 — 1	47	c
4	77	+25	2095	1	c	4	13	37	—10 ± 0	66	c
5	20	—30	2150	18	c	5	14	63	+10 + 1	25	c
6	54	+ 5	2115	68	?	6	15	46	— 5 — 1	44	c
7	39	—10	2130	24	c	7	16	8	—35 + 6	85	?
8	38	—10	2130	75	?	8	17	45	— 5 ± 0	10	c
9	82	+35	2085	56	c	9	18	79	+20 — 2	60	c
10	40	—10	2130	10	c	10	19	49	+ 0 ± 0	19	c
11	26	—25	2145	83	?	11	20	75	+15 — 3	49	c
12	53	± 0	2120	59	c	12	21	53	± 0 — 1	52	c
13	86	+40	2080	41	c	13	22	2	—55 + 7	63	c
14	60	+10	2110	27	c	14	23	45	— 5 ± 0	9	c
15	40	—10	2130	10	c	15	24	49	+ 0 + 0	14	c
16	3	—75	2195	34	c	16	25	66	+10 — 1	87	?
17	24	—25	2145	39	c	17	26	7	—40 + 3	62	c
18	36	—15	2135	67	c	18	27	19	—55 ± 0	51	c

The firing record resulting therefrom by application of the firing regulations is as follows:

No of gun.	COMMAND.	No. of shot.	Fuse set for elevation in terms of range. m.	OBSERVATION. batt'y.	OBSERVATION. target.
1.	2.	3.	4.	5.	6.
I.	P. s.! dir. f. batt'y 3rd p! 1800! r. fl. F.!	1	1800	—	—380
II.	....	2	2000	—	—110
III.	....	3	2200	+	— 65
IV.	....	4	2100	+	+ 5
V.	....	5	2050	—	—100
VI.	C. f. Shr. t. f.! inc. by 100, 2050! F. w.!	6	"	?	— 65
I.	....	7	"	—	— 80
II.	....	8	"	?	— 80
III.	....	9	"	—	— 35
I.	Chief 2d pl. disch. l. p. chief 1st pl. shr. t. f.↕	10	"	$\frac{?}{12}$	$\frac{-170}{12}$
II.	....	11	"	$\frac{?}{3}$	$\frac{-100}{3}$
III.	....	12	"	$\frac{?}{5}$	$\frac{-135}{5}$
IV.	....	13	"	$\frac{?}{6}$	$\frac{-130}{6}$
V.	....	14	"	$\frac{?}{7}$	$\frac{-110}{7}$
VI.	Next setting of fuse 2150!	15	"	$\frac{?}{5}$	$\frac{-125}{5}$
I.	Setting of fuse, new range!	16	2150	$\frac{?}{12}$	$\frac{-55}{12}$
II.	....	17	"	$\frac{?}{6}$	$\frac{-25}{6}$
III.	....	18	"	$\frac{?}{4}$	$\frac{\pm 0}{4}$
IV.	....	19	"	$\frac{?}{6}$	$\frac{-20}{6}$
V.	....	20	"	$\frac{?}{3}$	$\frac{-5}{3}$
VI.	Cut all the fuses for this range.	21	"	$\frac{?}{5}$	$\frac{-20}{5}$
I.	....	22	"	$\frac{?}{13}$	$\frac{-75}{13}$
II.	....	23	"	$\frac{?}{6}$	$\frac{-25}{6}$
III.	....	24	"	$\frac{?}{6}$	$\frac{-20}{6}$
IV.	....	25	"	$\frac{?}{5}$	$\frac{-10}{5}$
V.	....	26	"	$\frac{?}{9}$	$\frac{-60}{9}$
VI.	....	27	"	$\frac{?}{6}$	$\frac{-45}{6}$

Of all the shrapnel only the shots 11 and 20 had a height of explosion low enough to admit of observation at all; therefore, it is necessary in the case of these two shots alone to draw the lottery numbers which shall determine the character of the observation made.

DISCUSSION OF THE FIRING RECORD.

In spite of the fact that all the observations therefor are correct, the short fork is not properly determined, because shot four fired at an elevation corresponding to 2100 m., had a deviation of +25 m., and therefore struck *beyond* instead of *in front* of the target. The player who had charge of the firing, as soon as the short fork was established by shot five, changed to shrapnel-fire at 2050 m., increasing gradually 100 m. at a time. Both are perfectly correct. The transition to shrapnel-fire can be ordered at this point, because, of the shots two to five which were necessary to establish the short fork, two were observed to strike short and two over. Even if one of the shots had been falsely observed or had an excessive deviation, it was quite certain that the effect of the error could be practically overcome by a single correction of 50 or 100 m. Quite the reverse would have been the case had the short fork been established by 2000 and 2150 m. In such a case if a shot fired at 2000 or 2200 is observed falsely, there is nothing to tell the possible amount of the error; it may be 200 or it may be only 25 m. Therefore in my opinion, it is better to continue the firing with percussion shell before passing to shrapnel, so that the short fork may be established by means of one shot short of and three beyond the target, or the reverse (three short, one over), in order to obtain more reliable data as to the actual target distance.

The mode of firing by increasing the elevation 100 m. at a time was indicated as the proper one for two reasons. In the first place, the behavior of the fuses was as yet unknown, and they might require certain corrections, which, in this method of gradual increase, would be simpler and easier of execution. Then

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☞ See preceding page.

§ "Percussion shell, directly on firing battery, 3rd piece, 1800, from the right flank, Fire!"

† "Cease firing,—shrapnel, time fuses, increasing by 100 metres at a time, 2050, fire at will!"

‡ "Chief of 2nd platoon discharge loaded pieces! Chief 1st platoon, shrapnel time fuses!"

again, even in case of correct behavior of the fuses, it may be desirable to regulate more accurately the explosion distance. The observation of the shells already loaded which are fired before the first shrapnel, will probably give some idea of the accuracy of the range obtained. If the shells, as in the present case, are observed to strike only in front of the target (none beyond), it may be assumed that the range, which was ordered for the shrapnel firing is too small. The necessity for regulating the explosion distance more accurately is made evident in actual service when, after several changes by successive steps (50 or 100 m. at a time), no effect is noticeable.

For this reason was the increase by 100 m. in the present case entirely proper (Firing Regulations, par. 121),[*] in spite of the fact that the observation of all the points of explosion of the first setting of the shrapnel fuses was doubtful. Whether or not it would have been possible to observe in actual firing, under the conditions of this case that the points of explosion lay in front of the target, perhaps even far in front, may be regarded as undecided. Formerly when the battery commander took his position on one flank, the shots directed against the other flank of the target, and which fell short, appeared of necessity as if they passed by on one side. At a range of 2000 m. a shrapnel fired from the sixth piece, well laid as regards direction, and with a distance of explosion in front of the target of 100 m., will appear to the battery commander standing on the right flank, as if it were passing by the target some 5 m. to the left. If, on the contrary he stands near the centre, which is the rule now with smokeless powder, this apparent lateral deviation falls in amount to less than half and is hardly noticeable.

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[*] "For this purpose the range and time are increased by successive steps of 100 m., until some effect is observed, or until points of explosion appear behind the target: as soon as this happens they are reduced by 50 or 100 m., so that all points of explosion fall in front of the target.

In case a second increase or 100 m. produces no definite effect, or gives no points of explosion behind the target, the fork must be re-determined with shell.

In increasing or diminishing, both elevation and fuse are altered simultaneously. In thus increasing or decreasing by successive steps in all the guns of a battery, the battery commander, when it is found necessary to decrease the time for which the fuse is set, may, to prevent the ground hits, fire the pieces already loaded in rapid fire without changing the elevation." Schiessvorschrift für die Feld-Artillerie, 121—J. P. W.

A further increase was not necessary, because besides shot 4, which had to be regarded with suspicion, shot 5 was also observed as behind the target. Moreover in actual firing shots 16 to 17 would probably give good results; the mean point of explosion of these shots lies at $\frac{-30}{7}$. The director of the game had assumed that it lay at $\frac{-20}{6}$. The difference of 10 m. in the distances of the points of explosion in front of the target is explained by the fact that for the shots 16 to 27 more lottery numbers above 50 (namely 8), which correspond to greater explosion distances in front of the target, were drawn than under 50 (namely 4), which corresponds to smaller explosion distances. Such variations occur also in actual practice.

Had the director assumed that the fuse, instead of burning normally burned 40 m. too long, the mean point of explosion, for the elevation and fuse setting 2050 m., would have been at $\frac{-80}{1}$ $\left(\text{instead of } \frac{-120}{+6}\right)$. The director would then have noted down, in preparing to open the play:

Mean point of explosion for 2050 m.: $\frac{-80}{+1}$.

$\underline{2050}$ m.: $\frac{-80}{+8}$.

$\underline{2000}$ m.: $\frac{-130}{+8}$.

Up to shot nine the firing record would naturally be the same as on page 268. From shot ten on, it would become, in caes target distance and lottery numbers (including their interpretation) remained unaltered as follows:

No. of gun. 1.	COMMAND. 2.	No. of shot. 3.	Setting of Fuse. Elevation (in range). m. 4.	OBSERVATION. batt'y. 5.	OBSERVATION. target. 6.
I.		10	2050	$\frac{?}{7}$	$\frac{-130}{7}$
II.		11*	"	$\frac{?}{0}$	$\frac{-60}{-2}$
III.		12	"	$\frac{-}{0}$	$\frac{-95}{0}$
IV.		13	"	$\frac{-}{1}$	$\frac{-90}{1}$
V.	"1 plate higher!"	14	2050	$\frac{?}{9}$	$\frac{-70}{9}$
VI.	"Next range (and setting) 2050!"	15	"	$\frac{?}{7}$	$\frac{-85}{7}$
I.		16	"	$\frac{?}{14}$	$\frac{-115}{14}$
II.		17	"	$\frac{?}{8}$	$\frac{-85}{8}$
III.		18	"	$\frac{?}{6}$	$\frac{-60}{6}$
IV.		19	"	$\frac{?}{8}$	$\frac{-80}{8}$
V.		20	"	$\frac{?}{5}$	$\frac{-65}{5}$
VI.	"All fuses set at this range!"	21	"	$\frac{?}{7}$	$\frac{-80}{7}$
I.		22	2050	$\frac{?}{15}$	$\frac{-135}{15}$
II.		23	"	$\frac{?}{8}$	$\frac{-85}{8}$
III.		24	"	$\frac{?}{8}$	$\frac{-80}{8}$
IV.		25	"	$\frac{?}{7}$	$\frac{-70}{7}$
V.		26	"	$\frac{?}{11}$	$\frac{-120}{11}$
VI.		27	"	$\frac{?}{8}$	$\frac{-105}{8}$

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*At shot 11 under the heading "Observation, —Target" it reads $\frac{-60}{-2}$. Of course, the shot is not so observed at the target; indeed, it makes a ground hit at some 77 m. in front of the target. See page 137.

A plate was not inserted until after shot 13 which did not make a ground hit, but had a low point of explosion, while shots 11 and 12 had a height of explosion equal to 0, in other words made ground hits. Therefore, according to the Firing Regulations, the command "one plate higher" could have been given one shot earlier. In the present instance however, the delay in making the correction is warranted. Shot 11 was an undoubted ground hit, i. e. a shot such that the projectile, had the battery possessed no combination fuses but simple time fuses only, would probably not have exploded. But with shot 12 this was not the case; the projectile would have exploded even if the percussion fuse had not worked. It was in reality a shot with a very low point of explosion. Such shots, in case of projectiles provided with combination fuses cannot be distinguished from ground hits, a fact which must be regarded as a disadvantage of the combination fuse, though not a serious one. Had the battery commander instead of "—/0", written in his firing record "—½," everything would have been perfectly clear. In the present instance the great height of explosion of shot 10 indicated the advisability of proceeding with caution; the battery commander therefore waited until after shot 13 before he decided to insert a plate. Then he had but one shot with a normal height of explosion, but three with low points of explosion or making ground hits, and knew, therefore, for certain that the fuses were burning too long.

After the point of explosion was raised, the distances of the points of explosion from the target were no longer observed, because the height of explosion was in all cases 5 m. and over. In actual firing such would generally be the method pursued, and any further observation would hardly be possible in case of a target on a level surface of hard ground or on a green field. Whoever has looked over a number of firing records; knows that a far greater number of shots than is here indicated is generally marked therein as *observed*. This is due in part to the fact that our firing practice takes place only in summer when the ground is dry, and that our firing grounds are usually sandy and seldom covered with any considerable vegetation. In consequence of this the explosion fragments often throw up dust, thereby giving some clue to the actual position of the point of explosion. But, on the other hand there are many marks, mostly minus signs, in the column "Observation, Battery," which have no claim whatever to reliability. They are, so to speak guessed at. When a battery commander, as in the example here given, has observed shots like 12 and 13 to burst undoubtedly in front of the target, he *concludes* with a certain amount of reason, that the points of bursting of projectiles with the same setting of the fuse, and which he failed to observe also lie in front of the target, and calmly enters in the column in which the observation is recorded a minus sign, when in reality he should enter an interrogation point.

The next question is was it right for the battery commander, notwithstanding that from shot 14 on he observed no more distances of the points of explosion in front of the target, to keep range and fuse at 2050, or should he not, according to § 61 of the Firing Regulations have gone back 50 m.? The part of the section which is here referred to reads: "If, after ground hits are no longer obtained, the points of bursting *cannot with perfect certainty* be located in front of the target, the range and fuse setting must be correspondingly reduced." There is no doubt that no one could have accused the battery commander of any violation of the Firing Regulations had he, in consequence of his observations gone back at shot 22 to 2000 m. On the contrary, nevertheless his remaining at 2050 m. is justifiable, and indeed deserves the preference. In attempting to decide such questions the data of column six must be entirely neglected; all considerations which do not completely ignore the observations at the target, belong to the same domain as stair-case witticisms, which are well known always to occur to one after the opportunity to use them has slipped by. The player in charge of the firing had a perfect right to assume from the character of his observations that the points of explosion not actually observed by him, lay *in front of* the target. This was warranted by his observation of the shells in case of shots 5, 7 and 9, as well as the points of explosion of shrapnel 12 and 13. He had a right to draw the conclusion from shots 5, 7, 9 and 12, that 2050 m. must of necessity be considerably (at least by 30 to 40 m.) too short a range, and that, *since a single plate was sufficient to prevent ground hits*, the fuses burned *at most* 50 m. too long. The points of explosion necessarily *had* to lie *in front of* the target.

On the other hand it may be asked whether an *increase*, with a view to fixing the distance of the points of explosion in front of the target was not indicated as advisable, since, with 2050 m., every one of the shells burst in front of the target. This, in my opinion, must be answered in the negative. Since as stated above besides shot 4, shot 3 (with 2200 m.) was also observed as *behind* the target, it could be assumed that—even with a false observation of shot 4—the error could not be very great, at least not so great that all effective action would be lost. In actual firing the elevation and setting of the fuse of 2050 m. would have given a distance of the mean point of explosion in front of the target of nearly 90 m., which would have had a sufficiently effective action. On the firing ground the attempt to fix more accurately the distance of the point of explosion in front of the target would have been frustrated by the great heights of explosion.

Had the battery commander, however, adhering strictly to the wording of the Firing Regulations gone back at shot 22 to 2000 m., the conditions would have been about the same as with 2050 m. in case of fuses which burn correctly. The distance of the point of explosion in front of the target would have been about —140 m., and the effective action therefore very slight. In that case an increase of 100 m. would have been indicated as required, as it was in the firing record on page 268.

It remains to consider the case when the player inserts one or more plates *before* opening the fire with percussion shell, as he would if he knew the behavior of the fuses. Every shot has a greater elevation and a corresponding greater range, due to inserting a plate. In order to determine where each shot strikes, the director can deduct its amount each time from the range ordered; but he can attain his object in a simpler way by subtracting it *once for all* from the assumed target distance.

In the example just discussed, if the player had been informed that the insertion of a plate was necessary, the director would deduct from the actual target distance 2120 m., 60 m. ——1 plate $= \frac{3}{16}$° alters the range about 60 m.—and use in his calculations 2060 m. as target distance. In the record on page 267, all the calculated numbers of column four would naturally become 60 m. smaller.

In consequence of the range being increased 60 m., it must be assumed moreover, that the fuses, instead of burning 40 m. too long burn 20 m. too short. The director enters the following in his note-book:

Mean point of explosion with elevation and fuse 2050 m., : $\frac{-80}{+8}$.

The progress of the firing is given in the following firing record:

No. of gun.	COMMAND.	No. of shot.	Setting of fuse. Elevation. m.	OBSERVATION.	
				batt'y	target
1.	2.	3.	4.	5.	6.
I.	P. s., dir. f. batt'y, 3d. p., 1 pl. h., 1800, r. fl. F.! *	1	1800	—	—320
II.	. . . .	2	2000	—	— 50
III.	. . . .	3	2200	+	+125
IV.	. . . .	4	2100	+	+ 55
V.	. . . .	5	2050	—	— 40
VI.	C. f., shr., t. f., by steps, 2050, F. d.! †	6	"	?	— 5
I.	. . . .	7	2050	—	— 20
II.	. . . .	8	"	?	— 20
III.	. . . .	9	"	+	+ 35
I.	Ch. 2d plat.: Dis. l. p.! Ch. 1st plat.: Sh., t. f. ‡	10	"	$\frac{?}{14}$	$\frac{-130}{14}$
II.	. . . .	11	"	$\frac{?}{5}$	$\frac{-60}{5}$
III.	. . . .	12	"	$\frac{?}{7}$	$\frac{-95}{7}$
IV.	Cut the rest of the fuses for this distance!	13	"	$\frac{?}{8}$	$\frac{-90}{8}$
V.	. . . .	14	"	$\frac{?}{9}$	$\frac{-70}{9}$
VI.	. . . .	15	"	$\frac{?}{7}$	$\frac{-85}{7}$

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* "Percussion shell, directly on firing battery, 3d piece, 1 plate higher, 1800, from right flank. Fire!"

† "Cease firing, shrapnel, time fuses, by steps (increasing gradually 100 m. at a time), 2050, Fire dispersed!"

‡ Chief of 2d platoon: "Discharge the loaded pieces!" Chief of 1st platoon: "Shrapnel, time fuses!"

Shots 14 to 27 will be exactly as in the record on page 272.

In this case the determination of the correct fork was successful, and as shot nine was observed to fall behind the target, it could be assumed that 2050 m., or 2110 was the correct elevation. The mean distance of the points of explosion from the target, calculated from the 18 shrapnel fired, is —89 m., which would have given effective action.

C—FIRING WITH TORPEDO-SHELL.

A practice firing with torpedo-shell with time-fuses, is conducted on very much the same principle as firing with shrapnel. In order to give a graphic illustration of the results of such a firing, all the assumptions and preparations made in case of the shrapnel fire (pages 266 and 266) are supposed to hold true here. Let the target however, be a field intrenchment occupied by a firing line, which, in its position on the banquette, is perfectly covered against any angle of fall short of 22°. The distance in the former example was assumed to be 2120 m., and

Number. 1.	Number on firing record. 2.	Lottery-number. 3.	Deviation. m. 4.	Lottery-number. 5.	Observation. 6.	Number. 1.	Number on firing record. 2.	Lottery-number. 3.	Deviation. m. 4.	Lottery-number. 5.	Observation. 6.
19	36	87	+30 — 1	13	c	28	45	66	+10 ± 0	48	c
20	37	97	+45 — 6	21	c	29	46	49	+ 0 ± 0	77	?
21	38	52	+ 0 ± 0	63	c	30	47	44	— 5 ± 0	57	c
22	39	44	— 5 ± 0	46	c	31	48	72	+15 — 1	76	?
23	40	84	+25 — 3	22	c	32	49	34	—10 + 2	95	f
24	41	25	—15 + 4	19	c	33	50	19	—25 ± 0	63	c
25	42	80	+20 — 3	6	c	34	51	82	+25 ± 0	52	c
25	43	23	—20 + 2	9	c	35	52	25	—15 + 4	79	?
27	44	19	—25 ± 0	29	c	36	53	93	+35 — 6	2	c

it is supposed to remain the same in this. In order to obtain a firing-record conforming perfectly to the reality of the case, it must be borne in mind that the distances of the points of explosion of torpedo-shell in front of the target, with the same elevation, are known to be from experience and observation from 10 to 20 m. shorter than those of the shell c/82.

At a range of 2000 m. the difference amounts to about 15 m. Therefore from the determination of the position of the ground hits or points of explosion of torpedo-shell, the target distance must be assumed correspondingly greater, *i. e.*, instead of taking it at 2120 it must be taken at 2135 m.

Since the firing with torpedo-shell (with time fuses) is opened at a range greater by 50 m. than the target distance determined. and since moreover, the removal of a plate may be necessary in order to render the points of explosion capable of being observed. the director records in his note-book :

Mean point of explosion with elevation and fuse at

2150 m. $\frac{-35}{6}$, 2200 m. $\frac{+15}{6}$,

$\overline{2150}$ m. $\frac{-35}{-1}$, $\overline{2200}$ m. $\frac{+15}{-1}$,

$\underline{2150}$ m. $\frac{-35}{13}$, $\underline{2200}$ m. $\frac{+15}{13}$.

As it is doubtful that the firing will be completed with 18 torpedo-shell, the director, in order to complete the record given on page 267, must draw for 18 shots more the necessary lottery numbers for deviation and observation (see page 277).

By correctly applying the Firing Regulations, the following firing-record will result :

No. of gun.	COMMAND.	No. of shot.	Setting of fuse. Elevation. m.	OBSERVATION.	
				batt'y	target.
1.	2.	3.	4.	5.	6.
VI.	P. s., dir. on field intr. l. w. mill q. 1800, l. fl., F.!*	1	1800	—	—380
V.	. . . .	2	2000	—	—110
IV.	. . . .	3	2200	+	+ 65
III.	. . . .	4	2100	+	+ 5
II.	. . . .	3	2050	—	—100
I.	. . . .	6	2050	?	— 65
VI.	. . . .	7	2050	—	— 80
V.	. . . .	8	2050	?	— 80
IV.	. . . .	9	2030	—	— 35
III.	. . . .	10	2100	—	— 30
II.	. . . .	11	2100	?	— 45
I.	. . . .	12	2100	—	— 20
VI.	. . . .	13	2100	+	+20
V.	C. f., tor. s., t. f., incr. by steps, 2150, F. d.!†	14	2150	+	+40
IV.	. . . .	15	"	+	+20
III.	. . . .	16	"	+	+45
II.	. . . .	17	"	—	— 5
I.	. . . .	. .	. .	. .	. .
VI.	(For s., t. f.)	18	2150	? 13	—85 13
V.	. . . .	19	"	? 3	—15 3
IV.	. . . .	20	"	? 5	—50 3
III.	. . . .	21	"	? 6	—45 6
II.	. . . .	22	"	? 7	—25 7
I.	1 pl. l., next elevation and fuse 2150!‡	23	2150	— 0	—40 — 2
VI.	. . . .	24	"	? 5	—70 5
V.	. . . .	25	"	— 0	—40 — 1
IV.	. . . .	26	"	— 0	—15 — 3
III.	. . . .	27	"	— 0	—35 — 1
II.	Next elevation and fuse 2200!	28	"	— 0	— 50 — 4
I.	. . . .	29	"	— 0	—35 — 2

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* "Percussion shell, directly on field intrenchment to the left of the wind-mill, using quadrant for elevation, 1800, from the left flank, Fire!"

† "Cease firing, torpedo-shell, time fuses, increasing by steps (50 or 100 m.), 2150, Fire dispersed!"

‡ "One plate lower, etc."

No. of gun. 1.	COMMAND. 2.	No. of shot. 3.	Setting of fuse. Elevation. m. 4.	OBSERVATION. batt'y. 5.	OBSERVATION. target. 6.
VI.	(New fuse setting !)	30	2200	? 6	−40 6
V.	. . . .	31	"	+ 0	−10 −1
IV.	. . . .	32	"	+ 0	−15 −1
III.	. . . .	33	"	? 0	+25 −2
II.	. . . .	34	"	— 2	−25 2
I.	Next elevation and fuse 2200 !	35	"	— 0	−10 −1
VI.	1 pl. h., set the rest of the fuses for this range !*	36	2200	? 5	+45 5
V.	. . . .	37	"	+ 0	+60 0
IV.	1 pl. h.	38	2200	? 13	+15 13
III.	. . . .	39	"	? 13	−10 13
II.	. . . .	40	"	? 10	+40 10
I.	. . . .	41	"	? 17	± 0 17
VI.	. . . .	42	"	? 10	+35 10
V.	. . . .	43	"	? 15	− 5 15
IV.	. . . .	44	"	? 13	−10 13
III.	. . . .	45	"	? 13	−25 13
II.	. . . .	46	"	? 13	−15 13
I.	. . . .	47	"	? 13	−10 13

No. of gun.	COMMAND.	No. of shot.	Setting of Fuse. Elevation m.	OBSERVATION.	
				batt'y.	target.
1.	2.	3.	4.	5.	6.
VI.	. . . .	48	2200	$\frac{?}{12}$	$\frac{+30}{12}$
V.	. . . .	49	"	$\frac{?}{15}$	$\frac{-5}{15}$
IV.	. . . .	50	"	$\frac{?}{10}$	$\frac{-10}{13}$
III.	. . . .	51	"	$\frac{?}{13}$	$\frac{+40}{13}$
II.	. . . .	52	"	$\frac{?}{17}$	$\frac{\pm 0}{17}$
I.	. . . .	53	"	$\frac{?}{7}$	$\frac{+50}{7}$

Note.—In shots 31, 32 and 33 there may be some doubt as to where the ground hits are actually located. An application of the formula given on page 16 will show that all three shots strike beyond the target.

DISCUSSION OF THE FIRING-RECORD.

At 2100 m. the battery commander observed two shells to strike in front of the target and two behind (counting in shot four). His ordering at this point the firing with torpedo-shell (time fuses) at 2150 m. was perfectly correct; it makes no difference how the two preceding shells with an elevation of 2100 m. might fall, the latter would still be regarded as the proper elevation. The shells fired at 2150 m. lay mostly behind the target; from which it was fair to conclude that the firing with shell had been quite effective and entirely successful.

After passing to torpedo-shell (with time fuses), only one of the first five shots had a height of explosion admitting of observation, but the actual observation of this shot accidentally turned out to be doubtful. It was therefore proper to lower the points of explosion.* The removal of a plate however, resulted in giving a mean negative height of explosion, and so more than half of the shots were ground hits (this is the case at all ranges up to 2400 m.).

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* By calculation the probabilities are that with a height of explosion of 6 m. and a probable vertical deviation of 2 m., some 16 per cent. of the points of explosion obtained (*i. e.* one for every elevation), will have a height of explosion of 4 m. or less. Such a small number of points of explosion admitting of observation is naturally not sufficient for effective fire.

The battery commander thus found himself in a difficult situation. That the ground hits were not suitable for the determination of the proper fuse setting—and this, indeed, was the only point to be determined now, as the position of the trajectory had been determined by the firing with shell c/82—was clear, because the point of explosion observed might not have been caused by the time fuse at all. Had the battery commander decided, for this reason, to throw out the ground hits and not consider them at all, he would have had out of the fourteen shots in which the trajectory had been lowered but two, numbers 25 and 33, admitting of observation. In the case of shot 25, moreover, the height of explosion was zero, and it was at least doubtful whether the detonation was brought about by the percussion or the time fuse. He therefore regarded the ground hits as points of explosion produced by the time fuse, which in the present case accidentally led to the same result as if he had left them out of consideration.

Of the shots fired with $\overline{2150}$ m. elevation all points of explosion lay in front of the target; of those fired with $\overline{2200}$, two were observed correctly in front of the target and two behind; and therefore this length of fuse was apparently the correct one (Firing Regulations, 72[*]). After this the points of explosion were successively raised, and the probable mean height of explosion was 13 m.

Of the greatest interest is the question from which of the shots an effective action on the target is to be expected. To answer this question a little digression on the action of torpedo-shell must be made. In detonation the fragments of the projectile fly in *all* directions, because their velocity is much greater than that of the projectile itself. There are three different groups of fragments—those of the head of the projectile, those of the base and those of the cylindrical part. The two first groups will move principally in the direction of the tangent to the trajectory, forward and to the rear. No effective action on *covered targets* is to be expected from either of these. The fragments from the cylindrical part spread out in a cone of which the apex is the

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[*] "As soon as points of explosion are obtained both behind and in front of the target, it may be assumed that the range and length of fuse have been approximately determined."

point of explosion and the axis the trajectory. The angle of the conic mantle enclosing all the fragments, depends on the relation of the velocity of the projectile at the instant of detonation, to the velocity communicated by the bursting charge to the fragments in a direction perpendicular to the axis of the projectile. Suppose for instance, that the velocity of the projectile and the velocity of the fragments in a direction perpendicular to the axis are equal, then the angle of the cone is 90°; for, half the angle is 45°. If the velocity of the fragments is assumed to be about 500 m., then at 2000 m., where the velocity of the projectile is about 250 m., representing half the angle of the cone by α, we have tang $\alpha = \frac{500}{250} = 2$, from which it follows that $\alpha = 63°$, which is probably very near the truth. An absolutely accurate determination cannot probably be made, and would be comparatively without great value. The main mass of effective fragments on this assumption will probably strike down at an angle equal to 63° plus the angle of fall of the projectile; at 2000 m. therefore at about 70°.

Let two lines be drawn through the highest point of the target, making angles inclined respectively 70° and 22° at the horizontal —*A Z* and *B Z*—, then it is clear that effective action is to be expected only from those projectiles which detonate within the angle *A Z B* (see appendix 2).* The fragments of all the projectiles which detonate *above* the line *A Z* pass on over the target; those projectiles which detonate *below* the line *B Z* are also without effective action, because those fragments which strike down nearly vertically are caught by the parapet, while all others must pass over the target.

From this it follows that the most favorable position for the mean point of explosion lies near the line bisecting the angle *A Z B*, at a height of about 12 m., hence, in about the position $\frac{-15}{12}$.

In our example the mean point of explosion of the shots fired with 2200 m. lies at $\frac{+15}{13}$, therefore, quite outside the angle *A Z B*.

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* In the plate (appendix 2) the shots are supposed to come from the right. moving to the left, and the points of explosion are represented in vertical side elevation. J. P. W.

The mean point of explosion of the shots fired with 2150 m. would have been at $\frac{-35}{13}$ somewhat short, but still within the angle.

From the firing-record it is evident that of the shots fired with 2200, only Nos. 43, 55 and 50 could have had any effective action.

A graphic idea of the number of effective shots to be expected for every position of the mean point of explosion may be readily obtained. It is only necessary to make use of the diagram representing the time of burning of the fuses reproduced in Appendix 2, which was prepared from the data of column E of Appendix 1. Suppose it is desired to know how many effective shots are to be expected when the position of the mean point of explosion is at $\frac{-15}{12}$, then it is necessary to determine a point reckoned from the mean point of explosion which lies in the line of direction of the fire, and at the same time 12 m. lower. This will be the position of the target. From this point two lines are drawn, inclined respectively 22° and 70° to the horizontal,* and the points of explosion lying within that angle are counted. In this way it is seen that 45 per cent. lie within the effective space, 31 per cent. of all the shots lie too high or too far, 24 per cent of all shots too low. However it cannot be assumed that all of the 45 per cent. will be effective. In case of shots with distances of the points of explosion of over 25 m. effective action cannot be expected, because the fragments due to the explosion will spread out too much. Hence 10 per cent. more must therefore be lost, leaving 35 per cent. as effective.

In case of a mean point of explosion at $\frac{+15}{13}$ the number of shots lying within the angle falls to 21 per cent. giving 17 per cent as effective. The mean point of explosion $\frac{-35}{13}$ gives 31 per cent. within the angle and therefore 23 per cent. promising effective action.

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* In case the target is covered under a greater angle than 22°, the first line must naturally be drawn at that angle.

The conclusion may be drawn therefore, that mean points of explosion between +10 and —40 will give effective action, provided the heights of explosion correspond. If the point of explosion is a little far in advance, then the short shots produce the effective action; if it lies to the rear the far shots.

D—FIRING AGAINST MOVING TARGETS.

The representation of a practice firing against targets moving in the direction of the line of fire, forward or backward, is not difficult. It is only necessary to determine the exact movement of the target (direction and velocity), and the length of the pauses between successive shots. If, for instance, it is required to fire upon infantry advancing on the battery at the rate of 90 m. per minute, and the pauses between shots are 20 seconds long, the target distance is diminished for each successive shot some 30 m. The director need only assume in the preparatory record, that the target distance, which remained unchangeable in the case of fixed targets, becomes in this case less and less every shot, and must fill in the columns accordingly. Should the target move at trotting pace (240 m. a minute) then with a pause between shots of 20 seconds, 80 m. must be allowed; at a gallop (400 m. per minute) 130 m.

In case of short shots at rapid fire, the target distance is assumed the same for all, and that of the preceding shot (fired slowly) is taken as the true distance; for the next shot, fired slowly, the distance is diminished by the same amount as if all the rapid-fire shots had been fired in 20 seconds.

Since in firing on moving targets the guns cannot be pointed with the same accuracy as against fixed targets, it will be in conconformity to reality to assume large deviations. On the other hand, observation is generally easy as the targets are visible in their full height; hence, favorable observation conditions may be assumed. For the example here given, the following assumptions were made:

Target—Infantry advancing, rate 90 m. a minute.

Original distance—1880 m.

Observation—Lottery numbers 1 to 77, correct (77 per cent.).
Lottery numbers 78 to 96, doubtful (19 per cent.).
Lottery numbers 97 to 100, false (4 per cent.).

The list of the lottery numbers actually drawn and their signification was as follows:

Number. 1.	Number on firing record. 2.	Lottery number. 3.	Deviation. m. 4.	Target distance. 5.	Target distance minus deviation. m. 6.	Lottery number. 7.	Observation. 8.
1	1	64	+20	1880	1860	43	c
2	2	80	+40	1850	1810	47	c
3	3	38	—15	1820	1835	3	c
4	4	34	—20	1790	1810	89	?
5	5	42	—10	1760	1770	75	c
6	10	78	+40	1730	1690	82	?
7	11	70	+25	1700	1675	93	?
8	12	26	—35	1670	1705	17	c
9	13	41	—15	1640	1655	24	c
10	14	25	—35	1610	1645	19	c
11	15	43	—10	1580	1590	20	c
12	20	11	—65	1550	1615	82	?
13	21	29	—30	1520	1550	59	c
14	22	93	+75	1490	1415	21	c
15	23	52	± 0	1460	1460	41	c
16	24	60	+15	1430	1415	27	c
17	25	30	—30	1400	1430	98	f
18	30	69	+25	1370	1345	56	c
19	31	46	— 5	1340	1345	96	?
20	32	3	—105	1310	1415	7	c
21	33	82	+45	1280	1235	37	c
22	34	96	+90	1250	1160	34	c
23	35	63	+15	1220	1205	40	c
24		6	—85	1190	1275	15	c

The figures in column two are not entered of course, until the firing record is made out.

The firing record resulting from the foregoing, with due observance of the firing regulations, would be as follows:

No. of gun. 1.	COMMAND. 2.	No. of shot. 3.	Elevation. m. 4.	OBSERVATION. battery. 5.	OBSERVATION. target. 6.
I.	P. s., adv. inf., r of village, 2000, r. fl., F. ![*]	1	2000	+	+140
II.		2	1800	—	— 10
III.	Slow fire!	3	"	—	— 35
IV.		4	"	?	— 10
V.		5	"	+	+ 30
VI.	Rapid fire!	6	"	?	From + 30 to + 80
I.		7	"		
II.		8	"		
III.		9	"		
IV.		10	1600	?	— 90
V.		11	"	?	— 75
VI.		12	"	—	—105

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[*] Percussion shell, on the advancing infantry, to the right of the village, at 2000 m., from the right flank, Fire!

No. of gun. 1.	COMMAND. 2.	No. of shot. 3.	Elevation. m. 4.	OBSERVATION.	
				battery. 5.	target. 6.
I.		13	1600	—	— 55
II.		14	"	—	— 45
III.		15	"	+	+ 10
IV.	Rapid fire!	16	"	?	From + 10 to —45
V.		17	"		
VI.		18	"		
I.		19	"	?	From +10 to —45.
II.		20	1400	?	—215
III.		21	"	—	—150
IV.		22	"	—	— 15
V.		23	"	—	— 60
VI.		24	"	—	— 15
I.		25	"	+	— 30
II.	Rapid fire!	26	"	?	From — 30 to +25
III.		27	"		
IV.		28	"		
V.		29	"		
VI.		30	1200	—	—145
I.		31	"	?	—145
II.		32	"	—	—215
III.		33	"	—	— 35
IV.	Rapid fire!	34	"	+	— 40
V.		35	"	?	From + 40 to —35.
VI.		36	"		

For the shots fired at rapid fire the deviation is assumed to be that given in column four of the table, taking the deviation of the first shot striking behind the target (number 5, 15 etc.), and that of the succeeding shot in the record (Firing Record No. 10 or No. 20; Preparatory Record, 6 or 12), in each case. For instance the first rapid fire followed shot 5. According to the record of lottery numbers shot 5 had a deviation of —10; the following shot 6 (current number of the record of lottery numbers) had a deviation of +40. Since the target at the moment of opening the rapid fire was at the distance of 1760 m., the shots fired with 1800 m. elevation struck at 1790 to 1840, therefore from 30 to 80 m. behind the target.

The first rapid fire shots passed without effect over the target; the cause of this was the fact that shots number 3 and 4 accidentally fell short, and then too, the latter was not observed. The rapid fire at 1600 and 1400 m. was very effective, and in all probability in an actual firing of this kind, the advance of the target would not have been continued any farther. The rapid fire at 1400 m. was in fact ordered on a falsely observed shot: but the target had been for some time (since shot 22) in the effective zone of the fire, and, had this become known by the effect on the target, the rapid fire could have been ordered as early as this shot (22), or after shot 24.

[TO BE CONTINUED.]

ERRATA FOR ARTILLERY-FIRE GAME.

Page 124, fourth line from bottom, read "vertical side elevation of 100 points, etc."

Page 134, third line, "vertical" projection.

Page 134, note, second line from bottom, read 12°.

Page 136, fifth line, read $\frac{-70+80}{6-6\times 1.6}=$ etc.

eighth line, read $\frac{-100}{+10}$

Page 137, note, first line, *Aufsatz platten.*

Appendix 2, heading read "vertical side elevation of etc."

Page 260, for "I. Mode etc.," read II. Mode etc.

Page 277, thirteenth line, for "266 and 266" read 266 and 267.

Page 279, column four, elevation shot No. 9, for 2030 read 2050.

NOTES ON ARTILLERY.

Note in answer to a pamphlet published by Messrs. Armstrong and Co., in November, 1892, on R. F. guns. Translated from the French.

The *Army and Navy Gazette* published in its issue of November 5 [1892] a note in answer to the articles published in *Engineering* of September 30, and of October last. To guess the origin of this note was not difficult inasmuch as it favored so strongly the Elswick works, affirming their superiority to other constructors of artillery material. The same note has been reproduced in a pamphlet entitled "Remarks on 15 cm. and 6″ quick-firing guns," and signed by Sir W. G. Armstrong, Mitchell and Co., Elswick, November, 1892. There is therefore no longer room for doubt: we have to deal with an official Elswick document.

The article to which the Messrs. Armstrong replied, inserted as it was by an engineer of Le Creusot in defense of the cause, successively in the *Génie Civil*, and next, at the request of Le Creusot, in *Engineering*, may be considered as inaccurate on all points of which it treats, and seems to be the product of a person having rarely handled a R. F. gun. The question turned on a 15-cm. R. F. gun, the only piece of this sort existing in the Creusot works. This gun has the same length in calibres as the Canet built three years ago, and a projectile of the same weight, the breech-closure reproducing with modifications of no advantage, the principal features of the breech of the French Navy. In all this there is nothing new or original. We may remark, besides, that the Creusot works needing in 1886 and 1887 guns to test its armor plates, ordered of the *Forges et Chantiers* a 24-cm. and a 15-cm. gun of the Canet system. These guns are still to be found on their proving ground. At this epoch, Creusot was not engaged in gun-manufacture, and therefore, if it has since acquired experience, this experience is not of great extent. We may therefore not take seriously criticisms of the material of constructors whose R. F. guns, tested for three or four years, have been adopted by several governments and are in service in war-ships. The tests treated of in the *Génie Civil*, and *Engineering*, were carried out by the Creusot works on a proving ground where practice is possible only in a very narrow sand-enclosure (*chambre à sable*). Fire at sea to great ranges is out of the question. In consequence, special precautions were necessary, and the angles of elevation greatly limited. These are not strictly speaking rapidity tests, executed as they are under conditions wholly different from those to be found on board ship. This practice then established no superiority.

These things premised, we think it necessary to indicate, the points in which we cannot agree with the Elswick company in the technical discussion it has set on foot.

I. *Loading of the Piece.*—Messrs. Armstrong find an advantage in loading in two times, projectile first and then cartridge. They maintain that by thus avoiding the handling of a cartridge that is certainly inconveniently large when it carries a projectile at its end, an economy may be realised in the time of loading. This point is not borne out by practice. It is proved that with sufficiently strong men, loading in one time takes less time than two successive operations. In the first place when the men are not very well drilled, it is far easier to load in one time than in two. This is evident. Further the Messrs. Armstrong had at first only very small cartridges. This is due to the fact that they do not seek for high velocities, that are however necessary, and next to their employment of a powder of very high efficiency, permitting the use of small charges. But as it is established that this powder very rapidly deteriorates the gun, that the British government has not even yet made it regulation, it is certain that the MM. Armstrong will be forced sensibly to increase both the weight and length of their cartridge-cases, a thing they are as a matter of fact already doing. Under these conditions they fall back on the dimensions used in France; a single operation then offers weighty advantages. They have themselves recognized this fact for the 12-cm.

Finally, the separation of projectile from cartridge-case presents a serious drawback, which could have been foreseen and which has been verified by experience. The rifling-band of the projectile, the latter not being well seated, is not sufficiently forced into the grooves. Hence a play between the projectile and the surface of the bore with the erosions consequent on the escape of gas, through this play. These erosions have on several occasions been found to exist in English guns. Moreover, the lips of the cartridge-case not being well pressed against the surface of the chamber, the gases sometimes turn back producing serious degradations. From this point of view, a disposition that consists in mounting and setting the projectile at the end of a case acting as a rammer to set the projectile exactly in place, imposes itself as a necessity in these days of high pressures.

II. *Conical breech-plugs.*—The Messrs. Armstrong affirm that thousands of shots have been fired with the conical breech-plug: but were all these accompanied by high pressures?

In the reports of practice one often finds pressures of 2200, and Captain Lloyd has declared to the French Navy that Armstrong guns should not be fired with pressures exceeding 2125 kg. (Official Report). In any case, whenever high pressures have been developed have not the threads of the breech-screw been found upset? This is a point on which we should have accurate information. At Sevran-Livry, the trials of Armstrong guns have not answered expectations, as may be seen from the official reports

Messrs. Armstrong claim as an advantage for the conical breech an increase of the surface over which the pressure on tube or jacket distributes itself.

We shall answer first that a conical breech-screw is very hard to make, and that its bearing is far less certain than that of the cylindrical breech.

In the second place, by the mere fact of the increase in diameter, it cuts away far too much the rear of the sleeve and lessens in consequence the section of metal resisting the effort produced by gas-pressure on the breech-plug.

Thirdly, in a conical breech, the threads of the screw tend to slip on those of the nut, these having an inclined generatrix: this interferes with good bearing. Under these conditions the best system is still the cylindrical, which may be adjusted with mathematical precision, and gives an excellent distribution of effort,—distribution that becomes absolutely necessary, in the case of abnormal pressures that are often very great.

Besides there is no occasion with a suitable arrangement of the breech-working mechanism, to seek to suppress the motion of translation of the breech in the direction of the axis of the gun, this being briefly the purpose of the Armstrong conical breech.

The French Navy, after trial, has rejected outright this disposition. The official note of the *Direction de l'Artillerie* published in the report on the budget of 1893, expresses itself thus: "Guns already fitted with the cylindro-conical breech, *to-day abandoned*, will be used for ballistic purposes." This declaration is clear and settles the question.

III. *Manipulation of the breech.*—The Messrs. Armstrong have always criticised opening the breech by a single motion of the lever, alleging that with drilled men this gave no markedly greater rapidity of fire, and that in any case, the matter was of only secondary importance. But lately, they seem to have changed their views. In fact they announce in their report at the meeting of the stockholders, and in their last pamphlet, that they would have in the future a single-motion system that would give good results. But the description of this system has not yet been published. Not one of the guns delivered at the present time to foreign governments has this fermeture. We must wait then until the new system shall have stood its tests. It is proper to remark, that the single-motion system is not important merely with reference to rapidity of fire; we may admit rigorously that in a workshop or on a proving ground trained men can work both types of breech with about the same rapidity. But were there an advantage of only a few seconds, it would have to be taken into account, in view of the case of two ships passing broadside on, and having therefore in a very short interval of time, to send the greatest number possible of projectiles. The point of view of greatest importance is this: to succeed in removing all hesitation on the part of the more or less experienced man who works the breech; the cannoneer must not have the slightest hesitation in passing from one motion to another, and should have no tendency to begin one motion before the preceding one is completed. His task must then be made as easy as possible, his functions, so to speak, automatic. When this result may be achieved by means of very simple devices, it is inadmissible not to apply the advantage of these devices to R. F. guns. This automatic manœuvre is one of the chief advantages of Canet guns, and does not exist in the Armstrong. It may be added that in the Canet breech the block is accurately guided on the console, while in the Armstrong system the same block is so much out of plumb as to produce serious inconvenience.

IV. In respect of rapidity of fire, it is evident that during combat we shall hardly be able to count on a greater normal rate than from four to five shots a minute. Nevertheless, as indicated above, in the case of broadside to broadside, and particularly for smaller calibres, in the case of torpedo-boat attack, we must have a maximum rapidity. At sea, in correcting the aim with 12-cm. Canet guns, the rate of ten shots a minute has been attained, and without aiming, of twelve. This result is most satisfactory. With the 15-cm. the number of shots has been ten per minute. This rate has not been equalled with Armstrong guns.

V. As regards extraction, there is a serious inconvenience in throwing the cases to the rear. Not only are they injured thereby, but they may wound the men. Extractors of this sort must then be absolutely proscribed. Equally to be avoided are extractors acting too suddenly on the rim of the case. Here too the Armstrong system, more or less complicated as it is, offers certain defects. The Canet extractor on the other hand, with its gentle and progressive action, and with its release of the rim uninjured if its resistance be too great, presents positive advantages. The spring that forms a part of it has a satisfactory action.

We shall add that a mean term is needed between the extractor which ejects the cases, and the one which like the Armstrong, merely disengages them. The case must be brought as far as the rear of the chamber. In the contrary case, the cannoneer is obliged as in the Armstrong system to have a special hook (*griffe*) for seizing the base of the case. This complication involves a loss of time. The cannoneer must be able to take the case in his hands as it leaves the chamber and deposit it with care on the ground.

VI. We remark that Messrs. Armstrong avoid speaking of the safety apparatus intended to prevent opening the breech when a hang-fire occurs. They have long disputed the necessity of this apparatus, that we however for an equally long time have considered absolutely indispensable. We know however on good authority that they offer to furnish it with the guns that they propose to supply to foreign governments. They therefore admit its necessity.

VII. Taking up the carriage, it is necessary to have only one recoil-cylinder. The author of the article in the *Génie Civil* could have studied the question of carriages but very slightly to claim as an advantage the presence of four recoil-cylinders, necessitating four stuffing-boxes, four patterns of orifices, &c., &c. In respect of the absence of valves, the Messrs. Armstrong forget that in a carriage with a single cylinder, as there must needs be springs to bring back the gun, if there are no valves and special orifices for the return to battery, there will follow far too rapid a movement which dislocates the carriage. These valves are therefore not a complication, but a necessity if the return to battery is to take place under good conditions.

If the attempt is made to reduce the length of recoil in too great a degree, the strain is necessarily transferred to the deck, and it is a very bad calculation to exceed certain limits. It is very easy to say that the recuperator is complicated, but an examination of that of the Armstrong system shows that it is not less so. Moreover in the Canet carriage may be found the advantage always presented by the use of a recuperator, with reference to direct action upon the springs. For this arrangement, while lessening the number of springs, allows a more rational use to be made of them, the course being shorter.

The Messrs. Armstrong claim that cordite strains the recoil-check in a lesser degree than the French powders. This fact is not established; further, our experiments have shown that this difference is not appreciable. As for other reasons, cordite cannot be adopted for general service, we need not dwell on this point.

In the remainder of the article, the Messrs. Armstrong point out other errors and contradictions, as, e. g., that the Creusot works were the inventors of guns recoiling in the direction of their axis. This last factory appears rather to have imitated what had already been done for several years. There are other inaccuracies, that deprive the article in question of all semblance of authority.

VIII. *Ballistic Data.*—The Messrs. Armstrong declare that by arranging figures and results in suitable manner, one can succeed in making them support any desired conclusion. We shall try to examine the ballistic data in a perfectly impartial manner.

It is within limits accurate to compare a gun to a machine in which a sort of balance must be maintained between the advantages of such and such an arrangement with respect to another. But we must know, other things equal, and taking service conditions into account, which arrangement possesses the greatest number of advantages, even at the cost of disadvantages sometimes themselves by no means slight.

The Armstrongs prefer, so they say, low pressures, heavy projectiles,* and moderate velocities.

M. Canet uses higher pressures with relatively light projectiles animated by a high muzzle velocity.

The pressures in Canet guns do not, in general service surpass 2400 atmospheres: this may be taken as absolutely normal in guns that are always proved under 3000 and even 4000 atmospheres. These are, besides, the pressures developed by the Messrs. Armstrong in proving-ground trials for the attainment of published results. It is true that in service, they think it prudent not to exceed 2125 kg.

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* We may note here that this difference in weight of projectile is not an absolute rule, since the 10-cm. and 12-cm. Armstrong fire lighter projectiles than the Canet of same calibres.

If they find these pressures too high, having given the resistance of their guns, this is not the case with the Canet, which easily stand these pressures. In a ballistic point of view, it is unquestioned that the atmospheric resistance increases with the velocity and has proportionally more influence on a light projectile. But the eternally debated question is whether it is not better to have an extremely flat trajectory, with increased danger-zone, and efficiency of hits, even at the cost of a slight falling-off in living force. With R. F. guns, distances ordinarily will not exceed 1500—2000 m.; at these distances, the difference of living force between a light and a somewhat heavy projectile is absolutely insignificant. It is the business of R. F. guns to seek to cover with projectiles the decks and upper works of the enemy; the usual case will be fire against thinly armored vessels. It is evident that 12-cm. and 15-cm. guns, at the distances in question, cannot hope to sink a heavily armored ship. There is then no great importance if perforation should be diminished by a few millimetres. Under these conditions, whatever may be said, the advantage seems to us to remain with the high muzzle velocities; and, anyway, this is certainly the general opinion since in consequence of the impulsion given by M. Canet, all constructors and governments have felt the need of giving to high velocities a prominent place in their programmes.

The argument that consists in saying that the only way of estimating the efficiency of a gun is to take its living force at the muzzle is absolutely inaccurate, because this involves the supposition that shots are always exchanged muzzle to muzzle. To maintain this is to ignore combat-conditions; one cannot exclude all considerations of flatness of trajectory, of angle of fire, which are the principal factors. Neither must it be supposed that the best gun is that giving the highest efficiency per kilogramme of metal, and per kilogramme of powder: the best gun is that which, while of very high power, answers most closely to the necessities of combat. We may therefore not rest a definite opinion on considerations of muzzle-energy and of efficiency, on which is based the reasoning of Messrs. Armstrong.

We give below a few deductions from the figures obtained with Canet guns. As the adjoined table shows, these are from all points of view the most powerful. They have the advantage in certain cases, thanks to the high initial velocity that they give to the projectile, of a dangerous zone superior by ten per cent., fifteen per cent. and even thirty per cent. to that of other guns.

With projectiles of thirteen, twenty-one, forty kg., adopted by M. Canet for the 10, 12, 15-cm., L/40 and L/45, we have guns giving according to the powder, muzzle velocities of above 800 m. This velocity has now entered the domain of ordinary practice. The efforts of all artillerymen will tend to attain similar velocities.

As for the length of guns, it is to be remarked that other constructors have followed the example of M. Canet. Thus, the French Navy has built a 16-cm. gun of L/90. The Armstrongs too, in spite of the criticisms that they make, are, according to the English prints, building very long guns for the purpose of obtaining very high muzzle velocities.

This length of guns offers no difficulty in respect of droop, as has been proved by the nicest experiments made with Canet material, and it has the advantage of allowing every advantage to be drawn from the use of the new slow powders. The French Navy has shown that it had confidence in long guns by ordering thirty Canet pieces L/55.

We have the following comments to make in regard to the figures given by the *Génie Civil*, *Engineering*, and the *Army and Navy Gazette:*

According to the table, the 15-cm. gave for $V_0 = 760$ m. a pressure of 2400 atmospheres; as a matter fact, the pressure was less than this. With that of 2500 atmospheres (about 2580 kg.), indicated for the Creusot gun, one would get in the Canet 15-cm. gun, $V_0 = 800$ m., with 10.8 kg. of regulation powder B; that is, with two kg. of powder less than in the Creusot gun, thus showing a better utilisation of powder in the Canet.

The Canet 15-cm. is of the model of 1889. At that time, smokeless cannon powders were hardly known: the gun was designed for a velocity of 680 m., as published to the world. In giving 760 m., it has permitted us to reach a velocity 80 m. greater than that foreseen: a very satisfactory result.

If we compare the service data of Krupp, Armstrong and Canet guns, of the three calibres, we find the following results proving that with the same pressures, the Canet gun—in service, and not taking isolated shots—is superior to the Krupp and to the Armstrong.

TABLE I.

	R. F. GUNS.								
	10-cm. and 10.5-cm.			12-cm.			15-cm.		
	Armstrong.	Krupp 10.5-cm.	Canet.	Armstrong.	Krupp.	Canet.	Armstrong.	Krupp.	Canet.
Weight of gun, k.	1676	1200	1700	2083	1900	2900	5842	4770	5700
Weight of projectile, k.	11.34	12	13	20.41	18	21	45.30	34.5	40
Muzzle velocity, m.	740	747	740	670	716	750	673	742	760
Total Muzzle Energy, M.T.	316	341	363	467	470	602	1052	963	1177
Penetration in Wrought iron, mm.	195	195	221	221	221	234	261	251	277
Energy referr'd to English gun as unit	1	1.07	1.13	1	1.01	1.28	1	0.91	1.12
Penetration referred to English gun as unit	1	1	1.13	1	1	1.06	1	0.97	1.05

TABLE II.

RESULTS OBTAINED WITH CANET R. F. GUNS.

	Weight of projectile, K.	Weight of charge, K.	M. V.	Mean Pressure.
57-mm., L/80	2.7	1.35	998	2540
"	2.7	1.4	1013	2680
10-cm., L/80	13	6.2	977	2430
"	13	6.4	1002	2520
"	13	5.6	1026	2980
10-cm., L/48	13	2.75	804	2600
"	13	3.0	843	2660
"	13	3.0	842	2680
12-cm., L/45	21	4.5	800	2400
15-cm., L/45	40	9.75	760	2400
15-cm., L/48	40	8.0	765	2340
"	40	9.0	843	2720
"	40	9.5	870	3080

TABLE III.

FIRINGS WITH A R. F. 10-CM. CANET, L/80, CARRIED ON WITH THE FRENCH NAVY SMOKELESS POWDERS.

Date.	Weight of projectile, K.	Weight of charge, K.	Kind of Powder.	M. V.	Mean Pressure.
27 August, 1892.	13	5	Brown Prismatic.	577	1052
"	13	8	"	719	1946
"	13	10.025	"	826	2437
"	19.8	9.4	"	674	2497
20 September, '92.	13	4.8	Smokeless, Type I.	911	2117
"	12.9	4.9	"	930	2259
"	13	5.0	"	933	2276
"	13	5.1	"	950	2372
"	12.8	5.3	"	979	2512
"	13	5.5	"	1008	2789
"	13	5.6	"	1026	2979
"	13	5.4	Smokeless, Type II.	891	1936
"	13	5.6	"	901	1921
"	13	5.8	"	937	2094
"	13	6.0	"	954	2195
"	13	6.2	"	977	2430
"	13	6.4	"	1002	2523
"	13	6.2	Smokeless, Type III.	864	1875
"	13	6.4	"	892	1984
"	12.98	6.7	"	921	2052

In addition we reproduce above a summary of the most interesting rounds fired in Canet guns of great length. This table shows that with these, hitherto unattained velocities have been realised.*

To conclude, the Canet R. F. system has been adopted by Russia after comparative trials with other systems. It has been adopted by Chili. France has ordered Canet 10-cm., 14-cm., 16-cm., for the armament of all new ships and that after numerous comparative trials.

These are facts that reply more effectually than all arguments to criticisms tending to insinuate that the Armstrong system alone has stood the test of service on board ship, particularly as, unlike the Canet material, it has been adopted by no power after comparative trials. P. M. V.

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* We omit here Table I of firings carried on in May and in June, 1892. This table has already been given in the *Journal of the United States Artillery*, Vol. I, No. 3, p. 277a.—TR.

BOOK NOTICES.

The Applications of Elliptic Functions by Alfred George Greenhill, M. A., F. R. S., Professor of Mathematics in the Artillery College, Woolwich.

An apology may perhaps seem necessary for the appearance of a review of a purely mathematical work in so distinctively professional a journal as the *Journal of the United States Artillery*. A sufficient excuse will, the writer thinks, be found in the great importance of the theory of elliptic functions in almost all problems of applied mathematics, and in particular in the more elaborate investigations of the form of the path of a projectile.

It is interesting to notice that the present work, which is a masterpiece of its kind, and the greatest modern treatise on elliptic functions, viz: Halphen's *Traité des Fonctions Elliptiques* have both emanated from mathematicians closely identified with the artillery service of their respective countries. Greenhill, though not an artillery officer, has long been connected with the artillery college at Woolwich, and his theoretical investigations on some of the most difficult ballistic problems are well known. Halphen, whose premature death has left the third volume of his great work incomplete, was at his death a colonel of artillery; he was a most efficient officer and as a mathematician he ranked second to none.

Other instances might be given of distinguished officers of artillery, and of other branches of the service, particularly in France, who have also been distinguished as mathematicians and who have made important contributions to the theory of elliptic functions. The two cases mentioned, however, will perhaps serve as a justification of the presence of the following review in this journal.

The present work is not to be considered as a treatise on the elliptic functions nor, indeed, can it be recommended to any reader who has not already a fair knowledge of these functions, its object being mainly to apply the properties of the elliptic functions to the solution of certain important physical and mechanical problems. The author takes as his text the following words of Fourier:

"L'étude approfondie de la nature est la source la plus féconde des découvertes mathématiques.

"Non seulement cette étude, en offrant aux recherches un but déterminé, a l'avantage d'exclure les questions vagues et les calculs sans issue; elle est encore un moyen assuré de former l'Analyse elle-même, et d'en découvrir les éléments qu'il nous importe le plus de connaitre et que cette science doit toujours conserver.

"Ces éléments fondamentaux sont ceux qui reproduisent dans tous les effets naturels."

With such a text the work is naturally addressed principally "to the student of applied mathematics, who will generally acquire his mathematical equipment as he wants it for the solution of some definite actual problem." The work has been prepared then to enable such students "to see how the purely analytical formulas may be considered to arise in the discussion of definite physical problems."

A question, which this is not the place to discuss, suggests itself in connection with the author's remark that the student of applied mathematics in general gets up his pure mathematics as he needs it for the discussion of some particular problem. If this is the case it seems to the present writer that "in general" the student of applied mathematics needs very little pure mathematics, which is surely not the case, or he is "in general" a remarkably able analyst if he can get up merely as an incident in his regular work a whole theory of pure mathematics whenever such a theory presents itself in the solution of his physical or mechanical problem. It would be of interest to have the distinguished author's views on the subject of the necessary and sufficient amount of preliminary training in pure mathematics to be given to the young man whose subsequent career will require him to make much use of applied mathematics. For example is the preliminary mathematical training of our own Military Academy, admirable as it is so far as it goes, sufficient to enable an artillery officer to grapple successfully with the exceedingly complicated problems presented by modern artillery science? Or can such officer, with merely his West Point mathematics as a basis, work up as he needs it any theory of pure mathematics without outside assistance or instruction? The writer's experience as a teacher of higher mathematics would lead him to answer both questions in the negative, and, apropos of the actual subject, to advise the young American artillery officer to take at least a brief course of instruction in elliptic functions before undertaking Greenhill's work, much of which could indeed be read and appreciated without a previous knowledge of the general subject of elliptic functions, but more, and that the most interesting and important, would probably be hopelessly obscure. This is not in any way an adverse criticism of the work which, for its avowed purpose and consequent limitations, is most admirably prepared by one who is well known to be unquestionably a master in all that relates to the applications of the elliptic functions, whether to questions of pure or applied mathematics.

The author begins by the discussion of the classical problem of the simple pendulum as being the one best adapted to define the elliptic functions and to give the student an idea of their nature and importance. The equation of motion of the pendulum is

$$\frac{d^2s}{dt^2} = -g \sin \frac{s}{l}$$

where l is the length of the *equivalent simple* pendulum and s is the arc swung through in time t. Making $\frac{g}{l}=n$, n being what Sir William Thompson calls the *speed* (angular) of the pendulum, we find

$$nt=\int_0^\theta \frac{d\frac{1}{2}\theta}{\sqrt{\sin^2\frac{1}{2}\alpha-\sin^2\frac{1}{2}\theta}}$$

where 2α is the angle of oscillation and $\theta=\frac{s}{l}$. Making now $\sin\frac{1}{2}\theta=\sin\frac{1}{2}\alpha\sin\phi$ this equation becomes

$$nt=\int_0^\phi \frac{d\phi}{\sqrt{1-\sin^2\frac{1}{2}\alpha\sin^2\phi}}$$

and finally writing $\sin\frac{1}{2}\alpha=k$ we have the time given in the form of Legendre's integral of the first kind $F(\phi)$, or if the *modulus* k be brought into evidence, $F(\phi,k)$.

Dropping now for the moment the physical problem the author writes as usual $u=F(\phi)$ and quoting Abel's remark that $F(\phi)$ should be considered as an inverse function of u gives Jacobi's notation

$$\phi=\text{am } u,\ \sin\phi=\sin\text{am } u,\ \cos\phi=\cos\text{am } u,\ \Delta\phi=\Delta\text{am } u$$

(for am u read amplitude u), and then the briefer notation sn u, cn u, dn u of Gudermann. The values of the differential coefficients with respect to u of am u, sn u, cn u, dn u are now found and the author returns with these definitions and notations to the problem of the pendulum.

The circular functions of ordinary trigonometry are shown to be the limits of sn u, cn u for $k=0$ (then dn $u=1$), and a brief digression is made on cycloidal oscillations, the only class of finite oscillations which can be treated by the circular functions.

Adopting a definition given in the report of a committee at the *Conference of Electricians in Paris*, 1889, the *period* of a pendulum is the time of a *double* swing which, if the swing is small gives for the period the value $2\pi\sqrt{\frac{l}{g}}$, but if the angle of vibration 2α is finite we have for the period

$$T=\frac{4K}{n}=2\pi\sqrt{\frac{l}{g}}\left\{1+\left(\frac{1}{2}\right)^2k^2+\left(\frac{1.3}{2.4}\right)^2k^4+\left(\frac{1.3.5}{2.4.6}\right)^2k^6+-\right\}$$

where K is the *real quarter period* of the elliptic functions and is given by

$$K=\int_0^{\frac{\pi}{2}}\frac{d\phi}{\sqrt{1-k^2\sin^2\phi}}$$

in which the *modulus* k is given by

$$k=\sin\tfrac{1}{2}\alpha.$$

Defining the *complementary modulus* k' by the relation

$$k^2+k'^2=1$$

we have the *complementary quarter period* K' defined as the same function of k' that K is of k. A table is now given of the logarithms of the quarter periods K and K' corresponding to every half degree in the modular angle $\frac{1}{2}\alpha$; this angle is given in the table from 0 to 45°.

The particular case of $\alpha = \frac{1}{2}\pi$, that is when the pendulum drops from a horizontal position and swings through two right angles, is illustrated by the Navez Electro-Ballistic pendulum; now $K = K'$ and the modular angle is $\frac{1}{4}\pi$ so $k = k' = \frac{1}{2}\sqrt{2}$ and

$$\text{cn}\ u = \cos\phi,\ \text{sn}\ u = \sin\phi,\ \text{dn}\ u = \sqrt{1 - \tfrac{1}{2}\sin^2\phi}.$$

The two problems of a pendulum oscillating and of one performing complete revolutions are used to show how the elliptic functions whose modulus k is greater than unity can be transformed into other elliptic functions whose modulus is $\frac{1}{k}$ and is therefore less than unity. Rectilinear oscillations are considered as giving examples of differentiation of elliptic functions; a further example is afforded by the verification of the fact that the surface (discovered by Schwarz)

$$\text{cn}\ x + \text{cn}\ y + \text{cn}\ z + \text{cn}\ x\ \text{cn}\ y\ \text{cn}\ z = O$$

when $k = \frac{1}{2}$ is a *minimum* surface having zero curvature at every point.

In closing Chapter I the author gives as a further illustration of the mechanical interpretation of the elliptic functions the application of these functions to the solution of Euler's equations of motion for a body moving about a fixed point when no forces are acting. This problem is resumed in Chapter III and in the course of its treatment *the elliptic integral of the third kind* is found. Denoting by p, q, r the component angular velocities of the body about its principal axes, and by A, B, C the moments of inertia about the principal axes we have for the equations of motion.

$$A\frac{dp}{dt} = (B - C)qr$$

$$B\frac{dq}{dt} = (C - A)rp$$

$$C\frac{dr}{dt} = (A - B)pq$$

Two first integrals of these equations are found at once viz:

$$Ap^2 + Bq^2 + Cr^2 = T,\ \text{a constant,}$$
$$A^2p^2 + B^2q^2 + C^2r^2 = G^2,\ \text{a constant.}$$

G denotes the resultant angular momentum the axis of which is fixed in space. The direction cosines of the axis being

$$\frac{Ap}{G},\ \frac{Bq}{G},\ \frac{Cr}{G}$$

the component angular velocity about this axis will be

$$\frac{Ap^2 + Bq^2 + Cr^2}{G} = \frac{T}{G} = \text{const.}$$

where manifestly T is the kinetic energy of the body. This component is denoted by μ. Writing $\frac{T}{G} = \mu$, $\frac{G^2}{T} = D$;

D is evidently a constant quantity of the same dimensions as A, B, C. We have now

$$G=D\mu,\ T=D\mu^2$$

If I denotes the moment of inertia about the instantaneous axis of rotation OP and if OP denotes the vector of the momental ellipsoid at O then I varies as OP^{-2} so that we may put

$$I=\frac{Dh^2}{OP^2}$$

where h is a new constant length. Now if ω denotes the resultant angular velocity about OP,

$$T=I\omega^2, \text{ or } D\mu^2=\frac{Dh^2\omega^2}{OP^2}$$

so that the angular velocity ω varies as OP and

$$\frac{h}{\mu}=\frac{OP}{\omega}=\frac{x}{p}=\frac{y}{q}=\frac{z}{r}$$

The direction cosines of the normal to the momental ellipsoid at P being proportional to Ax, By, Cz are therefore $\frac{Ap}{G}$, $\frac{Bq}{G}$, $\frac{Cr}{G}$; so that OC, the axis of G, is perpendicular to the tangent plane at P; and if OC meets this tangent plane in C, it follows that $OC=h$, so that the tangent plane at P is a fixed plane; and during the motion the momental ellipsoid rolls on this fixed plane, called the ***invariable plane***, with angular velocity proportional to OP. The curve traced out on the momental ellipsoid by the point of contact P is called the ***polhode*** and the curve traced by P on the invariable plane is called the herpolhode. These curves of Poinsot's are now studied and their equations found.

Denote by v the component angular velocity about an axis OH where OH is equal and parallel to OC, then

$$p^2+q^2+r^2=\omega^2=\mu^2+v^2$$

The quantities v and ω are found as elliptic functions of t. Writing

$$\left(\frac{1}{B}+\frac{1}{C}\right)+\frac{G^2}{BC}=\omega_a$$

and defining ω_b and ω_c by cyclic permutations of the letters A, B, C; also

$v_a^2=-\left(1-\frac{D}{B}\right)\left(1-\frac{D}{A}\right)$ and so for v_b and v_c; it is shown now that

$$\frac{d\omega^2}{dt}=-\sqrt{4(\omega_a^2-\omega^2)(\omega_b^2-\omega^2)(\omega_c^2-\omega^2)}$$

$$\frac{dv^2}{dt}=-\sqrt{4(v_a^2-v^2)(v_b^2-v^2)(v_c^2-v^2)}$$

Weierstrass's forms of the elliptic functions are now naturally introduced (though not for the first time in the book) to complete the solution of the problem. We have in fact

$$\begin{aligned} \mathrm{p}'u &= -\sqrt{(4\mathrm{p}^3u - g_2\,\mathrm{p}u - g_3)} \\ &= -\sqrt{4(\mathrm{p}u - e_a)(\mathrm{p}u - e_b)(\mathrm{p}u - e_c)} \end{aligned}$$

where e_a, e_b, e_c are the roots of the equation

$$4s^3 - g_2s - g_3 = 0;$$

we see then that

$$\omega_a^2 - \omega^2, \quad - \; - \; - \qquad \text{or } v_a^2 - v^2, \cdot \; - \; - \; -$$

are proportional to

$$\mathrm{p}u - e_a, \ \mathrm{p}u - e_b, \ \mathrm{p}u - e_c$$

the quantity v is thus determined by aid of the elliptic functions. If ρ and φ denote with respect to C the polar coordinates of a point on the herpolhode it is easy to see that

$$\frac{d\rho^2}{dt} = \frac{\mu}{h}\sqrt{4(\rho_a^2 - \rho^2)(\rho_b^2 - \rho^2)(\rho_c^2 - \rho^2)}$$

ρ_a: ρ_b, ρ_c being defined similarly to v_a, v_b and v_c. It is also shown that

$$\rho^2\frac{d\phi}{dt} = \rho^2\mu + \frac{A-D.B-D.C-D}{ABC}h^2\mu$$

These last two equations then serve to determine the equation of the herpolhode. The elliptic integral of the third kind is introduced in the final formula for φ, this is

$$\phi = \mu t + \tfrac{1}{2}i\int\frac{\mathrm{p}'v\,dv}{\mathrm{p}v - \mathrm{p}u}$$

where $v = \omega_1 + t'\omega_3$, t' a proper fraction, $2\omega_1$ the *real period* and $2\omega_3$ the *imaginary period* of Weierstrass's elliptic function pu. This integral is the *elliptic integral of the third kind.* The author shows next how to put it in Jacobi's form, viz:

$$\int\frac{k^2\,\mathrm{sn}a\,\mathrm{cn}a\,\mathrm{dn}a\,\mathrm{sn}^2u}{1 - k^2\mathrm{sn}^2a\,\mathrm{sn}^2u}du$$

This Chapter (III) is devoted entirely to geometrical and mechanical illustrations of the elliptic functions among which it must suffice merely to mention the problems of Central Orbits, the motion of Watt's Governor, the reaction of the axis of suspension of a pendulum, the internal stresses of swinging bodies, the Elastica, Sumner lines on Mercator's Chart, Catenaries and Geodesics. The chapter closes with an interesting collection of problems.

Chapter II contains a most valuable collection of formulæ connected with the circular, hyperbolic and elliptic integrals. It is impossible to give here any adequate account of the contents of this chapter; but as the reader is supposed to be previously unacquainted with the elliptic functions it is necessary to show how the general elliptic integral in its algebraic form arises. It has been shown that

$$\frac{d\,\mathrm{sn}u}{du} = \mathrm{cn}u\,\mathrm{dn}u;$$

making now $x = \mathrm{sn}u$, we have $\mathrm{cn}u = \sqrt{1 - x^2}$, $\mathrm{dn}u = \sqrt{1 - k^2x^2}$ so that

$$\frac{dx}{du}=\sqrt{(1-x^2)(1-k^2x^2)}$$

or

$$u=\int_0^x\frac{dx}{\sqrt{1-x^2.1-k^2x^2}}$$

This is again the elliptic integral of the first kind in one of its canonical forms. It is a transform of Euler's general integral

$$\int\frac{dx}{\sqrt{X}}$$

where X is a quartic or cubic function of x. The function X is treated in the older theory as an even quartic function of x or, as above, a quadratic function of x^2. Riemann's form (which the author seems to ascribe to Klein)

$$\int\frac{dz}{\sqrt{z(1-z)(1-kz)}}$$

is introduced and reasons due to Klein are given for considering it as a more canonical form than the above form which was used by Legendre and Jacobi.

When the general cubic expression X is given not resolved into factors Weierstrass's notation becomes useful and the author proceeds to define it. Writing $x=s+f$ and determining f so as to make the coefficient of s^2 vanish in the new value of X denoted by $\frac{1}{4}S$, Weierstrass gets

$$S=4s^3-g_2s-g_3$$

where g_2, g_3 are called the invariants. The integral is now

$$\int^\infty\frac{dx}{2\sqrt{X}}=\int^\infty\frac{ds}{\sqrt{S}}=\int_0^\infty\frac{ds}{\sqrt{4s^3-g_2s-g_3}}=\text{, say, } u.$$

s is now an elliptic function of u denoted by pu so that

$$\int^\infty\frac{ds}{\sqrt{4S^3-g_2s-g_3}}=\mathrm{p}^{-1}(s)\text{ or }\mathrm{p}^{-1}(s;\ g_2,g_3)$$

when it is necessary to have the invariants in evidence. In Weierstrass's notation we are independent of the particular resolution of S into factors; but if S is resolved into real factors

$$S=4(s-e_1)(s-e_2)(s-e_3)\quad e_1>e_2>e_3$$

then with $\infty>s>e_1$

$$u=\int_s^\infty\frac{ds}{\sqrt{4(s-e_1)(s-e_2)(s-e_3)}}=\frac{1}{\sqrt{e_1-e_3}}\,\mathrm{sn}^{-1}\sqrt{\frac{e_1-e_3}{s-e_3}}$$

the relations connecting the functions sn, cn, dn with p are now readily found. The value of u for $s=e_1$ is denoted by ω_1; this is the *real half period* and is given by

$$\omega_1=\int_{e_1}^\infty\frac{ds}{\sqrt{S}}=\int_{e_3}^{e_2}\frac{ds}{\sqrt{S}}=\frac{K}{\sqrt{e_1-e_3}}$$

The imaginary half period ω_3 is given by

$$\omega_3 = \int_{e_2}^{e_1} \frac{ds}{\sqrt{S}} = \int_{-\infty}^{e_3} \frac{ds}{\sqrt{S}} = \frac{iK'}{\sqrt{e_1 - e_3}}$$

It is now shown that taking Legendre's canonical integral

$$u = \int \frac{dx}{\sqrt{(1-x^2)(1-k^2x^2)}}$$

the quantities $4K$ and $2iK'$ are the periods of the function sn$u$.

Landen's transformation is given in this chapter and also a table of degenerate elliptic integrals. The chapter closes with the definition of the elliptic integrals of the second kind which present themselves in the integration of the functions

$$\mathrm{sn}^2 u,\ \mathrm{cn}^2 u,\ \text{- - -}$$

and with some examples taken principally from Legendre's *Fonctions Elliptiques*.

Chapter IV is concerned with the addition theorem of the elliptic functions, that is with the formulæ which serve to give the elliptic functions of a sum or difference $u \pm v$ of two arguments u and v in terms of the elliptic functions of u and v themselves. A good account of Poncelet's Poristic polygons with respect to two circles is given and the relation is exhibited that exists between the formulæ of Spherical Trigonometry and different forms of the addition theorem for the elliptic functions. The chapter closes with a well selected number of examples for exercise.

Chapter V can only be mentioned, though, to the student of pure mathematics at least, it is probably the most interesting chapter in the book; it deals with the algebraic form of the addition theorem, that is the algebraic relation existing between x, y, X, Y resulting in the integration of the differential equation

$$\frac{dx}{\sqrt{X}} + \frac{dy}{\sqrt{Y}} = 0$$

where X and Y are general quartic functions of x and y respectively.

Limitations of space make it impossible to say much concerning the remainder of Greenhill's most admirable *Applications of Elliptic Functions*. The titles of the remaining chapters are as follows:

Chapter VI, The Elliptic Integrals of the Second and Third kinds. Chapter VII, The Elliptic Integrals in general and their applications. Chapter VIII, The double periodicity of the Elliptic Functions. Chapter IX, The resolution of the Elliptic Functions into Factors and Series. Chapter X, The transformation of the elliptic functions.

An appendix deals with a problem of mechanics and one of hydro-dynamics. These chapters are rich in most interesting and important applications but, together with Chapter V, they could hardly be read by one not pretty familiar with the general theory of elliptic functions and indeed with a large part of the whole field of modern analysis.

To most readers of this journal one of the most interesting of the applications is Greenhill's own investigation in Chapter VII of the Trajectory of a Projectile for the cubic law of Resistance. A brief sketch of this investigation is not possible here, it is much condensed in the book and would be unintelligible if still further condensed. The reader who works out, verifies and thoroughly understands the results of this research will have a very good *practical* knowledge of elliptic functions.

The writer has endeavored to indicate briefly Greenhill's plan of deriving the formulæ of elliptic functions directly from some definite physical or geometrical problem. This plan has been carried out in a most interesting and effective manner and if in places the book is found to be "hard reading," it must be noted that the author is addressing himself to students of a rather advanced degree of training. These students will find the work rich not only in the applications given but in those suggested. The less advanced student can hardly fail in reading the "Applications" to have a desire awakened in him for a fuller acquaintance with the immense and fascinating field of modern analysis.

THOMAS CRAIG,
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Aperçus sur la tactique de demain, mise en rapport avec la puissance du nouvel armement et l'emploi de la poudre sans fumée. Par le Commandant Coumès, chef de bataillon au 70e régiment d'infanterie. Paris, 1892; L. Baudoin. Pp. XIV., 700.

This work is the outcome of lectures (*conférences*), delivered by the author in accordance with a ministerial decision of October 2, 1889, requiring such *conférences* to be held in every garrison town before officers of all arms, for the study of combined tactics under modern conditions. Of the author's qualifications there can be no doubt, based as these are on service in the war of 1870-71, to say nothing of the various colonial wars in which France has been since engaged. He has been moreover adjunct professor of military art and history at the *Ecole Spéciale Militaire.*

The work itself is divided into three parts. The first treats of the tactical organization of the three arms, and is supplemented by an excellent chapter on the introduction of smokeless powder.

The second part applies to the great tactical units, the principles underlying the organization of each of the three arms, in respect of their combination, of marches, and, in particular, of the development of the phases of a modern battle. The probably increased importance of night operations as a consequence of the introduction of smokeless powder, is next considered.

The third part is concerned with the principles controlling the operations of strategical units, as regards marches and concentrations, supply and combat. The volume closes with supplementary notes on the new infantry armament in France and abroad, and on various other matters that could not conveniently be embodied in the main work.

This summary in no wise indicates the thoroughness with which the author has done his work. His object is to discuss, to illustrate, before drawing definite conclusions. In his discussions, theoretical views are completely ignored, the author justly considering that positive results can come only from a study of actual conditions, supported whenever possible by past experience. It is needless to say that he nowhere yields to the temptation of bringing out novelties, as such. War alone can solve the various problems that are suggested by the new powders and armaments. But if war be a continuous function of the various elements on which it depends, if the relations between it and these various elements may at any epoch be accurately traced, then, having given new elements, it is not in vain to try to determine the new relations that must arise in consequence.

Guided therefore by the experience of the past, the author investigates the following problem: Given the small-caliber repeating rifle using smokeless powder, how shall troops be led to the battle-field? how shall they be handled on the battle-field? how shall they be trained, so that a commander may not at the psychological moment see his most brilliant plans come to naught?

The division with complete accessory services, is selected as the typical unit to which the solution of these problems is applied. We accompany it on its march behind the cavalry of exploration, until, contact with the enemy being announced, it passes from its preparatory formations into the zone of actual combat. Never losing sight of the main result of the introduction of the new powders, namely, that to-day the three arms must act in concert, if they would act at all, their coöperation on the battle-field is clearly and fully brought out. So intimate, indeed, is this coöperation, that it is almost logical to say that there are now no such things as "auxiliary arms."

From the division we pass by an easy transition to the corps as the strategical unit, the variation in the principles already discussed being of degree rather than of kind.

Inasmuch as it is vouchsafed to but few of our officers to see the three arms acting together in the attainment of a given end, any study of the operations of troops in large numbers is in this country perforce more or less academic in its character. But from this statement must be excepted the chapter containing the final considerations suggested by the development of the subject. Dealing as it does with the foundation of a soldier's education, its deductions are in the nature of general truths, and therefore independent of numbers. The author here rises to an eloquence unusual in treatises on tactics. He describes admirably the place that the soldier ought to occupy in the State, now that the army is but the nation in arms. He pleads for the Line as against the Staff, and brings into strong relief the true relations that bind them together. He points out existing defects as they appear to an officer of the line, that is, to the class of officers best able to see and correct them. There is no more interesting chapter in the whole work: it would be hard to find anywhere, one more valuable. If the author convinces by his eloquence, it is surely because in this case, eloquence is "the truth fitly spoken."

The absence of an index is to be regretted: it constitutes the only serious defect in a work that presents so clear a view of the tactics of to-morrow as seen from to-day.

C. DEW. WILLCOX,
1st Lieutenant 2nd U. S. Artillery.

Gunnery for Non-commissioned Officers. Compiled by Adelbert Cronkhite, First Lieutenant Fourth Artillery. New York: John Wiley & Sons, 1893. Price $2.00.

The ambitious and thoughtful artilleryman has often felt the need of some handy, not too technical work that should supplement Tidball and the other drill books, supplying many features that they lack, and revising others that the recent improvements in artillery have rendered obsolete. Such is the little handbook lately prepared by Lieutenant Cronkhite and published by Wiley. In this brochure the compiler aims "to place before artillerymen, in as simple and comprehensive a manner as possible, descriptions and explanations of the various objects relating to their profession with which they come daily in contact," and we feel satisfied in saying that he has admirably succeeded in his task. The work is up to date, containing descriptions of our most recent guns, the ten- and twelve-inch B. L. R., of the dynamite gun and, briefly, of several proposed sea-coast carriages. It is unfortunate that the condition of our sea-coast armament is such as to require also descriptions of the old and obsolete smooth-bore guns and their carriages, but these are the tools with which the artilleryman must work for the present at least, and they will be found described, each in its proper place. There is a practical chapter devoted to estimating distances by sight, by sound, and by instruments, of which latter the principal ones are briefly but clearly described. In the chapter on sights and sighting will be found descriptions of the azimuth circle, barometer, thermometer, hygrometer, anemometer, densimeter, pressure guages and chronograph—a list that tends to show of what material the artillery non-commissioned officer of to-day should be made. The Zalinski sight is not forgotten, and sound practical directions are given for firing at moving objects.

The employment, transportation and preservation of artillery receive due attention; nor are the subjects of explosives and fuzes neglected.

In appendices are given Roger's Tables of fire, range-tables for the Hotchkiss 3" B. L. R. and barometric corrections; followed by Captain Chester's practical problems in ballistics.

Although the work modestly professes to be a handbook for the use of non-commissioned officers, the commissioned officer of artillery will find in it much that he can read with profit. It contains, in a concise and convenient form, much information that can be found elsewhere only in scattered and not readily accessible publications, and the entire arrangement is one that will commend itself to the artilleryman—be he officer or private.

W. P. N.

Descriptive Map of Army Posts, by 1st Lieutenant H. C. Hale, 20th U. S Infantry, Fort Assinniboine, Montana. Price $2.00.

An examination of this map, recently published by Lieutenant Hale, discloses a vast fund of valuable and practical information.

On it the location of every military post and reservation, together with the principal lines of communication, are distinctly marked; while in the form of a brief legend printed alongside of each reservation are noted the principal features of the surrounding country, the climate, water supply, healthfulness of the section, the number and character of quarters for troops and officers, etc., etc., so that when under orders to transfer from one department or post to another, a glance at the map readily gives this important information.

Lieutenant Hale's efforts have received the endorsement of the War Department in the form of an order for 200 maps, presumably for distribution among the various posts.

While the information thus compiled by Lieutenant Hale is of so great value to ourselves, the map would also prove invaluable to an enemy, but the same remark can be applied to our policy of affording gratuitously information on other subjects of vital importance connected with our military and naval establishments, which in turn is so carefully guarded and withheld from us by other nations.

The only suggestion which occurs to one studying this map is that a few more rail connections might be noted, and that the land-grant roads might be particularly marked for the benefit of those required to use them. W. W.

Cavalry Outpost Duties. By F. de Brack. Translated from the third French edition, 1863, by Major Camillo C. C. Carr, 8th Cavalry, U. S. Army. John Wiley & Sons, 53 East Tenth Street, N. Y. Price $2.00.

This very interesting book is tersely summed up in the second paragraph of the translator's preface:

"While the book might properly be called The Art of War in Miniature for Cavalry, it has this advantage over most of those written in recent times, especially since 1871, that it is not made up of theories and speculations emanating from the brains of men having no practical knowledge of the subject, but, on the contrary, is founded upon the actual experience of a distinguished cavalry officer who made eight campaigns under the generals who raised the fame of the cavalry to so lofty a pitch during the wars of the great Napoleon."

As the translator says, the treatise bears in every line the stamp of the practical mind whose information, and deductions therefrom, result directly from the hard knocks of war. Therefore, having no theories to establish, he writes these instructions for his regiment in a simple manner, basing all statements on facts within his own experience. A large portion of the book deals with *man* and the various emotions which impel him to acts of bravery, cowardice, or others of kindred nature, on the battle field. In portraying the moral qualities de Brack appears as a master.

The style (as translated) is clear and always to the point, and reminds one of the famous letters of Hohenlohe. Although the didactic method of question and answer is followed, the reader eagerly hastens on to learn the answer, and soon finds himself hurrying from one sentence to the succeeding to know what is coming next.

Justice cannot be done the work in a brief review and what is said here is intended merely to invite attention to its contents. The fact that the book is old is not against it, as some may think. Few indeed are the rules and principles given which with the use of a small amount of good sense, and allowance for changed conditions, are not applicable to-day. Outpost duties, in these days of rapid movements and long range fire, are *more* important than in the author's time: many conditions have changed since then but the fundamental object of these duties remains unchanged and the officer conversant with de Brack's teachings, and present requirements, will find no difficulty in applying them. Those which relate to the inner or moral man have not changed.

Beginning with the Duties of Cavalry, and the Chief in Campaign, he carries one through all the sub-divisions of the subject: each statement seems so sensible and self-evident that the mind accepts it without question. The chapters relating to Charges, Courage, Cowardice, Morale, and Moral Effect certainly embody all that can be said on these subjects and echo throughout the spirit of the true soldier. There is much in the book that is applicable to all arms. It is a leather bound pocket edition and therefore may be carried on all occasions and be ready for reference. The translator is entitled to the thanks of all officers, not only of his own arm but those of other combatant forces, for having put within their reach a book so valuable. J. W. R.

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VERTICAL FIRE.

BY BREVET BRIGADIER GENERAL HENRY L. ABBOT, U. S. ARMY, COLONEL, CORPS OF ENGINEERS.

The early completion of the new mortar batteries at Sandy Hook, Davids Island, Boston and San Francisco, the successful development of the new carriage, and the rapid fabrication and delivery of the pieces themselves will soon bring the weapon prominently to the attention of 'artillery officers, and the time therefore seems appropriate for presenting a paper upon the subject promised some months ago to the Editor of the *Journal of the U. S. Artillery*.

It is to be noted that although precision of fire has been wonderfully increased by rifling, and other modern improvements of construction, it must still be admitted as the result of careful analysis of recent practice with a 9-inch mortar that the chance of hitting a stationary target with vertical fire at ranges from one to four miles is only about half of that with guns of like calibre. This defect is in part due to the longer flight and less velocity of the projectile, which prolong the disturbing effect of the wind, and in part to the fact that the trajectory (often rising more than a mile above the ground) traverses atmospheric conditions wholly different from those at the surface, and therefore impossible to predict.

For this reason I have never advocated the general use of mortars against ships in rapid motion. Experience at Alexandria demonstrated that, to secure satisfactory gun practice, ships must anchor; or, as was done at Port Royal, circle in a manner to return to a fixed position. Under such conditions, even at a range of five or six miles, there is no reason why, if used with skill and good judgment, the inherent defects of vertical fire should not be overcome.

On the other hand mortars in coast defense possess incontestible advantages. (1) The blow is delivered precisely where armored protection is least effective, and in a direction which threatens danger to the magazines, the engines, the boilers and the other vitals of the ship covered against horizontal fire by the water and heavy armor; and even if these vitals are not reached by the projectile the explosion of its charge of 100 pounds of high explosive will occur in the shell-trap above the protected deck where the secondary armament and the bulk of the crew are fully exposed. (2) The mortar battery may usually be located where it is concealed from the enemy, and where no effective reply is practicable. This so materially reduces cost that the number of the mortars may be multiplied without extravagant outlay and their comparative lack of precision thus be corrected. (3) Another merit of vertical fire is that the force of the blow increases with the range instead of diminishing, as in horizontal fire,—the vertical velocity within ordinary limits of practice being measured by the square root of twice the acceleration of gravity into the fall. The latter may be taken roughly at one-fourth of the range for an angle of elevation of forty-five degrees. At sixty degrees of elevation the fall is one-half greater (and the range one-tenth less), and at seventy-five degrees elevation the fall is four-fifths greater (and the range one-half less) than at forty-five degrees. These vertical velocities unfortunately are not great, being below 1,000 feet, and hence the energy required for penetration must be obtained by using large calibres with their considerable weights of projectile. With our new 12-inch mortars these weights range from 625 to 1,000 pounds.

It may be noted in this connection that experience at Sandy Hook has shown that with elevations exceeding about sixty-five degrees there is difficulty in causing the axis of the projectile to remain parallel to the trajectory, and hence the use of higher angles is not favored. It is also found that the service of the piece is facilitated by selecting one of five fixed charges of suitable grades of powder, and regulating the range by slightly varying the elevation between forty-five and sixty-five degrees, rather than by the old method of depending wholly upon a variation of the charge.

The extensive use of vertical fire in the siege of Petersburg by the volunteer artillery troops under my command, as well as the previous preparatory training the regiment received when stationed in the defenses of Washington, first drew my attention strongly to this kind of fire. The results achieved proved the mortar, even in the crude form then in service, to be one of the most effective weapons on the lines of the army; but experience equally demonstrated that it required careful treatment to bring out its good points. Improved modes of pointing over that prescribed in the text books, systematic mixing of the powder for the day's firing to obtain uniformity of action, equalizing the weights of the shells, and many other points no longer necessary to mention in connection with the modern type proved to be essential to satisfactory service. One practical difficulty however was found to be inherent to the system, and it impressed itself upon my mind as something which should be corrected even with the large targets usual in field service, before all the efficiency possible could be secured. For use against so small a target as a ship this difficulty would become still more important; it is simply the impossibility of regulating the pointing by individual gunners when many pieces are directed at the same object. In gun practice the short time of flight enables each gunner to perceive where his own projectile strikes, and to regulate his pointing accordingly. With the long times of flight characteristic of vertical fire this is no longer the case. Shells are falling so thickly around the target that with a flight of many seconds he can no longer distinguish which is his own shot, and his aim may thus remain uncorrected because he imagines that he is doing much better than is really the case. Where, as in the case of a siege battery, the target remains immovable this difficulty may in a measure be overcome by determining and recording for future use the pointing of each piece separately; but against a target shifting position like a ship, I am satisfied that no dependence can be placed on individual pointing. One man must regulate the firing of a whole group of mortars to secure satisfactory results.

These considerations suggest how the engineer may assist the artillerist materially by designing the battery so that the fire of many pieces can be controlled as a unit by a single officer, stationed where he can observe the impacts. The problem is simple, and has been solved to develop this principle.

For example, suppose say sixteen mortars are grouped in a single square pit in close juxtaposition. Evidently all of them would call for a common pointing, which may be given mechanically by the gunners with the aid of a horizontal azimuth circle on each platform, with the lines connecting the zero and 180 degree points all parallel to each other, use being made of course of identical elevations and charges. Such a battery would fulfill the purely theoretical conditions of the problem, but any artillerist will see that its service would be impracticable, because the needful magazines and bomb-proofs and routes of supply for the ammunition would be lacking.

Next let us see if the tables of practice, giving the rectangles of mean dispersion in longitudinal and lateral directions, will not justify so separating the mortars in groups of four as to provide room for these magazines, bombproofs, and routes of supply in a central position without so far separating the pieces as to demand individual pointing for each. The following tables contain such data of this character for heavy rifled mortars as I have been able to collect.

Tables of this kind are often misunderstood, and a few words upon them may be not out of place. In preparing them the firing for each group of shots is conducted under as nearly identical conditions as possible. Whether there be a target or not is unimportant. The *mean range* is found by dividing the sum of all the ranges by the whole number of shots. The difference of each range from this mean range, without regard to sign, is taken, and the sum of these differences divided by the whole number of shots gives the *mean longitudinal dispersion.* By the law of error this latter quantity multiplied by 1.69 gives the width of the transverse zone which will include fifty per cent. of all the shots. In like manner is found the *mean lateral dispersion;* and this quantity multiplied by 1.69 gives the width of the longitudinal zone which will contain fifty per cent. of all the shots. Representing these zones upon paper, by two sets of double parallel lines at right angles to each other and of indefinite length, the included area common to both will receive fifty per cent. of fifty per cent., or twenty-five per cent. of all the shots. This rectangle is sometimes known as *the twenty-five per cent. probable rectangle,* and serves to compare relative accuracy of different pieces, firing at different ranges, etc.

The error of supposing that these probable rectangles afford the means of estimating the probable chance of hitting a target at which the piece may be pointed in artillery practice, is apparent. They take into account no mechanical errors of pointing whatever, no errors in the assumed range, and no atmospheric conditions different from those affecting the experiments from which they were derived. Their proper use is relative, not absolute; but together with zones of other percentages of probability, which may be derived from those for the fifty per cent. zones by the use of tables based on the general law of error, they are very helpful in discussing problems like the present. The following are the tables of data referred to above.

The first exhibits eleven records with the 28-centimetre (11.2-inch) mortar, made at the Krupp range at Meppen at various dates from March 14, 1879, to July 14, 1888.

The second table exhibits nineteen records at Meppen, made with the 28.55-centimetre (11.4-inch) mortar in September, 1889. It will be noted that only four shots were fired for determining each mean, and that the results are more discrepant than the preceding.

TABLE (1).

No. of Shots.	Elevation. Degrees.	Weight in lbs.		Mean Range. Yds.	50 per cent. zones in yds.		25 per cent. probable rectangle in square yards.	
		Shell.	Charge.		Lateral dispersion.	Longitudinal dispersion.	Observed.	By Eq. (1).
5	45	476	9	1600	1.6	36.4	58	26
5	45	476	40	8369	15.2	39.6	602	700
5	45	476	62	10781	11.0	23.5	259	1162
10	60	476	40	6859	13.9	39.6	550	471
10	45	761	13	1691	2.6	27.4	71	29
7	60	761	40	5170	17.7	27.1	480	268
5	58	506	13	1993	2.7	20.1	54	40
5	58	759	19	2158	5.6	9.1	51	46
8	58	759	33	4019	7.9	22.0	174	162
10	45	475	42	8513	7.6	59.2	450	725
10	45	475	62	10787	17.6	61.2	1077	1162
		Sums - - - - -			103.4	365.2	4326	4791

TABLE (2).

No. of Shots.	Elevation. Degrees.	Weight in lbs.		Mean Range. Yds.	50 per cent. zones in yds.		25 per cent. probable rectangle in square yards.	
		Shell.	Charge.		Lateral dispersion.	Longitudinal dispersion.	Observed.	By Eq. (1).
4	45	511	57.2	10000	23.8	60.1	1430	1000
4	45	660	17.6	2591	4.0	20.3	81	67
4	45	660	25.3	3994	3.2	7.4	24	159
4	45	660	57.2	9105	10.4	53.9	561	829
4	55	660	17.6	2355	4.6	27.1	125	56
4	55	660	50.6	7412	8.3	49.2	408	549
4	55	660	57.2	8385	12.0	18.8	226	703
4	60	660	25.3	3379	27.8	23.1	642	114
4	60	660	40.7	5361	19.4	80.1	1554	288
4	65	660	33.0	3939	38.8	20.7	803	155
4	65	660	50.6	5787	18.5	27.8	514	335
4	65	660	57.2	6644	25.9	83.8	2170	442
4	45	935	17.6	1906	2.7	25.4	69	36
4	45	935	25.3	2958	1.3	49.6	64	88
4	45	935	33.0	4038	5.6	11.5	64	163
4	55	935	17.6	1798	7.8	14.8	115	32
4	60	935	25.3	2476	21.2	38.8	823	61
4	60	935	40.7	4210	5.9	73.1	431	177
4	65	935	33.0	2938	24.1	53.6	1292	86
		Sums - - - - -			265.3	739.1	11396	5340

The third table exhibits six records of Russian practice made in 1885 with the 11-inch mortar. The details are reported with less completeness than at the Meppen firing, but it appears that the table is a consolidation of the results of about 600 rounds. If so, it is entitled to much more weight than any of the others.

The fourth table exhibits eleven records of Italian practice designed to develop experimentally their 28-centimetre (11.2-inch) mortar, and made between the years 1881 and 1884. The first two rectangles were made in deciding upon the best powder; the next eight, in determining whether a uniform or increasing pitch should be adopted for the rifling (the former received the preference); and the last one with the piece as finally adopted. The number of shots fired to determine these rectangles is reported only for the last one, but it is probable that the same number (10) was used for all the rest. The weight of the projectile is also somewhat in doubt, not being reported for each rectangle in detail.

The fifth table contains eight 10-shot rectangles, the first five with the 12-inch mortar rifled with uniform twist and the last three with an experimental 12.2-inch mortar rifled with an increasing twist–all obtained at Sandy Hook in 1888-90. Although the carriage was of an antiquated pattern, which probably impaired the accuracy of the firing, the precision exhibited is highly gratifying; it is understood that similar trials will be repeated with the new carriage at an early day. The increasing twist was adopted for the cast-iron pattern hooped with steel, as a result of these experiments.

TABLE (3).

No. of Shots.	Elevation.	Weight in lbs.		Mean Range. Yds.	50 per cent. zones in yds.		25 per cent. probable rectangle in square yards.	
	° ′	Shell.	Charge.		Lateral dispersion.	Longitudinal dispersion.	Observed.	By Eq. (1).
	43 30	477	36.1	5668	7.4	40.6	300	321
	43 30	477	46.9	7412	11.0	47.8	526	549
	43 30	559	18.0	2343	5.6	29.7	166	55
	43 30	559	27.1	3597	3.7	22.3	83	129
	43 30	559	36.1	5014	5.6	38.8	217	251
	43 30	559	45.1	6431	7.4	44.3	328	415
		Sums	- -	- -	40.7	223.5	1620	1720

TABLE (4).

No. of Shots.	Elevation Degrees.	Weight in lbs.		Mean Range. Yds.	50 per cent. zones in yds.		25 per cent. probable rectangle in square yards.	
		Shell.	Charge.		Lateral dispersion.	Longitudinal dispersion.	Observed.	By Eq. (1).
	45	496 ?	31.9	6766	7.4	48.3	357	458
	45	496 ?	35.2	6802	10.2	86.5	882	463
	60	496 ?	41.8	7005	8.5	42.3	359	491
	60	496 ?	41.8	6910	23.8	46.5	1107	478
	45	496 ?	27.5	6127	11.5	33.4	384	376
	45	496 ?	27.5	6203	12.7	50.9	646	385
	45	496 ?	22.0	4960	8.5	23.0	195	246
	45	496 ?	22.0	4896	7.4	30.9	229	240
	45	496 ?	11.0	2194	5.0?	27.8	139	48
	45	496 ?	11.0	2217	8.6	34.2	294	49
10	45	496 ?	44.0	8522	9.1	65.9	560	726
		Sums - - - - -			131.9	489.7	5152	3960

TABLE (5).

No. of Shots.	Elevation. Degrees.	Weight in lbs.		Mean Range. Yds.	50 per cent. zones in yds.		25 per cent. probable rectangle in square yards.	
		Shell.	Charge.		Lateral dispersion.	Longitudinal dispersion.	Observed.	By Eq. (1).
10	60	620	33	3913	15.2	59.0	897	153
10	60	627	33	3906				
10	60	627	32	4024	4.7	38.5	181	162
10	60	624	30	4032				
10	45	630	80	10480	70.8	105.6	7476	1098
10	45	669	75	9683	1.9	75.2	143	938
10	60	664	27	4532	6.8	35.5	241	205
10	60	665	17	1950	7.6	22.6	172	38
		Sums - - - - -			107.0	336.4	9110	2594

These tables give fifty 25 per cent. probable rectangles well distributed between ranges of 1500 yards and 10,500 yards, and are sufficiently numerous and accurate to justify an attempt at analysis. It appears that with these large mortars the longitudinal averages about three and a quarter times the lateral dispersion; and that the area of the 25 per cent. probable rectangle in square yards is about 0.00001 times the square of the range in yards. That is, denoting by A the area in square yards of the 25 per cent. probable rectangle; by W, its width in yards; by L, its length in yards; and by R, the range in yards; we have:

$$(1)\quad A = WL = 0.00001\,R^2$$

$$(2)\quad W = 0.0018\,R$$

$$(3)\quad L = 0.0058\,R$$

While great accuracy is not claimed for these formulæ, the discussion shows that precision of fire (measured by the reciprocals of the 25 per cent. probable rectangles) is inversely proportional to the square of the range, or thereabouts. The weight of evidence supporting this law may be seen by comparing the last two columns of the tables, which show that the largest discrepancies from it occur where different similar records diverge most widely from each other. These rectangles also give an approximate idea of what is to be expected from carefully conducted mortar fire *when the target lies at the mean point of impact;* but it is well to remember that this assumes absolute perfection in pointing, which is unattainable in service.

A better idea of the precision to be expected in firing at a stationary object may be formed from some practice in Japan, at a range of two miles, on March 19-20, 1891. The target represented part of a modern armored deck, and had a length in the plane of fire of 59 feet, and a width of 17 feet. It was composed of three sheets of Creusot steel deck armor, properly riveted and jointed, which had a total thickness of about three inches. This was supported by 9-foot steel beams spaced about four feet apart. The firing was with a 28-cm. (11.2-inch) howitzer of modern type, made in Japan from Japanese materials; powder charge, 20.9 pounds; shell, 477 pounds, carrying a bursting charge of 20 pounds; elevation, 58 degrees; range, 3773 yards. Thirty unloaded shell were fired with two hits, and fifteen live shell with one hit, giving an average of seven per cent. of hits. The mean error in range was 134.5 feet; and in direction, 26.2 feet. If the firing had been made under absolutely unvarying conditions, without correcting the pointing for errors noted, the 25 per cent. probable rectangle should have been 142 square yards by formula (1).

The trials also included firing at the same target with a 24-cm. (9.5-inch) mortar, of Japanese construction upon approved modern types; powder charge, 11 pounds; shell, 268 pounds, carrying a bursting charge of 13 pounds; elevation, 60 degrees; range, 3554 yards. Forty-three unloaded shell were fired with three hits, and thirty live shell with one hit; giving an average of five per cent. of hits. The 25 per cent. probable rectangle at this range by equation (1), should have been 129 square yards. The actually observed mean error in range was 131.2 feet, and in direction 49.2 feet.

Lord Brassey remarks: "It will be seen from the drawing that if the target had been a ship's deck, instead of only a portion of it, the number of hits under actual conditions would have been twenty-three, making a percentage of twenty on the whole number of rounds. This is about the same result, as at the Bucharest trials some years ago, where the percentage under the same conditions was twenty-two."

The target (3-inch steel) was curved in form like a real deck and of more than the ordinary strength. The projectiles were of chilled cast-iron. Every shell went clean through, and buried itself deeply in the ground. Two of the hits were with live shells, and both exploded after penetration.

An inspection of these 50 per cent. zones makes it plain that the dispersion in the direction of the trajectory is much more than at right angles thereto, and that to avoid a central sector of comparative safety, our four mortar pits should be placed at the angles not of a square but of a parallelogram with the longer sides directed toward the position most likely to be occupied by the enemy. A careful study of the requirements for magazine space, bombproofs, connecting passages, ample thickness of cover to keep out projectiles, and other engineering details, has led to the conclusion that, with the four pits placed so that the pintles of the outer mortars are on the circumference of a circle 150 feet in radius, and at positions which make the distances between these outer pintles 140 feet in a transverse direction, and 265 feet in a longitudinal direction, all the needful engineering requirements will be fulfilled.

It remains to consider how such a battery would fulfill the artillery conditions. These are of two kinds, ballistic and tactical.

The ballistic conditions may be studied graphically, by the aid of the rectangles showing the probable dispersion of fire from such a battery in zones of different percentages overlapping each other. This was carefully done some years ago when the typical battery was projected.* A range of 4.5 miles was selected, and use was made of the tenth shot of the first table and of the second shot of the third table—the best data available at that date. They indicated for the mean 50 per cent. zones containing half of the projectiles of a single mortar, widths of 28 feet laterally and 162 feet longitudinally. The discussion, taking into account overlapping zones as affected by the partial dispersion of the mortars, showed that a space of 800 feet long and 300 feet wide is covered so effectively that, assuming the battery to be fired by volleys once in ten minutes, a battle-ship having the dimensions of the *Inflexible* would be struck from two to nineteen times per hour according to the position occupied in this space. For the average position about ten per cent. of the projectiles fired would take effect. Ordinary service projectiles for the 12-inch mortar have an energy of impact at this range of about fifty foot-tons per inch of the circumference, while about thirteen to fifteen foot-tons are required to penetrate a 3-inch wrought-iron deck. Hence one hit would end the battle.

In actual firing from a group of mortars it is quite certain that the dispersion of the projectiles would differ from that indicated by these computed rectangles, inasmuch as the different mortars could never be served so as to give identical trajectories parallel to each other; but the greater and more irregular dispersion resulting from this cause would be of immense benefit, because the overlapping of the different zones would be disposed in a manner to cover more ground and with more uniformity. The great practical difficulty in all firing is to make the center of impact coincide with the target, and this is to a measure overcome by the certain wandering of the shots from their theoretical

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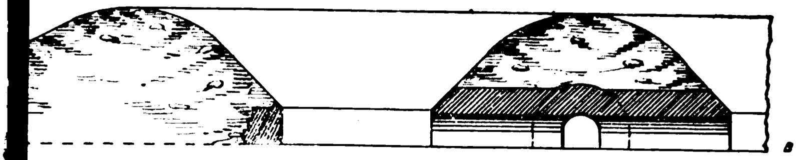
* See plate.

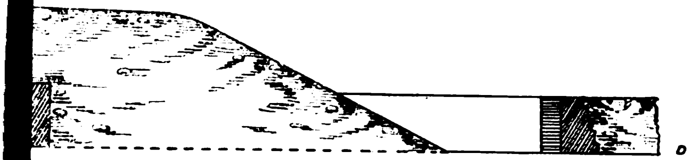
positions. Assuming that the pieces are well served with the assistance of modern position finders, these figures make it evident that no ship could remain at anchor at this range (4½ miles) with impunity.

But certain conditions other than ballistic are demanded to enable the gunners to properly perform their duties; these are met as follows in the batteries under construction: (1) There must be ample room about each mortar for loading; this is secured with the adopted carriage when the four pintles of each pit are placed at the corners of a square twenty feet on the side. (2) Bombproof cover must be furnished to protect the men from the blast at firing, and for passages for conveying the ammunition in safety from the magazines to the mortars; this is provided to the extent of over 350 running feet ten feet wide. (3) Convenient magazine accommodation must be given; there are two, each with a floor space of 580 square feet, disposed at right angles to the long gallery, and with anterooms and entrances so placed that two adjacent pits can be served independently of the other two, without requiring the different detachments to pass each other in the gallery. Capacity for over 100 rounds is provided, the shells (loaded but without fuzes) being stored chiefly along one side of the long gallery. (4) The ammunition will be served on truck cars running on tracks, with overhead facilities for loading. (5) The whole interior will be lighted by incandescent lamps, run by a small dynamo under bombproof cover. (6) All firing of course will be done by electricity; and (7) where arrangements for resisting attacks by boat parties are necessary they will consist of a counterscarp fifteen feet high, with a ditch thirty feet wide flanked by counterscarp galleries at two angles diagonally opposite to each other. Two machine guns in casemates will thus sweep each of the four ditches. Musketry fire over the approaches will be obtained by field intrenchments on the top of the central covering mass, prepared by the garrison after the outbreak of hostilities.

To secure the highest possible accuracy with this system, care should be taken by the Ordnance Department to insist on well graduated azimuth and vertical circles, and any failure in this respect should cause instant rejection of the defective work.



Section on A-B



Section on C-D

on E-F

for Plan.

Sections.

K MORTAR BATTERY,

H DEFENSE.

The engineer cannot be too careful to place all the platforms horizontal, with the lines connecting the zero and 180 degree marks truly in the meridian. Of course any other position for these lines would serve equally well for a single battery, so long as they are parallel to each other; but the true meridian is named in the instructions of the Chief of Engineers in order to assist the commanding artillery officer at a central station where the position of the enemy is supposed to be known, to designate the first trial azimuth to be used at any mortar battery in the harbor.

One of these batteries can be served either by volleys of sixteen mortars, by volleys of four mortars, or by single pieces. The latter method will naturally be used in obtaining the exact range and azimuth after the position of the enemy is approximately determined by the position finder. The effect of the conditions existing in the upper atmosphere will thus be determined by actual trial, and the commanding officer will have every detail under his control, and will be enabled to bring into play the highest professional skill and good judgment. It is to be hoped that at an early day the completion of several of these batteries will permit regular practice to be had by the artillery troops stationed in the neighboring fortifications, and that by this means the entire system may be put to a practical test. Practice over a land range would afford data of extreme value, as by marking the projectiles with a cold chisel, as was done in the preliminary training of my regiment in the Defenses of Washington, it would be possible to discuss the trajectory of each piece separately, and thus obtain precious information respecting group firing which can no where be found in existing records. Indeed, experimental investigation in this new field can hardly fail to lead to useful conclusions as to the best modes of serving modern mortars.

THE ARTILLERY OF THE U. S. NATIONAL GUARD.[*]

By First Lieutenant ELISHA S. BENTON, Third Artillery, U. S. A.

OHIO ARTILLERY.

Ohio has taken the initiative in forming a regimental artillery organization; this, the only regiment of light artillery in our national guard, occupies therefore a distinctive place in the volunteer establishment.

By General Orders No. 7, from General Headquarters State of Ohio, Adjutant General's Office, Columbus, Ohio, May 6, 1886, all the artillery organizations in the state, consisting of eight four-gun batteries, were consolidated into a regiment designated as the First Regiment of Light Artillery, Ohio National Guard.

This regiment has a colonel, a lieutenant colonel, two majors, an adjutant, a quartermaster, a surgeon and an assistant surgeon, and a chaplain—besides, the usual non-commissioned staff.

Each battery has a captain, one first and two second lieutenants, an assistant surgeon with the rank of a captain; one first, one quartermaster, one veterinary and four line sergeants, eight corporals and from forty to sixty privates.

The regiment has also a band of about twenty-five musicians.

The regiment, when full, therefore has, 9 commissioned officers field and staff; 40 commissioned officers attached to batteries; 480 privates in batteries and 25 in band; an aggregate of about 550—these numbers of course vary from time to time.

The batteries are stationed and armed as follows:

Battery "A," Cleveland, organized in 1872, 4, 3-inch rifles.

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[*] It is proposed to continue these papers descriptive of the Artillery of the National Guard until that of all the states has been considered. Afterwards it is hoped that the opinions of prominent officers in this service will be presented touching organization armament, drill, instruction and all other questions which relate to the subject of efficiency. In this manner defects and points of excellence will be drawn out to the view of all. Such discussion should analyze methods and suggest improvements, and constantly collect good practical ideas for the use of all.—Ed. *Journal.*

Battery "B," Cincinnati, organized in 1882, 4 Gatling guns, cal. .45, 1883.
Battery "C," Zanesville, organized in 1886, 4, 3-inch rifles.
Battery "D," Toledo, organized in 1866, 4 Gatling guns, cal. .45, 1883.
Battery "E," Springfield, organized in 1881, 2, 3-inch rifles, 2 Gatling guns. cal. .45, 1883.
Battery "F," Akron, organized in 1877, 4, 3-inch rifles.
Battery "G," Marietta, organized in 1877, 4 12-pdr. Napoleons.
Battery "H," Columbus, organized in 1884, 2 Gatlings model 1891, 2 breech-loading 3".2 rifles.

There are no traveling forges and battery wagons with these batteries, but each of the pieces is supplied with a good limber and caisson. Each of the Gatling guns is fully supplied with the necessary tools.

Each officer has a full outfit of horse equipments. The uniform, both dress and fatigue; the blankets, haversacks, canteens, sabers, etc., are the U. S. army regulation.

The men are required to buy their dress uniform and the officers are required to buy their own uniform and equipment throughout.

The regimental colors and battery guidons are also in accordance with the U. S. army regulations.

Officers are elected by the votes of the men. After election the officer goes before the regimental examining board and if he passes a satisfactory examination, he is recommended for a commission and receives one, for five years, from the governor.

This system of examination for commissioned officers keeps the standard of this regiment high. All the officers, or nearly all, have seen long previous service as enlisted men, either as non-commissioned officers or as privates, or as both, and have not only become familiar with their duties in that way, but many of them have studied the theory of artillery and are somewhat versed in the science of their profession.

The enlisted men are between the ages of sixteen and forty-five. The ranks of this regiment are recruited from the best walks of life; the men being nearly all young, vigorous, and active in the cause.

There seems to be a marked military courtesy which extends throughout. the regiment—there is a prompt and cheerful obedience to orders, and a self-respecting and prompt response to the requirements of military courtesy. By such a spirit as this the regiment has been brought to a high state of efficiency.

Officers on duty receive the pay of officers of like grade in the army, while in camp they receive half pay; men on duty receive two dollars a day for thirty days and then one dollar a day—while in camp they receive one dollar a day. All are allowed forty cents a day in camp for subsistence.

Batteries "A," "B," "C" and "D" have very fine armories with very large drill floors and all facilities for instruction. the other four batteries also have good armories but are not so well fitted up.

The batteries drill once a week with special drills for recruits besides. These drills are usually standing gun drill, or marching drill in the school of the battery dismounted. These batteries are drilled well and understandingly. but have little mounted drill, with perhaps the exception of Battery "E" which nearly always marches to the annual regimental encampments. In those cases, however, in which the batteries march to camp they are kept well in hand on the journey and brought into camp in good condition.

In some of the camps, notably that of 1887, the regiment had some target practice. In the case mentioned the record of firing, at 1000 yards, was very creditable.

All the batteries are accustomed to participate in local celebrations and thus always get some mounted drill.

The regiment usually encamps every summer for about eight days—this time is always crowded with instruction—drill follows drill, and inspection follows inspection.

This regiment has the peculiar advantage that being wholly artillery the entire course in camp is artillery instruction. In many batteries in other states, associated as they are with infantry in their camps, the instruction received during this most valuable time is much of it applicable only to the infantry.

Each of the batteries has a fairly complete messing outfit.

The usual battery and regimental record books are as a rule well kept and there seems to be a fairly good idea of the "paper work" necessary to a good organization which is usually lacking among militia organizations.

In addition to the inspections in camp by U. S. army and regimental officers, each battery is occasionally inspected in its armory by a regimental officer detailed for that purpose.

Several of the batteries have seen active duty and each time acquitted themselves well.

In 1884 Battery "A" figured conspicuously in the Cincinnati riots. Anticipating orders, the captain had his battery assembled at the armory; the battery was on the train, guns and baggage loaded, and was leaving the station thirty-five minutes after the order was received.

Since its organization this battery has fired 25,000 rounds at target practice and in the way of salutes without an accident of any kind.

Battery "B" has seen more service than any of the others; it was on duty during the Cincinnati floods of 1883 and 1884, during the Cincinnati riot of 1884 and the labor troubles of 1886. This battery won the first prize for machine gun drill at Washington in May, 1887.

Battery "D" was organized in 1866 by the surviving veterans of Battery "H," First Ohio Volunteer Light Artillery, for the purpose of perpetuating their record and history. This battery has seen much active service snce the war; notably in the labor troubles in Toledo in 1877, and in 1887 at the Paulding county reservoir against the "Dynamiters."

This regiment stands upon a fairly good war footing to-day—it can be assembled in Columbus in ten hours, some of the batteries getting there in half that time. In large cities, where there is a riot alarm, it takes but a few minutes to get the men to their armories. In other places it is only the work of an hour or so to notify all the men.

Many examples could be given of the zeal and enthusiasm of the men. In loading for the trip to New York to participate in the celebration of the centennial of Washington's inauguration, April 30, 1889, Battery "A" succeeded in getting its four guns, four caissons, harness and horse equipment into one car.

In the same trip Battery "B" was subsisted from Cincinnati to New York by provisions purchased before, and by aid of an oil stove in one end of the car the men were supplied with hot coffee.

These examples show that this regiment could be very quickly placed in condition for active service. The various officers of the army who have inspected this regiment have spoken in the highest terms of its condition.

At the time the regiment was organized it was commanded by Colonel Louis Smithnight, of Cleveland, who had been for many years the captain of Battery "A." He resigned June 11, 1891, followed by the regrets of the entire regiment, by whom he was beloved for his kindly yet firm character. The present colonel is Edmund C. Brush of Zanesville; he is an enthusiast upon the subject of his regiment and works continually for its good. In a letter to the writer he says:

"The general government should arm the militia and take a more active part in its affairs. The armament should be the same as that of the U. S. army, so that the two organizations could take the field and be supplied by the same ammunition train.

"The organization of the guard into regiments and larger units should correspond to the U. S. army, so that there would be no confusion in case the organizations were brought together.

"The uniformed and equipped militia should be called the 'National Volunteers,' as for instance, the 'Ohio National Volunteers.' The oath administered to officers and men should so read as to swear to obey orders from the President of the United States, &c. He has the power to call for the militia, let the militia include in the oath the above."

"I believe that the education given by the U. S. government at West Point, to the young men, is for the good of our country first and for the young men next. Give these young men a chance to impart their knowledge gained at West Point to the national guard. It would benefit the guard and the regular service by keeping officers interested and up in the art of war."

"For a state the size of Ohio let two or three educated military men be detailed to visit every armory monthly and deliver a series of talks on practical subjects of use to the guard. The regular and militia forces each have a mission to fulfill; let each understand its position, throw aside all feelings but one--the good of our country—and elbow to elbow try to be the best military organizations in the world. Men who are in the army and guard, through motives of pure love for country, are ready to do this."

He further adds: "The magazine being published at the U. S. Artillery School should be found in every guard battery's armory and should be devoted to the interests of the regular and militia artillery. Make the militia feel that the regulars take an active interest in its welfare. Have artillery officers at every camp of militia artillery, and militia officers of artillery with regular artillery on practice marches and camp tours. Get the two organizations together—encamp them together."

The other officers are as follows:

Lieutenant Colonel E. O. Dana, Cincinnati.
Major Owen J. Hopkins, Toledo.
Major Joseph C. Ewart, Akron.
Surgeon Willis W. Hall, Springfield.
Assistant Surgeon Henry M. Clewell, Cleveland.
Quartermaster C. V. Shryock, Zanesville.
Adjutant C. T. Atwell, Zanesville.
Chaplain, Rev. L. B. Moore, Cambridge.
"A," Captain George T. McConnell, Cleveland.
"B," Captain Fred. J. Herman, Cincinnati.
"C," Captain Henry A. Leslie, Zanesville.
"D," Captain George V. Roulet, Toledo.
"E," Captain John G. Kennan, Springfield.
"F," Captain James D. Chandler, Akron.
"G," Captain David Dow, Marietta.
"H," Captain W. N. P. Darrow, Columbus.

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MASSACHUSETTS ARTILLERY.

The field artillery of the Massachusetts Volunteer Militia consists of three batteries. The first, Battery "A," Light Artillery, is attached to the Second Brigade: the other two, Batteries "B" and "C," are formed into a battalion called the First Battalion of Light Artillery, with field and staff, and attached to the First Brigade.

The battalion mentioned above is commanded by a major, who has a staff as follows: an adjutant, a quartermaster, a surgeon (major), an assistant surgeon, a veterinary surgeon and a paymaster.

Battery "A" is located at Boston; Battery "B," organized May 10, 1869, at Worcester, and Battery "C," organized May 10, 1886, at Lawrence.

Each of the batteries has a captain, two first and two second lieutenants; one first, one quartermaster and six line sergeants, one guidon (corporal), twelve corporals, two buglers and eighty-four privates—making a total of 112.

The uniform both dress and undress is the same as the regular army and consists of great coat, dress coat, trousers, white and black helmets, forage cap and blouse. The entire state troops have been recently furnished.

The officers are elected by the enlisted men, but are examined by a board of officers, convened for that purpose, in regard to their military and general knowledge; they hold commissions for life.

Privates are enlisted for three years and, after serving one term, may re-enlist for a period of one, two or three years. When young men present themselves and desire to enlist they are questioned as to their taste for military life, their character is investigated and, after being properly vouched for, they are put into squads and drilled. If found apt, they are accepted. The men are from all professions and trades, clerks, etc.

Each battery has four three-inch rifles and two Gatling guns. Each rifle and caisson has two teams, making eight horses, the Gatlings take only two horses each; so that the batteries require thirty-six draft and sixteen saddle horses. Red blankets are used for draft horses and the red saddle cloths for saddle horses. The batteries have the regulation belts, sabers, canteens and haversacks.

The officers receive the same pay as officers of like grade in the regular army when called to perform duty, as follows: invasion or insurrection, tumult, riot or mob, fall drill five consecutive days in camp, escort and other duty.

Enlisted men at all times are paid two dollars a day. For all horses four dollars a day is paid. Food for officers, men and horses must be provided out of pay.

The armories in large cities in Massachusetts are built by the state and are very good buildings. That of Battery "B," Worcester, cost about $100,000, and is well arranged. The drill room is 150×75 feet, besides good large company room, officers' room, harness room, store room, lavatories and all possible conveniences.

At the risk of taking up too much space I will describe the new armory of the Lawrence battery, which also contains the headquarters of the 1st Battalion of Light Artillery. This armory cost $90,000 and is built to accommodate four infantry companies and the battery.

The main body of the building is one large drill shed 68×125 feet, at one end of which is the head house so called, and at the other end the gun room.

The battery occupies the lower floor of the head house, which is 58×74 feet. There is one room for battalion staff 19×8, one for battery officers 19×8, one for non-commissioned officers 14×26, one for privates about 26×40, one for uniform (full dress) 16×25, two for storage, in basement.

The gun room is 25×70 feet—in this room there are six harness racks, built on trucks, which can be moved about like any other carriage. The armory contains elaborate toilet rooms and a boiler room with a sixty horse-power boiler, etc.

Everything is finished in ash, with light finish of filling. The furniture furnished by the state will cost about $2200; besides which, the furniture of battery rooms will be old oak at a cost to the battery of about $1000. The state builds these armories and the city pays annually the interest and one-thirtieth of the bonds, so that in thirty years the armories become the property of the city.

The batteries have one drill a week and also some non-commissioned officers' meetings and drivers' drills. These drills are usually given out beforehand, by paragraphs, and the non-commissioned officers and drivers are instructed orally and by blackboard. In camp they usually have one day of mounted drill: the drivers are permanent men in the company and from a class that have to do with horses.

The permanent camp is at South Framingham, and Battery "B" always marches to camp, a distance of twenty-five miles. Battery "C" frequently has marched, but the distance, thirty-five miles, is too far for one day and therefore impracticable. The batteries seldom, if ever, get any target practice.

The batteries are quite fully equipped for field service and could be placed in Boston within six hours after receipt of order. There are however some things lacking for immediate field service, such as tentage, cooking utensils, etc., besides which there is but very little if any ammunition kept on hand, except for the Gatling guns.

The battery at Worcester has always had a very high reputation for excellence. The captain, Lawrence G. Bigelow, writes as follows:

"I think the militia a very necessary institution, and everything that it is possible to do to make it more effective in time of need should be done. For instance, more money spent in arming, equipping and in armories; also, better care of property and more care in selecting officers. I would like regular army officers detailed to instruct militia officers in their more particular duties by lectures and examples. Have the two go to camp together and the one try to learn the teachings of the other."

Captain L. N. Duchesney, of the Lawrence battery, is an old soldier and saw four years service during the war from 1861 to

1865; serving three months in 6th Massachusetts Infantry, three years and six months in 1st Massachusetts and 26th New York Cavalry, from private to captain, including sixteen months in Libby and Salisbury prisons. He writes as follows:

"The greatest difficulty in the artillery is in regard to the horses. If it were possible to have the state buy horses and so arrange to have stables in close proximity to armories, and under the careful management of some competent man have the animals employed sufficiently to pay expenses and to replace those lost by death or by becoming unfit for artillery work, it would solve the problem; this is the only obstacle in the way to insure for the militia artillery the greatest possible success."

"The very best of our young men would flock to our ranks, and, it may be my fanciful idea, but I would be willing to risk my reputation in predicting a popularity for the artillery which would be irresistable."

"I have a scheme, and I think every other militia artillery officer has, to form stock companies for this very purpose, to secure at all times a sure and perfect supply of ready trained animals and permanent drivers, so that the battery would become as proficient when mounted as on foot or gun drill."

"In reply to the question as to what could be done, it is hard to state. I am sorry to say that too many of our leaders in the militia do not appreciate the value of the light artillery service for future wars, and to advance ideas for the betterment of the interest of this branch of the public service, with no hope of doing anything in the enactment of laws to increase its efficiency, is like writing a romance without a hero. We need the coöperation of the general government--the forts in Boston harbor should be at the disposal of the artillery for the purpose of target practice, and ammunition should be furnished by general government and regular officers detailed to instruct the officers and men of the state artillery."

"Occasional batteries of regulars and militia should be joined in route marches for instruction in the bivouac, care of horses, selecting camping grounds, to teach men to care for themselves in cooking and everything that men should know in case they were called to active service."

"I believe that the battles of the future will be fought at long range so that the artillery thus demanded for them will be greatly increased as shown by the experiences of the late war. I appreciate everything in the advancements made in the regular army and navy, in improved guns and projectiles, etc., since the war and now under way and it is galling to an old soldier who loves the service as I do not to be able to see these improvements going on and not to have the opportunity to practice and keep up with the times. You will readily see that the only thing which the poor batterymen of the national guard need is 'an appropriation of money with which to thoroughly equip themselves. We are millions who are willing to train so as to be ever ready, if need be, to battle for our country.'"

Major George S. Merrill, who also served during the war in the Massachusetts Volunteers, commanding the First Battalion Artillery, M. V. M., writes at length and very thoughtfully upon the artillery question; I can only quote his closing sentences.

"The need of the artillery to-day is actual target practice, it is in all other respects well drilled and ready for efficient service. I, last year, after several personal suggestions of a like character, sent to the Adjutant General a communication asking that instead of the one day annual drill, which with untrained horses is of very little advantage to the artillery, I be permitted to take my battalion to Fort Warren, in Boston Harbor, the consent of the government being obtained for its use, and that there under the direction of the regular artillery officers it have a day of actual target practice."

"Unfortunately such extensive repairs were being made in the fort that it was found impracticable to carry out this suggestion at that time, but I hope in the immediate future that this will be adopted and this branch of the service be given, as is the infantry, one day each year of target practice."

"One other need of the militia of this commonwealth, and that I think will be remedied in the immediate future, is the providing of cooking utensils to each organization and a change in the system so that each company may have the experience during five days of encampment, which they would so much need in the field, in preparing and serving their own rations.

This would not only very materially reduce the expense to the men, as the rations are provided out of the pay allowed by the state, but it would be of advantage in case any portion of the militia was suddenly called upon for actual service. The need of this was strongly illustrated when a portion of the New York national guard was called out during the strike at Buffalo."

TEXAS ARTILLERY.

The Texas Volunteer Guard has three batteries of field artillery, known as the First Battalion of Artillery.

Battery "A," of Galveston, organized in 1839, contains about 100 men; Battery "B," of Dallas, organized in 1879 and contains about 60 men; Battery "C," of Brenham, was organized June 17, 1887, and contains about 41 men.

The uniform is the United States army regulation: the Dallas artillery has adopted a braid on the coat and a red trimmed cap. while the Galveston battery has both a dress and undress uniform. All the batteries are obliged to purchase their uniforms, as the state has never provided them. The average cost of the undress uniform is about twenty dollars, while the dress uniform costs something more.

Each battery has one captain and three lieutenants; these officers are elected by the votes of active members in good standing, and, by recent orders, must pass a compulsory examination. Those of Batteries "A" and "B" have held office for one year and those of Battery "C" for three years, but the term is now fixed at three years. The qualifications necessary are military and always have been shown by previous service in the battery; they may be briefly stated as follows: Proficiency in the manual of the piece, school of the battery, such rules and regulations as are necessary for the discipline of a camp of instruction, a sufficient knowledge of the articles of war as is applicable to the national guard, courts-martial, military courtesy, ability to handle and instruct men, and a knowledge of the militia laws of Texas.

The privates are enlisted for three years and sworn into the state service, but have the privilege of resigning at any time

They are obtained as a general rule by their own choice, they join because of the social features connected with such organizations and from patriotism, and are generally obtained from the young men of the country who are fond of military display, possessed of courage, and a desire to serve their state if needed.

In most cases enlistments are voluntary, without solicitation. The members of the battery vote on each and every application, three black balls usually rejecting, and good substantial young men are generally obtained. In the Brenham artillery nearly every man is a business man and man of family.

The armament of Battery "A" consists of two 12-pounder Napoleon guns, two 3-inch rifles, four mountain howitzers and one .45 cal. Gatling gun; that of Battery "B" is one .45 cal. Gatling gun, recent model, and one 12-pound bronze gun, together with some few sabers, etc; that of Battery "C" is two .45 cal. Gatling guns, with harness for eight horses together with revolvers and sabers.

The pay allowed by the state is that of U. S. army. Enlisted men one dollar per day. No pay is allowed in camp, but at this time commutation is allowed at the rate of fifty cents per man, with an allowance of one dollar per day for horses.

The state allows no money for rent or purchase of armories, but, notwithstanding this fact, all these batteries have fine armories which are owned by or in the battery.

Battery "A" has a large two-story building suitable for military purposes, very well arranged and handsomely fitted up. The value of the armory and furnishings is about twenty-three thousand dollars.

Battery "B" has a fine armory, worth about ten thousand dollars; this building is 130 × 60 feet, standing on a lot 100 × 228 feet, drill room on ground floor 60 × 100, large company room, rooms for saber rack, store room, etc.—the upper story has a large ball room.

Battery "C" has also a fine armory sufficiently large to comfortably house the guns and harness, the latter is carefully cared for.

The batteries are all very proficient at dismounted drill, usually drill once a week or oftener, but as the state provides no horses and the harness is nearly all unserviceable it is almost impossible to get any mounted drill—they always have a little practice during their annual encampment, but not much.

The Brenham battery is, however, an exception to this; during the summer months they usually have one mounted drill per week: the members of the company own their horses and they are used in the battery drills free of charge. The drivers are selected from among the members, those best fitted are picked out and change about riding lead and wheel teams; they are exempt from payment of dues, etc.

The benefits enjoyed by the members of these batteries are, exemption from road duty, jury duty and the payment of poll taxes—counting the probable time that would be served on jury duty this amounts to about ten dollars per year. The individual expenses incurred by the members are much greater than this each year.

The only active service seen recently by Battery "A" has been two days in strike of 1886. Battery "B" also served at this time, and, reporting with one 3-inch gun, was obliged to improvise its own ammunition by filling oil cans with buckshot after knocking off the spouts. Battery "C" has never been ordered out.

These batteries camp each year for about ten days at the permanent state camp established at Austin, Camp "Mabry," named after the present adjutant general of Texas. All these batteries have been frequently complimented on their drilling. Battery "C" usually goes into camp mounted.

All the batteries have had target practice with Gatling guns, with most satisfactory results.

The condition for active service of the Brenham battery is very good, since they have horses and men already well up in mounted drill; but the condition of the other two batteries is not so good. This is owing entirely to their poor equipment, however, since the men could be readily assembled. The Brenham battery could take the field at once, while the others would be obliged to get nearly all the necessary field equipment before moving.

The Dallas battery is exceptionally well drilled and has drilled in prize drills as follows: At Austin in May, 1888, they took second place; at Nashville, the following week, they were fifth in a field of six batteries; at Galveston, in 1889, they won first prize; at Indianapolis in July, 1891, first prize in a field of four batteries; at Omaha, Nebraska, in June, 1892, second, three batteries competing.

These batteries have had the good fortune during their last three or four annual encampments to encamp with Light Battery "F," 3rd U. S. Artillery, on which occasions the officers of the army have been untiring in their efforts to aid them.

The following opinions of the captains of the different batteries will be of value, as showing the needs of the militia artillery.

Captain S. L. Crawford, of Galveston, writes as follows: "I do not consider the Gatling gun as belonging to our branch. We cannot practice with the 3-inch rifles as the state persistently refuses to furnish us with the necessary ammunition, and the military organization that furnishes its own uniforms, pays its own armory rent, and keeps its arms in good condition, must draw the line of expense somewhere. I might mention that this lack of interest, in both state and national government, is causing a very lukewarm feeling to enter the mind of the militiaman. As to our condition for active service, it is a hard question to answer frankly. As you know, our drill is the dismounted drill; we could assemble a battery for same in defense of this city in less than one hour, and serve our guns, provided we had the necessary ammunition. But when you ask me how soon my battery could assemble equipped for the field, horsed, with the necessary drivers, artisans, etc., I must say 'I give it up;' although, should a crisis require it, I think that we could get into shape quicker than our unorganized condition would indicate.

"As the militia are proficient with the dismounted drill, handling of the piece, etc., it may be a good idea for them to continue in that line; for the regulars excel in handling the horses and driving. Could we meet at our annual state encampments and combine forces, I think that it would do us decidedly more good than our present mode of drilling, for it seems to be out of the question for us to receive horses or ammunition with which to practice."

"If the regulars and militia would devote a week or ten days to this joint drill, and be on the move part of the time, with target practice, etc., I think that we would derive as much experience in ten days as we would in ten years of our present mode of doing business. Of course, this would be all for our benefit."

"We need from the government, uniforms, money to pay armory rent, and ammunition for practice, none of which we receive. I will say this, that batteries in sea-coast towns, which towns should all have some *stationary guns* of defense, should be manned by cannoneers who, from constant practice, have become familiar with their range, etc. As the defense of one's town naturally stirs up the patriotism of a man, I think that there would be no trouble in arousing interest in said work."

Captain F. V. Blythe, of Dallas, writes as follows: "That a well armed and disciplined national guard is absolutely necessary to the maintainance of law and order, has been so clearly demonstrated in the last few months that no doubt on that point exists in the minds of any but the fanatical so-called friends of the working classes and demagogues pandering to the same class with an eye single to their own glory and future political advancement."

"This force must be free from all political influence, and, regardless of class or prejudice, be prepared to repel any assault against the laws or established authority."

"The civil authorities, fearful of losing place and influence, will too often parley with men whose incendiary and unlawful conduct has placed them outside the pale of the law, and only the strong arm of those whose training has taught them that law and order are of the first importance, regardless of class or party or the effect it will have on the next election, will suffice to undo the harm such weak and vacillating officials may cause. Pennsylvania, in my opinion, has solved the problem, and the magnificent manner in which her force was concentrated at Homestead last July shows what may be done with the national guard when under the command of able men and backed by a patriotism that does not stop to count the cost in dollars and cents when the necessity is shown to exist for the maintenance of such a force."

"The legislation necessary to place the force in this state on an effective footing would call for the framing of an entirely new militia law, the one under which we are organized not contemplating any financial assistance for the volunteers."

"Every dollar of the expense connected with the service comes from the individual members, and the artillery branch of the service must provide ammunition for target practice, must pay all repair bills on ordnance which is issued to them in unserviceable condition, and if they have a mounted drill it is a considerable expense for horses."

"Men should be uniformed and equipped for actual service; armory rent, lights and janitors' wages should be provided for; ten days in annual encampment should be compulsory with pay for such time, and this time should be spent in practical instruction in field exercises, target practice, marching, camping, guards and outposts, and the handling of the men in the enemy's country. Systematic target practice during the year should be provided for and required. We have none of these nor will have under the present law."

"I am of the opinion that a national militia law, making the guard a national force in fact, would be better than the present method."

Captain C. F. Herbst, of Brenham, writes as follows: "In my opinion the militia service can only derive the greatest benefit from being thrown in contact with the regular army forces at the various annual state encampments, the example set by them has had a wonderful effect on the volunteer guards. In order to have a thoroughly drilled and equipped militia force in our state a great deal of friendly legislation is necessary. So little is done for the men who voluntarily enlist for the good of their state that in my opinion the increase of the militia forces, or even the keeping of them at a proper standard, is out of the question. The state furnishes absolutely nothing except arms, accoutrements, and rations at the state encampments. It certainly would be a credit to the United States should the national congress pass such laws as would not only encourage the military spirit but aid the volunteer forces materially by large appropriations of funds for the purchase of uniforms, for defraying the expenses of armory rent, loss of time, etc., to be regulated by the executives of the different states."

"I think that a union of interest and duty between the U. S. army artillery service and the national guard or state troops could be brought about by a uniform armament, by placing modern guns (not old, dilapidated, worthless, condemned ordnance) in the hands of volunteer artillerymen, such as Gatling or breech-loading rifled guns; by establishing a system of instructions through competent army men, commissioned and non-commissioned, at convenient times at the different towns and cities where enough interest is taken by the state organizations."

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KANSAS ARTILLERY.

The Kansas national guard has only one battery of light artillery, Battery "A;" this battery is divided into two platoons, the first stationed at Wichita consists of one captain, one first lieutenant, one second lieutenant and thirty non-commissioned officers and privates. The second platoon is stationed at Topeka and consists of one first and one second lieutenant, and thirty non-commissioned officers and privates. The present organization is dated from July 16, 1888.

The uniform is the same as U. S. army, with the white helmet for summer wear.

Commissioned officers are elected by men and commissioned for five years. The privates are recruited from young men of good physique, less than six feet tall; the battery is always full of the best material and always has a great many applicants to select from.

The battery is armed with four bronze cannon and one Gatling gun—the brass guns are very old, some of them cast in 1842 and are perfectly useless; they were a part of the 2nd Kansas Artillery during the war. The battery has artillery sabers and belts, canteens, haversacks, blanket bags, ponchos, with 9x9 wall tents for men and 10x12 for officers, The battery is also armed with .50 cal. Sharp's carbines and slings and belts.

The same pay is allowed the officers as in the regular army, but only when ordered out by governor or sheriff of county.

The state allows $50.00 to each platoon each quarter, for rent. The platoons each have good drill halls with large rooms attached for commissioned officers, etc.

The battery drills twice a week the year round, usually dismounted drills with pieces; they drill enough with carbines to learn how to handle them well; the percentage of attendance at these drills is about seventy-five. There is also mounted drill five or six times a year; the drivers are cannoneers who volunteer to drive.

The battery was ordered to Stevens county seat war for four weeks in 1884 with Gatling guns, and again for six weeks in fall of same year and has been turned out to guard the county jail several times. Although no appropriations have been made by the state for camping since 1886, the battery has camped five times a year with the G. A. R. on the average at the state reunions and various county reunions, and is well known in the state for discipline and proficiency in drill.

Captain Willis Metcalf, of Wichita, writes as follows: "I have been in the national guard of this state for twelve years and think the service the best possible place for young men. It sets them up, gives them a better carriage and teaches them something that some day will be of use to them and the state that is doing so little for them now. I want to see the U. S. army officers and national guard officers stand together, organize and make an assault upon congress this fall and obtain what legislation we need; for in case of crisis you will look to us to organize armies, etc., and the better the shape in which you find us the better service we can accomplish.

"If we could encamp or go on a practice march with the battalion at Fort Riley thirty days each year, we could learn more than in ten years in the armory. But of course it is hard to get men who can give up thirty days without great loss to themselves. I think that one officer from each battery in the national guard should be sent to some artillery school similar to the one at Fort Riley, for six months, then they will be in shape to practically instruct recruits. They will then be something near the standard of the U. S. Army, at least be instructed by officers of the regular army."

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RHODE ISLAND ARTILLERY.

The light artillery of Rhode Island consists of a Gatling gun battery and a light battery, both of which are in Providence.

The light battery, designated as Battery "A," was organized in 1801 and chartered by the state; it is the oldest artillery organization in the United States. It consists of one captain, two first lieutenants and one second, and the usual non-commissioned officers; the aggregate is about sixty. The Gatling gun battery was reorganized July 31, 1891, by act of legislature and consists of one captain, one first and one second lieutenant, one first, one quartermaster and four line sergeants, four corporals, one musician, one guidon and twenty-eight privates; an aggregate of forty-three.

The uniform is patterned after the United States service and consists of dress and undress, with overcoat.

The officers are elected for a period of three years and are commissioned after passing the prescribed examination. The men enlist for the same period. The enlisted men are mechanics, clerks, accountants and horsemen. Many of the machinists in the light battery are familiar with guns, as they work on the Martini rifle, the breech-loading mortar, Howell torpedoes, etc.

The Gatling gun battery is a four gun battery without caissons. The light battery is armed with six 6-pdr. bronze guns with caissons, and two 3-inch rifles. The men have canteens, haversacks, rubber and woolen blankets; sergeants only are armed with saber.

The officers, when on duty, receive pay at same rate as in the regular service; men receive one dollar and a half a day.

The armory for the light artillery is owned by the state, is built of stone, and is in good condition, but not as convenient as some more modern in construction; the armory of the Gatling gun company is leased by the state.

Drills are held about twice a week and are usually confined to the standing gun drill, mechanical manœuvres, school of the battery dismounted and squad drill for recruits. There is also a school of instruction for officers and non-commissioned officers. The batteries go to camp each year at Oakland Beach, for a period of five days; they are also horsed at other times during the year for parade. Drivers at mounted drills are men who handle the same horses in their regular business.

The light battery could be manned and horsed in twelve hours or less notice, and could go into the field with personnel well clothed and with sufficient camp equipage. Has battery wagon and forge and the battery does its own horse shoeing in camp.

Light Battery "A" has quite a distinguished history. It was first paraded as a light artillery organization in May, 1848, and was the first light battery in the volunteer service. Rhode Island's famous war governor, William Sprague, resigned his commission as commander of the battery to accept the position of governor during the war. This battery sent out, or were instrumental in sending out, during the war, eleven light batteries numbering some two thousand men. More than fifty of the men whose names may be seen on the signature book held commissions from brigadier general down. Among the most prominent are: Brevet Brigadier General Charles H. Thompkins, Chief of Artillery, 6th Army Corps; Brevet Brigadier General Francis F. Lippitt; Brevet Brigadier General John G. Hazzard, Chief of Artillery, 2nd Army Corps; Lieutenant Colonel J. Albert Monroe, Chief of Artillery, 2nd and 9th Army Corps, and commander of Camp Berry school of instruction for batteries, Washington, D. C.; Colonel Henry T. Sisson, 5th Heavy Artillery;

Colonel George L. Andrews, 10th Missouri and Lieutenant Colonel 17th U. S. Infantry; Lieutenant Colonel William H. Reynolds, 1st Rhode Island Light Artillery, and Major J. B. Patch, 1st Rhode Island Infantry.

Captain E. R. Barker, commanding Battery "A," although not a veteran of the war, has seen continuous service in the Rhode Island militia, both infantry and artillery, since 1878. He is an enthusiastic artillerist and writes as follows: "I believe that the volunteer service will compose the greater portion of any army of size that the United States government will put in the field in future wars, as in the war of the rebellion; that it has made great improvement and advancement in drill, discipline and equipment in the last ten years; and that in many states it is prepared for and should have better facilities, in theoretical and practical study, in the use of instruments, a general knowledge of chemistry and explosives, which knowledge I believe should be imparted at the expense of the general government.

"I believe the national government should own lands and buildings in each state, where there could be constructed proper appliances for study and instruction. Until then, I believe that the best results would be obtained by detailing officers to the United States schools and coast garrisons for a period of weeks and then sending them back to their commands. There should be furnished to each officer, through the adjutant general of states, publications of high character, such as the *Journal of the Military Service Institution.*"

THE FORAGE RATION FOR HORSES OF FIELD ARTILLERY AND CAVALRY.

By First Lieutenant EDWARD E. GAYLE, Second Artillery, U. S. A.

The relation which the food of man bears to his useful work has been under investigation since scientific knowledge first afforded a means for its determination, and, at the present day, modern methods have established it with a degree of accuracy but little short of perfection. As a result of these investigations we know that a soldier's ration, in order that he may retain good health and be able to perform moderate work, should contain certain nutrients in definite proportions, and to enable him to perform hard work they should bear different relations to each other.

While this is true of man it is equally true of the horse, and, if it be economical to adjust the food of the former to suit different grades of work, it is reasonable to infer that the same should be done for the latter.

To a clear understanding of the close relationship existing between the animal body and food it may be well briefly to consider the composition of each. This may seem superfluous, since it is a matter of every day knowledge, but its intimate connection with our subject justifies its repetition.

While the animal body is a complex machine whose intricate workings have not yet been fully mastered, we do know that it is built up as the result of digestion and assimilation of food and that the character of the food may be such as to hasten or retard that which we wish to produce—muscle, bone, fat, &c. For present purposes it may be reduced to four substances, namely: protein (lean flesh), fat, water, and ash or saline materials. The amount of water varies from about forty to sixty per cent. and ash from about two to five per cent. of the live weight. The latter consists mainly of lime, phosphoric acid, potash, soda, magnesia and small quantities of sulphuric and muriatic acids which, in point of quantity, rank about in the order given.

By analyzing lean flesh (protein) and fat we find they are made up of four chemical elements in certain definite proportions. The protein consists of carbon, oxygen, hydrogen and nitrogen and the fat of the first three only. It is not necessary to point out the relative amounts of these elements in the two tissues, but it should be noted that the chief difference between them consists in this: that the former contains nitrogen while the latter does not.

These tissues are constantly undergoing waste and require constant renewal, the material for which is supplied by the food.

Turning to the food materials we find that they are composed of the same elements and in the same combination as those found in the body. While this is true, feeding stuffs may differ from each other on three very important points, namely: quality, quantity and digestibility of the nutrients contained in them. When we speak of a food as being more or less digestible, we mean simply that the animal has the power of appropriating more or less of the nourishment which it contains. Chemical analysis will reveal the exact amount of nourishing elements bound up in a food; but of two foods of the same composition one may be more digestible than the other. Some are completely, others only partially, digestible. The grains, hay, straw, &c., contain a certain amount of nourishment which cannot be appropriated; the animal body has not the power of extracting all of it. This is important, because in compounding a ration it is only on the *digestible portion* that we can count. Every one is aware that feeding stuffs differ in the quantity of their nutrients; grain contains much more nutrition in a given bulk than straw or hay or any of the so-called coarse fodders. The most important point in a feeding stuff is its quality; that is, the absolute and relative amounts of the nutrient elements which it contains. These nutrients are protein, or albuminoids, the substance which contains nitrogen; it differs greatly in quantity in different materials as may be seen by reference to the table of analysis of feeding stuffs. It is the only substance from which flesh can be formed, rapid growth and development of muscle being impossible when food is deficient in protein. It is the most important and indispensable element in all food; indispensable because an animal would starve to death on a food such as starch or sugar, which contained no protein.*

The carbo-hydrates are next in importance; they consist chiefly of starch, sugar, fibre and gum, are present in relative abundance in ordinary feeding stuffs, and are utilized as fuel to supply the body with heat.

Fat, the third nutrient, is essentially of the same character as the fat of the body, is present only in small quantities in feeding stuffs suitable for the forage ration, and goes to the formation of fat in the body; it is not, however, its only source, the other nutrients aiding to some extent in this regard.

Other things being equal, that feeding stuff is of the best quality which is richest in digestible albuminoids.

Based upon these facts of animal nutrition experiments have established other facts in regard to the economic use of feeding stuffs with a view to diminishing the waste of nutrients and to getting the greatest production of muscle, &c., for the food consumed. They are the ratio which the albuminoids and carbohydrates must bear to each other, called the nutritive ratio; and the quantity of these nutrients required by an animal under different conditions of work.

The results of these experiments have been reduced to figures and tabulated under the name of Feeding Standards, and although they have been compiled by German experimenters, they are as applicable in this country as in Germany. The results represent averages of a large number of experiments with horses, cattle and other animals under various conditions of work, weight, age and growth. Regarding their practical value there can be no question, as they are in daily use by intelligent and progressive stockmen, dairymen and farmers for the fattening of stock, the production of milk and for various other purposes, and have thus been subjected to the test of experience.

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* This word is used to represent the essential nitrogeneous constituent of food.

"Horses doing hard work will require food containing a large proportion of both nitrogenous and non-nitrogenous principles. Not only is the waste of the various tissues accelerated by long continued exertion, but chemical combustion takes place more rapidly.

"If the nitrogenous elements [protein] are not supplied in quantities sufficient to repair the waste the animal will fall away in muscle.

"If the non-nitrogenous elements [carbo-hydrates and fats] are not supplied in quantities sufficient to compensate for the chemical combustion, the fat stored up in the various parts of the body will be called upon to supply the deficiency and the animal will become thin."—Fitzwygram.

It is proposed to apply data taken from the table of Feeding Standards to the regulation forage ration for our horses of field artillery and cavalry, to point out certain deficiencies existing in it and to suggest the means for their correction.

Paragraph 1142 A. R. gives as the forage ration for a horse, fourteen pounds of hay and twelve pounds of oats, corn or barley. In special cases of hard service the grain ration may be increased not to exceed three pounds. We thus have six distinct rations.

Paragraph 1127 A. R. requires that the minimum and maximum weights of artillery horses shall be 1050 and 1300 pounds respectively.

From the table of Feeding Standards we get the following: A horse weighing 1000 lbs. requires per day:

	Total organic substance.	Protein.	Carbo-hydrates.	Fats.	Total Nutrients.	Nutritive ratio.
Under moderate work - -	22.5	1.8	11.2	.60	13.60	1:7
Under hard work - - -	25.5	2.8	13.4	.80	17.00	1:5.5

Adjusting this table to the weights of our artillery horses by increasing the numbers in each column by five per cent. for the minimum and thirty per cent. for the maximum, we have the following:

TABLE I.

	Total organic substance, lbs.	Protein, lbs.	Carbo-hydrates, lbs.	Fats, lbs.	Total nutrients, lbs.
For moderate work:					
Weight of horse, 1050 - -	23.62	1.89	11.76	.63	14.28
" " 1300 - - -	29.25	2.34	14.56	.78	17.68
Average weight in battery, 1105 - -	24.80	1.98	12.37	.66	15.01
For hard work:					
Weight of horse, 1050 - -	26.77	2.94	14.07	.84	17.85
" " 1300 - - -	33.15	3.64	17.42	1.04	22.10
Average weight in battery, 1105 - -	28.17	3.09	14.80	.88	18.77

An examination of the weights of horses in Light Battery "A," 2nd Artillery, shows, with the exception of two unusually tall and heavy horses—which are thought to be unfit for the service—that the difference between the minimum weight as authorized by regulations and the heaviest horse in the battery is about 150 pounds; while the average weight, including the two above mentioned, is 1105 pounds. This is the average weight for which calculation is made in the above table.

For purposes of comparison it is necessary to compute the amount of digestible nutrients contained in the six forage rations: three for ordinary or moderate work, in which the grain allowance is twelve pounds, and three for hard work, in which it is fifteen pounds; the weight of hay being the same in all.

The result is embodied in the following:

TABLE II.

	Total organic substance. lbs.	Protein, lbs.	Carbo-hydrates, lbs.	Fats, lbs.	Total nutrients. lbs.	Nutritive ratio.
Moderate work:						
14 lbs. Hay (mixed grasses) - -	11.17	.448	5.628	.126		
12 lbs. Oats - - -	10.33	1.176	5.760	.468		
12 lbs Corn - - -	10.50	1.002	7.800	.505		
12 lbs. Barley - - -	10.40	1.164	7.440	.204		
Hay and Oats - - -	21.50	1.624	11.388	.594	13.606	1:8
Hay and Corn - - -	21.67	1.450	13.428	.631	15.509	1:10
Hay and Barley - -	21.57	1.612	13.068	.330	15.010	1:8.5
Hard work:						
14 lbs. Hay - - -	11.17	.448	5.628	.126		
15 lbs. Oats - - - -	12.91	1.470	7.200	.585		
15 lbs. Corn - - -	13.13	1.252	9.750	.631		
15 lbs. Barley - - -	13.00	1.455	9.300	.255		
Hay and Oats - - -	24.08	1.918	12.828	.711	15.457	1:7.6
Hay and Corn - - -	24.30	1.700	15.378	.757	17.835	1:10
Hay and Barley - -	24.17	1.903	14.928	.381	17.212	1:8.3

We are now ready to compare our rations with those required by the Feeding Standards. Before doing so it is well to state that the hay selected as forming a part of the ration in the above calculations is that given in the table of analyses of feeding stuffs as "mixed grasses." This selection was made because the per cent. of digestible nutrients given for it is about equal to that of timothy hay and, in all probability, equal to that of any hay likely to be issued as part of the ration. Also because the name would indicate a near approximation to the hay used at this post, with the exception, however, that no mention is made of weeds of which we have an abundance. In consequence of this the ration is considered under the most favorable circumstances, as far as its nutritive qualities are concerned.

We will first consider the ordinary or moderate work ration. Referring to tables I and II, ration hay and oats, we note the following:

For horse weighing 1050 pounds, the organic substance is deficient by 2.12 pounds, protein 16 per cent., carbo-hydrates 3 per cent., fats 6 per cent.

For horse weighing 1300 pounds, organic substance deficient by 7.75 pounds, protein 44 per cent., carbo-hydrates 27 per cent., fats 32 per cent.

For horse weighing 1105 pounds, organic substance deficient 3.3 pounds, protein 22 per cent., carbo-hydrates 8 per cent., fats 12 per cent.

Ration hay and corn.

For weight 1050 pounds, organic substance deficient 1.95 pounds, protein 30 per cent., carbo-hydrates in excess 14 per cent., fats about normal.

For weight 1300 pounds, organic substance deficient 7.58 pounds, protein 61 per cent., carbo-hydrates 8 per cent., fats 23 per cent.

For weight 1105 pounds, organic substance deficient 3.3 pounds, protein 36 per cent., carbo-hydrates in excess 8 per cent., fats deficient 5 per cent.

Ration hay and barley.

For weight 1050 pounds, organic substance deficient 2.05 pounds, protein 17 per cent., carbo-hydrates in excess 11 per cent., fat deficient 90 per cent.

For weight 1300 pounds, organic substance deficient 7.68 pounds, protein 45 per cent., carbo-hydrates 11 per cent., fats 130 per cent.

For weight 1105 pounds, organic substance deficient 3.23 pounds, protein 23 per cent., carbo-hydrates in excess 5 per cent., fats deficient 100 per cent.

Considering the hard service ration we find as follows:

Ration hay and oats.

For weight 1050 pounds, organic substance deficient 2.69 pounds, protein 53 per cent., carbo-hydrates 9 per cent., fats 18 per cent.

For weight 1300 pounds, organic substance deficient 9.07 pounds, protein 89 per cent., carbo-hydrates 35 per cent., fats 46 per cent.

For weight 1105 pounds, organic substance deficient 4.09

pounds, protein 60 per cent., carbo-hydrates 15 per cent., fats 23 per cent.

Ration hay and corn.

For weight 1050 pounds, organic substance deficient 2.47 pounds, protein 72 per cent., carbo-hydrates in excess 9 per cent., fats deficient 10 per cent.

For weight 1300 pounds, organic substance deficient 8.85 pounds, protein 114 pec rent., carbo-hydrates 13 per cent., fats 36 per cent.

For weight 1105 pounds, organic substance deficient 3.87 pounds, protein 82 per cent., carbo-hydrates in excess 2½ per cent., fats deficient 15 per cent.

Ration hay and barley.

For weight 1050 pounds, organic substance deficient 2.6 pounds, protein 54 per cent., carbo-hydrates in excess 6 per cent., fats deficient 121 per cent.

For weight 1300 pounds, organic substance deficient 8.98 pounds, protein 91 per cent., carbo-hydrates 16 per cent., fats 172 per cent.

For weight 1105 pounds, organic substance deficient 4 pounds, protein 62 per cent., carbo-hydrates about normal, fats deficient 131 per cent.

By examining these results it will be seen, in the light of the Feeding Standards, that all of the rations are deficient in organic substance between the limits 1.95 pounds and 9.07 pounds; that in carbo-hydrates they approach nearest the normal, though in some cases the deficiency and in others the excess in this nutrient is marked; that in fats the deficiency for the heaviest horse is large throughout, and in the ration in which barley is an ingredient it is exceedingly large, amounting in one case to 172 per cent.; that in protein, the most important and indispensable nutrient, the deficiency obtains throughout, varying, for all weights, between the limits 16 per cent. and 114 per cent., and for the average horse, in the ration hay and oats, its shortage is 22 per cent. and 60 per cent. for moderate and hard work respectively.

From this our conclusion must be that the ration is sadly deficient in that most essential nutrient, protein, or muscle making food: in other words, it cannot supply the necessary material to renew the wear and tear of muscular fiber because it does not contain it and, as a necessary consequence, our horses under moderate work and particularly under the hard work incident to active service, would show fatigue and distress sooner than they would under more favorable conditions of feeding.

It is stated by those who are well informed on the subject that cavalry will be able to make twenty-five miles, day in and day out; hence horse artillery will have to do the same, or travel eight hours per day at three miles per hour. For this time and rate a horse can, according to Aide Mémoire R. E., exert a useful tractive force of 125 pounds, which would give as a measure of his day's work 15,840,000 ft. lbs.

This is without doubt hard service for artillery horses and will require for its successful performance all the aid to be derived from the hard service ration, that is 17 lbs. of digestible nutrients as given in the Feeding Standards. Moderate work, for which there is required 13.6 lbs. of digestible nutrients, will therefore be that represented by a day's work of 12,672,000 ft. lbs., which is very nearly the work performed by artillery accompanying infantry at the ordinary rate, the number of ft. lbs. being 12,790,000. The proportions of digestible nutrients for the hard and moderate service rations have already been determined; we will now determine them for—we will call it—the garrison ration. It is assumed that the exercises of field artillery in garrison will consume two hours per day at the rate of six miles per hour. This is a little in excess of that actually determined at Fort Riley, Kansas, by one of the batteries stationed there. It is stated—Trautwine, Handbook of Civil Engineering—that if the number of hours remain constant tractive force varies inversely as the speed, and speed remaining constant it varies inversely as the time. While this is not strictly true for the time and rate assumed, the slight error is in favor of the horse. We thus have for the assumed time and rate a tractive force of 250 lbs., for which the corresponding load is 2036 lbs. The present light field carriage, without ammunition, with three men, the usual number mounted on it at drill, weighs 3539 lbs., or 885 lbs. per horse, the corresponding tractive force for which is 108 lbs. Since the team consists of four horses with drivers on two of them the tractive force of 250 lbs. is reduced for effective hauling to 148 lbs., a loss of 40 per cent., and as the 108 lbs. above is that available for actual hauling the total will be 180 lbs.; giving as a day's work 11,404,800 ft. lbs., which requires a ration containing 12¼ lbs. of digestible nutrients.

There is still another ration to be determined, for which, however, there is no immediate need, since the carriage for which it is calculated does not exist in our service, and when it is constructed the preceding ration may be abandoned. The proper weight for the light field carriage should be about 4432 lbs., deducting weight of ammunition and retaining weight of three men we have 3218 lbs. as the load in garrison service for four horses, with a tractive force for all purposes of 163 lbs. per horse, giving as a day's work 10,327,680 ft. lbs., which requires a ration containing 11 lbs. of digestible nutrients.

It is interesting to note, in passing, the amount of work our horses are at present required to do in actual service. Horse artillery under these conditions have, for hauling, an available tractive force of 65 lbs. per horse, which corresponds to a load of 530 lbs.; the present caisson completely equipped weighs 4753 lbs., 792 lbs. per horse, which requires under same conditions of time and rate a tractive force of 97 lbs. for hauling, or 186 lbs. for all purposes. This gives for the day's work of one horse 23,570,000 ft. lbs., which requires, to supply the corresponding wear and tear of tissue, a ration of more than 50 lbs., which the horse is not capable of consuming. This would indicate that the caisson is too heavy by 32 per cent. In the event of a light battery being ordered into the field, with its present organization, fully equipped for active service, we would have as a load for four horses a caisson weighing 5713 lbs. or 1428 lbs. per horse. This requires a tractive force of 175 lbs. available for hauling, or 333⅓ lbs. for all purposes, which would give as the measure of a day's work per horse 26,400,000 ft. lbs. and requires a ration of 56½ lbs.

Paragraph 1126 A. R. states that the weight of the cavalry horse "must not be less than 900 nor more than 1200 pounds."

Based upon the opinion of well informed officers of cavalry it is assumed that 1025 pounds will be a fair representative of the weight of an average cavalry horse, while an inspection of the weights of horses of a troop of the 7th Cavalry shows that the difference between this assumed weight and the average of those within regulation limits is but three pounds.

Adapting the Feeding Standard table, as before, to the required and assumed weights, we have the following:

	Total organic substance.	Protein.	Carbo-hydrates.	Fats.	Total nutrients.
Moderate work.					
Weight of horse, 900 lbs. -	20.25	1.62	10.08	.54	12.24
" " 1200 lbs. -	27.00	2.16	13.44	.72	16.32
" " 1025 lbs. -	23.06	1.85	11.48	.62	13.95
Hard work.					
Weight of horse, 900 lbs. -	22.95	2.52	12.06	.72	15.30
" " 1200 lbs. -	30.60	3.36	16.08	.96	20.40
" " 1025 lbs. -	26.13	2.87	13.73	.82	17.42

Comparing these with the digestible nutrients contained in the forage rations as given by Table II, we note as follows:

ORDINARY WORK.

Ration hay and oats.

Weight of horse 900 lbs., protein normal, carbo-hydrates and fats in excess 11 and 9 per cent. respectively.

Weight 1200 lbs., deficiency in protein 33 per cent., carbohydrates 18 per cent. and fats 21 per cent.

Weight 1025 lbs., protein deficient 14 per cent., carbo-hydrates nearly normal, fats deficient 4 per cent.

Ration hay and corn.

Weight 900 lbs., protein deficient 12 per cent., carbo-hydrates and fats in excess 25 and 14 per cent. respectively.

Weight 1200 lbs., protein deficient 50 per cent., carbo-hydrates normal, fats deficient 12 per cent.

Weight 1025 lbs., protein deficient 27 per cent., carbo-hydrates in excess 11 per cent., fats normal.

Ration hay and barley.

Weight 900 lbs., protein normal, carbo-hydrates in excess 22 per cent., fats deficient 63 per cent.

Weight 1200 lbs., protein deficient 34 per cent., carbo-hydrates normal, fats deficient 118 per cent.

Weight 1025 lbs., protein deficient 14 per cent., carbo-hydrates in excess 12 per cent., fats deficient 87 per cent.

HARD WORK.

Ration hay and oats.

Weight 900 lbs., protein deficient 31 per cent., carbo-hydrates and fats about normal.

Weight 1200 lbs., protein, carbo-hydrates and fats deficient 70 per cent., 33 per cent. and 35 per cent., respectively.

Weight 1025 lbs., protein, carbo-hydrates and fats deficient 50 per cent., 7 per cent. and 15 per cent., respectively.

Ration hay and corn.

Weight 900 lbs., protein deficient 48 per cent., carbo-hydrates and fats in excess 21 and 5 per cent., respectively.

Weight 1200 lbs., protein, carbo-hydrates and fats deficient 97 per cent., 4 per cent. and 26 per cent., respectively.

Weight 1025 lbs., protein deficient 68 per cent., carbo-hydrates in excess 10 per cent., fats deficient 87 per cent.

Ration hay and barley.

Weight 900 lbs. protein deficient 32 per cent., carbo-hydrates in excess 20 per cent., fats deficient 88 per cent.

Weight 1200 lbs., protein deficient 76 per cent., carbo-hydrates 8 per cent. and fats 152 per cent.

Weight 1025 lbs., protein deficient 50 per cent., carbo-hydrates in excess 8 per cent., fats deficient 115 per cent.

In a word, the same state of affairs is shown to exist for cavalry horses as has been pointed out for those of artillery.

To determine the proper ration for service conditions we will assume that cavalry will be able to make twenty-five miles a day six days in the week at the rate of three miles per hour, and that each horse will carry as a maximum weight 280 lbs., which we find from Aide-Mémoires R. E. he can do without over-exerting himself, and from the same authority that this weight is equivalent to a tractive force of 125 lbs. for same time and rate. A day's work would therefore be represented by 15,840,000 ft. lbs., and being hard service, would require the seventeen lbs. of digestible nutrients of the Feeding Standards. A day's work which will require the moderate work ration will be 12,672,000 ft. lbs., equivalent to the horse carrying a weight of 224 lbs., for eight hours at three miles per hour, or 280 lbs. for 6½ hours at same rate.

For data upon which to compute the proportions of nutrients for the garrison ration we will assume that drill and other mounted exercises consume 2½ hours a day at an average rate of eight miles per hour. This is supported by the opinion of cavalry officers at this post—Fort Riley—and is believed to be a sufficiently high limit to cover all cases. The weight of rider, equipment, arms, &c., will in round numbers be 200 lbs., as is shown below:

	lbs.	oz.
Saddle (complete) - - - - - -	18	08
Saddle blanket - - - - - - - -	4	10
Bridle and bit - - - - - -	3	01.5
Spurs and straps - - - - - - - -	0	12
Surcingle - - - - - - -	0	13
Carbine and 20 rounds - - - - - -	10	07
Pistol, holster and 12 rounds - - -	3	10
Sabre and knot - - - - - - - -	3	15
Cartride belt - - - - - - -	0	12
Sling-belt and swivel - - - - - -	1	04.5
Average cavalryman - - - - - -	155	00

The weights of the equipment were obtained by weighing the articles.

The day's work under these conditions would be 9,504,000 ft. lbs., which would require a ration containing 10.2 lbs. of digestible nutrients.

Calculating by means of the Feeding Standards the amounts of protein, carbo-hydrates and fats required for the two garrison rations for artillery and one for cavalry, we find them to be as follows:

	Protein.	Carbo-hydrates.	Fats.	Total nutrients.
Horse weighing 1105 lbs., Artillery .	1.60	10.00	.53	12.13
" " " " "	1.79	11.14	.59	13.52
" " 1025 lbs., Cavalry . .	1.38	8.61	.46	10.45

Having the proper proportions of digestible nutrients for all the rations, to compound them is, with the tables at hand, a question of but a few moments. Before selecting our feeding stuffs for this purpose three conditions must be fulfilled: first, we must be able to get the materials when required; second, they must be sufficiently cheap, and, third, they must be such as the horse will eat. The result is given below:

ARTILLERY.

	Total organic matter, lbs.	Protein, lbs.	Carbo-hydrates, lbs.	Fats, lbs.	Total nutrients, lbs.
Horse weighing 1105 lbs.					
Garrison ration, proper carriage, requires . .	19.55	1.60	10.00	.53	12.13
12 lbs. hay, 10 lbs. oats, 1 lb. beans contain . .	19.70	1.59	10.12	.51	12.22
Garrison ration, present carriage, requires . .	21.04	1.79	11.14	.59	13.52
14 lbs. hay, 11 lbs. oats, 1 lb. beans contain . .	21.37	1.75	11.41	.57	13.73
Moderate work, or field ration, requires . .	24.80	1.98	12.37	.66	15.01
14 lbs. hay, 13 lbs. oats, 1 lb. beans contain . .	24.42	1.95	12.37	.64	14.96
Hard work, or active service ration requires .	28.17	3.09	14.80	.88	18.77
14 lbs. hay, 15 lbs. oats, 5 lbs. beans contain .	28.20	3.06	15.33	.78	18.18
CAVALRY.					
Horse weighing 1025 lbs.					
Garrison ration requires	17.27	1.38	8.61	.46	10.45
12 lbs. hay, 8 lbs. oats, 1 lb. beans contain . .	17.29	1.39	9.15	.43	10.97
Moderate work ration requires	23.06	1.85	11.48	.62	13.95
14 lbs. hay, 12 lbs. oats, 1 lb. beans contain . .	23.70	1.85	11.88	.61	14.34
Hard service ration requires	26.13	2.87	13.73	.82	17.42
14 lbs. hay, 16 lbs. oats, 4 lbs. beans contain .	28.23	2.87	14.50	.79	18.16

These are as near the standard rations as they can be made with the feeding stuffs selected and are near enough for all practical purposes.

It thus appears that there should be three distinct rations for horses of field artillery and three for those of cavalry corresponding to the grades of work they are required to perform. Should it become necessary to reduce the ration in consequence of less exercise than that assumed above for garrison work, the reduction should be made in the proportions .6, .3, and .1 for hay, oats and beans respectively.

An estimate of the comparative cost of the regulatiion ration and that suggested for garrison service based upon prices of the St. Louis market shows that for the cavalry and light artillery service for one year the difference would be $84,315.00 in favor of the latter.

At what time the present ration was adopted, or upon what principles, if any, its component parts were adjusted, cannot be ascertained. It is a fact that it has existed for many years, that it has served its purpose without serious criticism and that it will probably remain as it now is, defects to the contrary notwithstanding. If, however, with it our horses have accomplished so much it is reasonable to infer that with rations properly compounded and graded they would accomplish more. A simple statement that it is sufficient for all purposes, though supported by an experience of many years, is not a final answer to the question, for the foregoing conclusions are based upon facts which are the results not of theory but of carefully conducted experiments and are entitled to more than a passing notice.

A CONTRIBUTION TO THE INTERIOR BALLISTICS OF SMOKELESS POWDERS.

By First Lieutenant LUCIEN G. BERRY, Fourth Artillery, U. S. A.

PART I.

So long as the smokeless powders were uncertain in their action, it is evident that any attempt to apply to them the principles of thermodynamics must have given confused and unreliable results. At present this uncertainty no longer exists, as is shown in the very interesting study recently published in the *Journal of the United States Artillery* of the effects of smokeless powders in a 57-mm. gun, by Mr. Lawrence V. Benét, Artillery Engineer of the Hotchkiss Ordnance Co., Limited, Paris.*

The results of the comparison of the data there given with certain theoretical deductions may be of interest to some of the readers of the *Journal*. We assume the following notation:

$E =$ A general expression for the kinetic energies of the projectile, powder and piece at any instant.

$\Sigma pv =$ The sum of the products arising from multiplying each pressure by the volume of gas at that pressure at the same instant.

$f =$ The force of the powder, a quantity which is expressed in units of energy.

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* This article originally appeared in the *Journal* (No. 3, July, 1892.) It has since been the subject of considerable discussion in both this country and Europe. It has also received the very high compliment of having been officially noticed and reprinted, by the Chief of Ordnance, U. S. Army, in the form of an Ordnance Construction Note (No. 61, 1892). While appreciating the compliment, and at the same time being willing to further the dissemination of professional information in any way possible, it is greatly to be regretted that no credit was given to the *Journal* as the original publisher of this article, since to those not acquainted with the circumstances the *Journal* is placed in the doubtful position of having plagiarized the article from a subsequent Ordnance publication. The act of reprinting an original and copyrighted article without authority and without even an acknowledgement of its origin was wholly unnecessary, since a request to reprint it would have been most cheerfully granted.—[Editor *Journal*.]

y = The weight of powder burned at any instant in kilograms.
W = Weight of the projectile in kilograms.
$\tilde{\omega}$ = Weight of the charge in kilograms.
z_0 = Initial space behind the projectile not occupied by the charge, divided by area of cross-section of bore in decimetres.
u = Length of travel of projectile, in decimetres.
δ = Density of the powder.
ω = Cross-section of the bore, in square decimetres.
g = Acceleration due to gravity, in metres.
V = Velocity of the projectile, in metres.
A = A constant depending on the conditions of loading, see Part II.
W_1 = Weight of gun in kilograms.
p = Pressure on the base of the projectile in kilograms per square decimetre.

Neglecting the passive resistances we have from the principles of mechanics, using metric units;

$$E = \int_{v_0}^{v} p\,dv$$

if the expansion is adiabatic

$$p = \frac{p_0 v_0^{1.41}}{v^{1.41}}$$

hence

$$E = \int_{v_0}^{v} p_0 v_0^{1.41} \frac{dv}{v^{1.41}} = \frac{p_0 v_0}{.41} - \frac{p_0 v_0^{1.41}}{.41\, v^{.41}} = \frac{p_0 v_0}{.41} - \frac{pv}{.41}$$

placing $p_0 v_0 = fy$ we have

$$.41 E = fy - \Sigma pv$$

The kinetic energy of the projectile is $\frac{WV^2}{2g}$,

That of the charge is $\frac{WV^2}{2g}\left(\frac{\tilde{\omega}}{2W}\frac{1}{A} - 1\right)$ (See Part II),

That of the gun is $\frac{WV^2}{2g} A_1^2 \frac{W}{W_1}$ (See Part II),

The value of Σpv is $\frac{\tilde{\omega}}{2W}\frac{1}{A} p\omega \left(z_0 + u + \frac{y}{\delta\omega}\right)$ (See part II).

Neglecting the kinetic energy of rotation of the projectile we have:

$$.41\,\frac{WV^2}{2g}\left(\frac{\bar{\omega}}{2W}\,\frac{1}{A}+A_1^2\,\frac{W}{W_1}\right)=fy-\frac{\bar{\omega}}{2W}\,\frac{1}{A}\,p\omega\left(z_0+u+\frac{y}{\omega\delta}\right)$$

Neglecting $A_1^2\,\frac{W}{W_1}$, dividing through by $\frac{\bar{\omega}}{2W}\,\frac{1}{A}$, and placing

$f'=\dfrac{f}{\frac{\bar{\omega}}{2W}\,\frac{1}{A}}$, we have:

$$.41\,\frac{WV^2}{2g}=f'y-\omega p\left(z_0+u+\frac{y}{\omega\delta}\right)$$

or

$$p=\frac{f'y-.41\,\frac{WV_2}{2g}}{\omega\left(z_0+u+\frac{y}{\omega\delta}\right)} \quad - \quad - \qquad (1)$$

f is a constant for a given powder if the products of combustion are constant. f' is a constant for the same powder and conditions of loading.

Under the suppositions made

$$p=\frac{W}{2g}\,\frac{d(v^2)}{du}$$

substituting in (1) and integrating between the limits $z_0+\frac{y}{\omega\delta}$ and $z_0+u+\frac{y}{\omega\delta}$ for u we have, since $\frac{2}{.41}=4.9$

$$V^2=4.9gf'\,\frac{y}{W}\left\{1-\left[\frac{z_0+\frac{y}{\omega\delta}}{z^0+u+\frac{y}{\omega\delta}}\right]^{.41}\right\} \quad - \qquad (2)$$

It now remains to determine the amount of powder consumed at any time. If we take Sarrau's expression for black powders as a tentative expression for the law of burning of smokeless powders, we have,

$$\frac{dl}{dt}=\frac{l_0}{\tau}\left(\frac{p'}{p_0}\right)^{\frac{1}{2}}$$

in which $l_0=\frac{1}{2}$ of the mean least dimension of the grains of which the charge is composed, and l the length burned in the time t under a variable pressure p', $\tau =$ the time of total combustion in air under the atmospheric pressure p_0*.

Taking as a mean value of p', $A_1 p$, we have

$$dl^2 = \left(\frac{l_0}{\tau}\right)^2 \frac{A_1}{p_0} d^2u$$

integrating twice

$$l^2 = \left(\frac{l_0}{\tau}\right)^2 \frac{2A_1}{p_0} u$$

or

$$\frac{l}{l_0} = K_1 u^{\frac{1}{2}}$$

It can be shown that the amount of powder burned when a length l is consumed is

$$y = \tilde{\omega} a \frac{l}{l_0}\left(1 - \lambda \frac{l}{l_0} + \mu \frac{l^2}{l_0^2}\right)$$

in which, if we represent by α β and γ the three dimensions of the grain, α being the least,

$$a = 1 + \frac{\alpha}{\beta} + \frac{\alpha}{\gamma},\ \lambda = \frac{\frac{\alpha}{\beta} + \frac{\alpha}{\gamma} + \frac{\alpha^2}{\beta\gamma}}{1 + \frac{\alpha}{\beta} + \frac{\alpha}{\gamma}},\ \mu = \frac{\frac{\alpha^2}{\beta\gamma}}{1 + \frac{\alpha}{\beta} + \frac{\alpha}{\gamma}}\ \dagger$$

Substituting for $\frac{l}{l_0}$ its value $K_1 u^{\frac{1}{2}}$, we have

$$y = \tilde{\omega} a K_1 u^{\frac{1}{2}}\left(1 - \lambda K_1 u^{\frac{1}{2}} + \mu K_1^2 u\right) \quad \cdot \quad (3)$$

We then have for the equations expressing the value of the pressure on the base of the projectile, velocity and weight of powder consumed, Equations (1), (2) and (3).

When the units of the English system are used, that is, when u, z_0, V and g are expressed in feet, W, y and $\tilde{\omega}$ in pounds, ω in square feet, p in lbs. per square foot, f' in ft. lbs., the formulas become:

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* Ingalls' Interior Ballistics, p. 66.

† Ingalls' Interior Ballistics, p. 64.

$$p=\frac{f'y-\frac{WV^2}{2g}.41}{\omega\left(z_0+u+\frac{y}{\omega\delta 62.4}\right)} \qquad (4)$$

$$V^2=4.9gf'\frac{y}{W}\left\{1-\left(\frac{z_0+\frac{y}{\omega\delta 62.4}}{z_0+u+\frac{y}{\omega\delta 62.4}}\right)^{.41}\right\} \qquad (5)$$

$$y=\tilde{\omega}aK_1u^{\frac{1}{2}}\left(1-\lambda K_1u^{\frac{1}{2}}+\mu K_1^2u\right) \qquad (6)$$

f' and K_1 being obtained by trial will have the values appropriate to the system of measures in which the data are given.

In order to apply these formulas it will be necessary to know the rate of burning of the powder used. Since the velocity is a function of the amount of powder burned, and not of its rate of burning; if the powder be entirely consumed, the velocity will not differ whatever be the point of completed combustion. By taking one charge sufficiently small to insure complete combustion and measuring the velocity, all other quantities being known, we may find f', and from the conditions of loading, f. Since f is constant for the same powder we may now find f' for any charge. If we take the charge sufficiently large so that all of the powder will not be consumed in the gun then the value of y can be found by solving (2) by trial; having found y and knowing the dimensions of the grain we may find K_1 and hence the amount of powder consumed at any point in the projectile's travel *under the assumed law*. With this value of y we may from (2) find the corresponding value of V and having these two we may find the pressure on the base of the projectile from (1). It will be observed that these formulas will require modification if, as in the case of small arms, the powder does a large amount of work in compressing the projectile, and that they will apply only when the products of combustion are measurably constant.

Let us consider the application of these formulas to the data given by Mr. Benét. He, in effect, determined the velocity at eight points along the bore with two different charges and kinds of powder. If the powder was not wholly consumed at any point of the bore, the quantity $4.9 g f' \frac{y}{W}$ would vary from that point to the point of complete combustion; but if at any point the powder is wholly consumed, then from that point on this quantity should be a constant, and V in (2) should vary only with u.

Assuming the powder all burned at the muzzle and computing the velocities at the other points along the bore under the same supposition, we have the following table:

Weight of Projectile 2.72 kg. Weight of Charge .46 kg. BN$_1$ Powder. Velocity in Metres.			Travel of shell, decimetres.	Weight of Projectile 2.72 kg. Weight of Charge .4 kg. BN$_{144}$ Powder. Velocities in Metres.		
Observed.	Computed under the supposition that the powder is all burned.	Diff.		Observed.	Computed under the supposition that the powder is all burned.	Diff.
682.1	682.1	0.0	28.45	632.8	632.8	0.0
648.3	651.7	+ 3.4	20.20	600.7	604.6	+ 3.9
636.5	640.1	+ 3.6	17.92	591.0	593.8	+ 2.8
622.3	626.1	+ 3.8	15.64	573.5	580.8	+ 7.3
612.6	614.2	+ 1.6	13.93	565.0	569.8	+ 4.8
595.0	599.9	+ 4.9	12.22	553.1	556.6	+ 3.5
574.4	582.9	+ 8.5	10.51	534.9	540.8	+ 5.9
543.1	561.9	+ 18.8	8.80	503.7	521.3	+ 17.6

These results show conclusively that the powder was all consumed at a point in the bore corresponding to a travel of about 10.5 decimetres, and that the subsequent increase in velocity was due to the adiabatic expansion of the powder gases.

If we assume the combustion completed at the point $u = 10.5$ we have under the assumed law for rate of burning, for BN$_{144}$ $\varpi = .4$, $a = 1.41$, $\lambda = .29$ and $\mu =$ a negligible quantity, $K = .308$, which give for $u = 8.80$, $y = .378$ and $V = 508.2$, a difference of 4.5 from the observed. In the same way for BN$_1$ we have $\varpi = .46$, $a = 1.36$, $\lambda = .267$, $\mu =$ a negligible quantity and $K_1 = .310$. For $u = 8.80$ we find $y = .424$ and $V = 542.3$, which is a difference of $-.8$ from the observed. While these results are not sufficient to enable us to draw any absolute conclusions with respect to the law of combustion, they tend to confirm the correctness of the assumed law.

There is one deduction which can be clearly made, that is, that the limit of progressiveness with the smokeless powders had not been reached in this case. The main question, the rate of burning of smokeless powders, remains still to be solved. Mr. Benét is entitled to credit for what he has done and for the honesty and care with which he has recorded it.

The formulas here deduced have been applied to several examples and seem to give very good results. In the case of brown powder, also, it has been observed that the velocity is more nearly a function of the one-half power of the weight of the charge, than of the five-eighths power. This is to be expected, since it is known that the brown powders give little residue.

PART II.

Let us suppose that we have given the pressure on the base of the projectile at any point of its travel along the bore of the gun, and *let it be required to find the pressure at any point of the bore in rear and at any point of the powder chamber.* Let

p_u = pressure on the base of the projectile,

p = pressure at any point in rear of the base of the projectile.

u_0 = the length of the powder chamber, assuming that it has the same diameter as the rest of the bore.

c = a constant for any given position of the projectile.

s = a variable coordinate equal at the base of the projectile to u_0+u but which is supposed to have values from o to $u+u_0$ for any given position of the projectile.

Other symbols as before.

Then the increment of pressure between any two sections is equal to the mass between the sections multiplied by its acceleration and divided by the area of the section. The mass between any two sections is equal to the volume multiplied by the density; if we suppose the temperature to be uniform behind the projectile the density $= cp$. The acceleration varies with the acceleration of the projectile multiplied by the ratio of their distances from the bottom of the bore, or

$$dp = \left(\frac{\omega ds}{g}\right) cp \left(\frac{dv}{dt}\,\frac{s}{u+u_0}\right)\frac{1}{\omega}$$

$$dp = \frac{cp}{g}\,\frac{dv}{dt}\,\frac{sds}{u+u_0}$$

In this equation s and p are the only variables, u and $\frac{dv}{dt}$ becoming for the instant constants, hence placing

$$A = c\frac{dv}{dt}\,\frac{u+u_0}{2g}$$

we have

$$\frac{dp}{p} = A\,\frac{2sds}{(u+u_0)^2}$$

integrating between the limits s and $u+u_0$ for s corresponding to p and p_u we have

$$\log_e\left(\frac{p}{p_u}\right) = A\left(1-\frac{s^2}{(u+u_0)^2}\right)$$

or

$$p = p_u\, e^{A\left(1-\left(\frac{s}{u+u_0}\right)^2\right)}$$

It is evident that the weight of powder consumed and unconsumed must equal the weight of the charge, hence

$$\int_0^{u+u_0} \omega c p ds = \tilde{\omega}$$

or substituting for p

$$\tilde{\omega} = \int_0^{u+u_0} \omega c p_u\, e^{A\left(1-\left(\frac{s}{u+u_0}\right)^2\right)} ds$$

$$\text{but } \omega c p_u = \frac{2W}{2g}\,\frac{dv}{dt}\,c\,\frac{u+u_0}{u+u_0} = \frac{2WA}{u+u_0}$$

$$\text{and placing } A\left(\frac{s}{u+u_0}\right)^2 = x^2,\ dx = \frac{A^{\frac{1}{2}}}{u+u_0}\,ds$$

$$\tilde{\omega} = 2WA^{\frac{1}{2}}\,e^{A}\int_0^{A^{\frac{1}{2}}} e^{-x^2}dx$$

$$\text{or } \frac{\tilde{\omega}}{2W} = A^{\frac{1}{2}}\,e^{A}\int_0^{A^{\frac{1}{2}}} e^{-x^2}dx$$

The definite integral $\int_0^{A^{\frac{1}{2}}} e^{-x^2}dx$ is a well known elliptic integral whose values have been tabulated. Hence we might form a table giving for all values of $\frac{\tilde{\omega}}{2W}$ the corresponding value of A. We may obtain a sufficiently close approximation in the following manner: for all values of x between 0 and .5 the curve whose equation is $y = e^{-x^2}$ is practically coincident with the parabola whose equation is $y = 1 - .924x^2$, hence substituting for e^{-x^2} this expression $1 - .924x^2$ we have

$$\frac{\tilde{\omega}}{2W} = A^{\frac{1}{2}} e^{A} \int_0^{A^{\frac{1}{2}}} (1 - .924x^2)dx \quad \text{integrating}$$

$$\frac{\omega}{2W} = A^{\frac{1}{2}} e^{A} \left(A^{\frac{1}{2}} - .308A^{\frac{3}{2}}\right)$$

$$\text{but } e^{A} = 1 + A + \frac{A^2}{2} + \frac{A^3}{6} + \&\text{c} \quad \text{hence}$$

$$\frac{\tilde{\omega}}{2W} = A(1 + .692A + .192A^2 + .012A^3) \text{ or}$$

$$\frac{\tilde{\omega}}{2W} = A(1 + .232A)^3$$

As the value of A is always less than .25, its value can be easily determined by one or two approximations; first assuming a value for A within the brackets and finding the corresponding value for A outside of the brackets, then substituting this last value for A in the brackets and solving again.

We have then for the pressure at any point,

$$\log_e p = \log_e p_u + A\left(1 - \left(\frac{s}{u + u_0}\right)^2\right)$$

for the breech, place $A = \log_e A_1$ then $p_1 = A_1 p_u$

These formulas explain why the smokeless powders give greater velocities, with no greater pressure, than the black or brown powders. For example, take the case of the Canet 32-centimetre gun constructed for the Japanese government, and compare these shots:

Wt. of charge.	Wt. of projectile.	Initial Velocity.	Maximum Pressure.
255 kg. of PB_1	451 kg.	718 metres.	2866 kg. per cm^2
144 kg. of BN_1	450.5 kg.	727 metres.	2553 kg. per cm^2

In the first case $A = .24$, in the second $A = .1452$, which give values for A_1 of 1.27 and 1.15 respectively; which would indicate that the pressure in the first case should be about ten per cent. greater than in the second, which was fully verified by the indications of the pressure gauge.

In this respect the nitro-glycerine powders are superior to the gun-cotton powders. They give less pressure at the breech and less recoil for equal pressures on the base of the projectile.

To find the kinetic energy of the powder and gun.

The weight of any elementary section of powder gas and unconsumed powder is $cp\omega ds$; its velocity is $\frac{s}{u+u_0}$, hence we have, representing the kinetic energy of the powder by E

$$E=\int_0^{u+u_0} \frac{cp\omega}{g} ds \left(\frac{s}{u+u_0}\right)^2 \frac{V^2}{2}$$

$$E=\int_0^{u+u_0} MV^2 \frac{A}{u+u_0} e^{A\left(1+\left(\frac{s}{u+u_0}\right)^2\right)} \left(\frac{s}{u+u_0}\right)^2 ds$$

placing $x=A^{\frac{1}{2}}\frac{s}{u+u_0}$

$$E=MV^2 \frac{A^{\frac{1}{2}}}{u+u_0} e^A \int_0^{A^{\frac{1}{2}}} e^{-x^2} x^2 dx$$

Integrating by parts, remembering that

$$A^{\frac{1}{2}} e^A \int_0^{A^{\frac{1}{2}}} e^{-x^2} dx = \frac{\tilde{\omega}}{2W}$$

we have

$$E=\tfrac{1}{2}MV^2 \left(\frac{\tilde{\omega}}{2W}\ \frac{1}{A}-1\right)$$

For the breech we have

$$p_1=A_1 p$$

whence we have

$$M_1 V_1=A_1 MV$$

and

$$\tfrac{1}{2}M_1 V_1^2=\tfrac{1}{2}MV^2 A_1^2\ \frac{W}{W_1}$$

To find the sum of the products arising from multiplying each volume by the pressure of the gas which it contains.

The powder gas is all contained in the volume $\omega\left(z_0+u+\frac{y}{\omega\delta}\right)$ and its pressure varies in this volume according to the law

$$p=p_u\, e^{A\left[1-\left[\frac{s}{z_0+u+\frac{y}{\omega\delta}}\right]^2\right]}$$

hence

$$\Sigma pv=\int_0^{z_0+u+\frac{y}{\omega\delta}} \omega p_u\, e^{A\left(1-\left(\frac{s}{z_0+u+\frac{y}{\omega\delta}}\right)^2\right)} ds$$

placing $x=A^{\frac{1}{2}}\frac{s}{z_0+u+\frac{y}{\omega\delta}}$

we have

$$\Sigma pv=\int_0^{A^{\frac{1}{2}}} \omega p_u\left(e^A\right)\frac{\left(z^0+u+\frac{y}{\omega\delta}\right)}{A^{\frac{1}{2}}}\, e^{-x^2} dx$$

but

$$\int_0^{A^{\frac{1}{2}}} e^{-x^2} dx=\frac{\tilde{\omega}}{2W}\ \frac{1}{A^{\frac{1}{2}} e^A}$$

hence

$$\Sigma pv=\omega p_u\left(z_0+u+\frac{y}{\omega\delta}\right)\frac{\tilde{\omega}}{2W}\ \frac{1}{A}$$

NOTE.—The writer wishes to acknowledge his indebtedness to Lieutenant C. DeW Willcox, 2nd Artillery, for assistance in the way of computations and valuable suggestions.

A NEW POWDER.

THE PRESENT PHASE OF SMOKELESS COMPOUNDS.

By First Lieutenant WILLOUGHBY WALKE, Fifth Artillery, U. S. A.

During the earlier stages of the development of modern smokeless powders, the most important feature was clearly shown to be the stability of the compounds, and the principal tests to which they were subjected sought to establish or disprove their power to resist the extreme changes, climatic and atmospheric, to which they would naturally be exposed under the ordinary conditions of service. Under these tests the majority of the new powders failed. The causes that led to their rapid deterioration and decomposition are now too well known to be dwelt upon, and the question of stability may be considered as settled.

In its stead, however, a far more serious, and as yet more difficult problem has appeared, that is the control of the enormous pressures developed by the new powders when burned, exploded or detonated in the bore of a gun.

These pressures result from the thermo-chemical conditions inherent in the powders, especially those which obtain at the instant of decomposition, and secondly from the rate of this decomposition or transformation, which determines the character of the phenomenon, whether it be a simple combustion or a detonation.

The heat of formation of the explosive itself, the temperature of explosion, the chemical composition of the products of explosion, and the specific heats of these products are factors which may be partly calculated according to well established physical and chemical principles, and partly measured at the instant of explosion.

These conditions are determined absolutely by the chemical composition of the explosives. Therefore for a given temperature of combustion, the pressures developed will vary directly with the rate with which the gases are produced within the containing volume, and the amount of gas already evolved. The problem as presented then resolves itself into the control of this rate of combustion or detonation.

Up to the present time the attainment of this object has been sought by introducing into the powders various salts which offer physical rather than chemical obstruction to the spread of inflammation, or introduce a physical interference to the propagation of the explosive wave.

With the introduction of foreign substances, however, which as a rule, do not enter into chemical union with the explosive constituents of the compound, not only is the mode of action changed, but the entire character of the powder is transformed.

Of the original powders it may be said that they were true chemical compounds, whereas, in their modified form, they have become to a greater or less extent mechanical mixtures, and, as such, subject to the usual difficulties in the way of securing homogeneity in the final result.

In microscopic examinations of several of the new powders, the almost total lack of uniformity discovered between separate grains of the same powder, would alone explain the anomalous results frequently obtained of late from the same powder under practically the same conditions, upon the assumption that in the manufacture of the individual cartridges, the actual composition of the explosive has varied between very considerable limits. The great difficulty in securing uniformity of incorporation in these powders is due to the inherent danger attending this stage of their manipulation, and to it largely is to be attributed the irreconcilability of the ballistic results obtained.

Thus from the records of the official tests of the more prominent powders we note the following results; the conditions, ballistic and atmospheric, being as nearly as possible identical for the same powder, which however is to be considered independently of the others:

Poudre BN: Initial velocity, 1765 to 1944 feet per second: pressure, 39,400 to 62,400 pounds per square inch.

Cordite: Initial velocity, 1876 to 2040 feet per second; pressure, 49,500 to 59,000 pounds per square inch.

Maxim: Initial velocity, 1910 to 2076 feet per second; pressure, 44,000 to 63,200 pounds per square inch.

Wetteren: Initial velocity, 1916 to 1992 feet per second; pressure, 46,700 to 62,700 pounds per square inch.

Ballistite: Initial velocity, 2004 to 2296 feet per second; pressure, 57,000 to 73,500 pounds per square inch.

These results were obtained with small arms having an average calibre of 0".30, and beyond a reduction in granulation, the powder was similar to that used in guns of heavier calibre (field and rapid-fire) for which it was originally designed, and in which far more satisfactory results were obtained.

Thus in the mad haste with which experimenters have plunged into this new line of investigation, the well established principle that the powder must be fitted to the gun, which had been so thoroughly developed with the old compositions, was entirely lost sight of, and in so far has the growth of the new powders been seriously impeded. That the increase in pressure referred to is not only out of all proportion with the corresponding increase in velocity, but also beyond the limits allowable in guns of small calibre is manifest.

In support of this assertion, it is not necessary to enter into an elaborate calculation involving the consideration of the elastic strength of the rifle barrel and the expansive force of the confined gases. That the small-arm rifle barrel can withstand these strains has been demonstrated theoretically and proven practically. There are however other parts to the modern rifle, and with the universal demand for magazine arms, the intricacy and delicacy of the parts which go to make up the whole are greatly multiplied, in spite of all efforts to simplify the mechanism as much as possible.

The question at present is no longer confined to the strength of the barrel; but can this complicated machine, the modern magazine rifle, with its carefully constructed cams, its accurately calibrated springs, its bolts and pins, resist the terrible strain to which it is subjected at each discharge?

We find an answer to this query in the numerous reports of injuries to small-arms during the field manœuvres in recent years. During the manœuvres of 1891, we find that, of the magazine rifles in which the new powders were used, from 35 to 50 per cent. were rendered unfit for service, and, in the majority of cases, before ten rounds had been fired. These accidents were at first attributed to imperfect workmanship; but the real cause of the trouble became known only after searching investigations, and was summed up in an official report which stated "*that the gun was not designed for the increased pressures produced by the smokeless powders of the day.*" It is to be noted that in no instance above referred to did the rifle barrel burst or even become swelled; it was the breech and magazine mechanism that became jammed or was broken, and rendered the arm for the time being a worthless encumbrance. We are thus confronted with what is believed to be the latest phase in the development of the new powder which has been already alluded to, but which, by reason of its vital importance may be emphasized in the question "Can the enormous pressures developed by the modern smokeless powders be brought within the limits of the magazine small-arm, and controlled?"

A careful consideration of the facts above stated, accompanied by thorough analyses of the powders themselves, indicate that the difficulties heretofore encountered in efforts to solve this problem can be entirely overcome, and during the past eight months a systematic investigation has been carried on in the Chemical and Explosive Laboratory of the U. S. Artillery School, with results pointing to ultimate success. It would be inexpedient at the present stage of the investigation to more than indicate the methods pursued, and state the results obtained.

Stability under climatic extremes and during long storage was recognized as the absolute *sine qua non* of a service explosive, and imposed the first condition to be fulfilled by the new powder. So far as laboratory tests can be assimilated to the actual atmospheric and climatic conditions of service, this object appears to have been attained, although the storage test can be decided absolutely only after lapse of time.

An important factor considered in the determination of the theoretical composition of the powder, was the work required in order to obtain the following ballistic results, viz: bullet; calibre, 0″.30, weight, 230 grains; powder; weight of charge, 36 to 40 grains; muzzle velocity, 2000 feet per second; pressure, not to exceed 45,000 pounds per square inch. An analysis of the first twenty shots fired indicated the necessary modification of the theoretical powder, and a new lot was made accordingly and tested. As a result of the second firing, the actual composition of the powder was determined, and also the method of manipulation with a view of controlling the pressures developed, so that with but a single change in the relative proportions of the ingredients, for the same muzzle velocity, the pressure was reduced 43,400 pounds per square inch.

To subject this method of controlling the pressures to as rigid a test as possible, from the same incorporation, several lots of powder were subjected to varying degrees of the same general method of manipulation, and subsequently made up into cartridges. In every instance did the pressure respond to the treatment, ranging for the same charge of 42 grains from 25,500 to 47,800 pounds per square inch.

As was expected the velocities varied correspondingly, but one appeared invariably a direct function of the other, so that the operator at the rifle upon reading the pressures, knew immediately the velocity within ten feet per second, and conversely the operator at the chronograph knew the pressure within 100 pounds per square inch, as soon as he took from the tables the velocity corresponding to the reading of his instrument.

Not the least encouraging feature of these experiments has been the remarkable uniformity in the action of the powder, that has obtained throughout the trials. After the final proportions of the ingredients were determined and the methods of manipulation adopted, scarcely a shot was fired the result of which could not have been foretold. In the few instances of what might possibly have been classed as abnormal results, the causes leading thereto were readily discovered, and were directly attributable to the difficulty attending the manufacture of the powder by hand.

In all the trials for velocity two chronographs arranged in independent circuits were used, and the pressures were checked by alternating the copper pressure discs. One set of the latter together with the corresponding pressure curve was obtained from the Ordnance Bureau of the U. S. Navy, and the other made from a different lot of copper was furnished with the maximum, minimum and mean compressions by the Ordnance Department of the Army.

It is proposed to continue this investigation, the results of which as indicated encourage me to look for greater success than that already attained. In the meantime the following results observed and calculated for some of the better known foreign powders, are tabulated for comparison with the results actually obtained with the experimental powder, which for the present is designated * 3 P.P.G.

Table I contains data actually obtained from experimental firing.

Table II is calculated from data contained in Table I, upon the hypothesis that the chamber of the rifle remains constant and that the density of loading varies with the charge, being unity for the given service charge (Table I).

Table III is calculated from the same data, upon the hypothesis that the volume of the chamber varies with the charge, so that the density of loading is constantly equal to unity.

In the case of the powder under investigation (* 3 P.P.G.), the results were actually obtained on the firing ground, and are repeated in Tables II and III so as to be more readily compared.

TABLE I.*

Powder.	Rifle.	Weight of charge.	Weight of bullet.	I. V. f. s.	P_0 lbs. per sq. in.
Smokeless, No. 6, P.	Mauser—0''.3012.	37 grains.	216 grains.	2139	44128
Smokeless, BN.	Lebel—0''.3149.	43.2 "	231.5 "	2073	. . .
Smokeless, G. C.	Mannlicher—0''.3110.	42.43 "	223.7 "	2034	47040
Ballistite.	Mannlicher—0''.2569.	30.5 "	162 "	2296	73472
Cordite.	Lee 0''.3030.	30.5 "	215 "	2000	33600
Smokeless.	Krag-Jorgensen—0''.3149.	33.9 "	238 "	1968	33810
* 3 P. P. G.	Expr.—0''.300.	38 "	230 "	2026.25	31775
" " " "	" "	40 "	" "	2216.25	33517
" " " "	" "	42 "	" "	2367.50	35325

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* For assistance in the computation of these tables, I desire to acknowledge my indebtedness to Captain James M. Ingalls, 1st Artillery, Instructor Department of Ballistics, U. S. Artillery School.

TABLE II.

Powder·	Rifle.	Weight of charge.	Weight of bullet.	I. V. f. s.	P_0 lbs. per sq. in.
Smokeless, No. 6 P.	Mauser—0''.3012.	38 grains.	230 grains.	2108	46968
		40 "		2176	51379
		42 "		2244	55959
Smokeless, B. N.	Lebel—0''.3149.	38 "	" "	1918	. .
		40 "		1981	. .
		42 "		2042	. .
Smokeless, G. C.	Mannlicher—0''.3110.	38 "	" "	1872	39055
		40 "		1933	42723
		42 "		1993	46531
Ballistite.	Mannlicher—0''.2569.	38 "	" "	2211	117830
		40 "		2283	128900
		42 "		2354	140390
Cordite.	Lee—0''.3030.	38 "	" "	2219	50207
		40 "		2291	54921
		42 "		2362	59817
Smokeless.	Krag-Jorgensen—0''3149.	38 "	" "	2150	40932
		40 "		2220	44776
		42 "		2289	48767
* 3 P.P.G.	Experimental—0''.3000.	38 "	" "	2026.25	31775
		40 "		2216.25	33517
		42 "		2367.50	35325

TABLE III.

Powder.	Rifle.	Weight of charge.	Weight of bullet.	I. V. f. s.	P_0 lbs. per sq. in.
Smokeless, No. 6 P.	Mauser—0''.3012.	38 grains.	230 grains.	2094	45732
		40 "		2134	47525
		42 "		2174	49297
Smokeless, B.N.	Lebel—0''.4149.	38 "	" "	1982	. .
		40 "		2021	. .
		42 "		2058	. .
Smokeless, G.C.	Mannlicher—0''.3110.	38 "	" "	1912	43024
		40 "		1949	44711
		42 "		1985	46377
Ballistite.	Mannlicher—0''.2569.	38 "	" "	2093	94577
		40 "		2134	98287
		42 "		2173	101950
Cordite.	Lee—0''.3030.	38 "	" "	2100	40297
		40 "		2141	41878
		42 "		2180	43438
Smokeless.	Krag-Jorgensen—0''.3149.	38 "	" "	2090	36515
		40 "		2130	37948
		42 "		2170	39362
*3 P.P.G.	Experimental—0''.3000.	38 "	" "	2026.25	31775
		40 "		2216.25	33517
		42 "		2367.50	35325

THE ARTILLERY-FIRE GAME.

BY H. ROHNE, COLONEL, COMMANDING THE SCHLESWIG FIELD ARTILLERY REGIMENT NO. 9.

TRANSLATED BY FIRST LIEUTENANT JOHN P. WISSER, FIRST ARTILLERY, U. S. A., 1892.

[CONTINUED.]

III. EXAMPLES IN APPLICATION.

The rules and principles of the fire game having been discussed and established, a few examples illustrating its application under different circumstances are added.

I. FIRING AGAINST ARTILLERY AT LONG RANGE.

Assumptions made by the director:

Target:—A firing battery of 6 pieces at 3180 m.
Dispersion:—Great.
Observation:—Lottery numbers 1 to 43, correct (43 per cent.);
Lottery numbers 44 to 93, doubtful (50 per cent.);
Lottery numbers 94 to 100, false (7 per cent.).
Shrapnel fuses burn 10 m. too long.

Mean point of bursting with 3100 m. elevation and fuse, $\frac{-120}{9}$;

Mean point of bursting with 3200 m. elevation and fuse, $\frac{-20}{10}$;

Mean point of bursting with 3300 m. elevation and fuse, $\frac{+18}{10}$.

Record of lottery numbers drawn and their signification.

Number. 1.	Lottery number. 2.	Deviation. m. 3.	Tar. dist'nce minus deviation. m. 4.	Lottery number. 5.	Observation. 6.	Number. 1.	No. on the firing record 2.	Lottery number. 3.	Deviation. m. 4.	Lottery number. 5.	Observation. 6.
1	4	—100	3280	56	?	25	18	50	$\frac{\pm 0}{0}$	57	?
2	11	— 65	3245	34	c	26	19	6	$\frac{-45}{+10}$	5	c
3	71	+ 30	3150	72	?	27	20	36	$\frac{-10}{+3}$	89	?
4	23	— 40	3220	26	c	28	21	48	$\frac{\pm 0}{+1}$	35	c
5	20	— 45	3225	30	c	29	22	69	$\frac{+15}{-2}$	21	c
6	88	+ 60	3120	78	c	30	23	10	$\frac{-40}{+3}$	76	?
7	56	+ 5	3175	64	?	31	24	95	$\frac{+45}{-10}$	79	?
8	45	— 5	3185	72	?	32	25	51	$\frac{\pm 0}{0}$	27	c
9	85	+ 55	3125	61	?	33	26	6	$\frac{-45}{+10}$	41	c
10	59	+ 10	3170	81	?	34	27	98	$\frac{+60}{-15}$	30	c
11	84	+ 50	3130	97	f	35	28	41	$\frac{-5}{+3}$	6	c
12	6	— 85	3265	10	c	36	29	80	$\frac{+25}{-3}$	40	c
13	76	+ 35	3145	78	?	37	30	21	$\frac{-25}{+3}$	17	c
14	77	+ 35	3145	61	?	38	31	55	$\frac{+5}{+3}$	1	c
15	37	— 20	3200	18	c	39	32	42	$\frac{-5}{+2}$	38	c
16	10	— 70	3250	26	c	40	33	57	$\frac{+5}{\pm 0}$	84	?
17	79	+ 40	3140	17	c	41	34	27	$\frac{-20}{+1}$	49	?
18	1	—140	3320	93	?	42	35	89	$\frac{+35}{-7}$	74	?
19	40	— 15	3195	15	c	43	36	42	$\frac{-5}{+2}$	78	?
20	73	+ 30	3150	16	c	44	37	13	$\frac{-35}{+5}$	24	c
21	61	+ 15	3165	63	?	45	38	72	$\frac{+15}{-5}$	34	c
22	22	— 40	3220	19	c	46	39	96	$\frac{+50}{-10}$	3	c
23	3	—105	3285	67	?	47	40	40	$\frac{-5}{-4}$	97	f
24	11	— 65	3245	89	?	48	41	11	$\frac{-35}{+12}$	37	c

Firing record.

No. of gun. 1.	COMMAND. 2.	No. of shot. 3.	Fuse. Elevation. m. 4.	OBSERVATION. batt'y. 6.	OBSERVATION. target. 6.
I.	P. s. dir. f. batt'y in woods, 4th p., 2800, r. fl. F.!*	1	2800	?	—480
II.	. . . .	2	"	—	—445
III.	. . . .	3	3200	?	+ 50
IV.	. . . .	4	"	—	— 20
V.	. . . .	5	3600	+	+375
VI.	. . . .	6	3400	—	+280
I.	. . . .	7	3300	?	+125
II.	. . . .	8	"	?	+115
III.	. . . .	9	"	?	+175
IV.	. . . .	10	3200	?	+ 30
V.	. . . .	11	"	—	+ 70
VI.	. . . .	12	3400	+	+135
I.	C. f. sh. t. f., by steps, (50 or 100 at a t.) F. at w!†	13	3300	?	+155
II.	. . . .	14	"	?	+155
III.	. . . .	15	"	+	+100
IV.	. . . .	16	"	+	+ 50
V.	. . . .	17	"	+	+160
VI.	(Discharge loaded pieces!)	. .	. . .	. . .	. . .
I.	(Shr. t. f.!)	18	3300	? 10	+80 10
II.	. . . .	19	"	? 20	+35 20
III.	. . . .	20	"	? 13	+70 13
IV.	. . . .	21	"	? 11	+80 11
V.	. . . .	22	"	? 3	+65 8
VI.	New elevation and fuse, 3200!	23	"	? 13	+40 13
I.	(New fuse setting!)	24	3200	? 0	+25 0
II.	. . . .	25	"	? 10	—20 10
III.	. . . .	26	"	? 20	—65 20
IV.	. . . .	27	"	+ 0	+40 — 5
V.	. . . .	28	"	? 13	—25 13
VI.	New elevation and fuse, 3200!	29	"	? 7	+ 5 7

* "Percussion shell, directly on firing battery in the woods, 4th piece, at 2800 m., from the right flank, Fire!"

† Cease firing, shrapnel, time fuses, by steps (50 or 100 m. at a time), Fire at will!

No. of gun.	COMMAND.	No. of shot.	Fuse. elevation. m.	OBSERVATION.	
				batt'y.	target.
1.	2.	3.	4.	5.	6.
I.		30	3200	$\frac{?}{13}$	$\frac{-45}{13}$
II.		31	"	$\frac{?}{13}$	$\frac{-15}{13}$
III.		32	"	$\frac{?}{12}$	$\frac{-25}{12}$
IV.		33	"	$\frac{?}{10}$	$\frac{-15}{10}$
V.	New elevation and fuse, 3200 !	34	"	$\frac{?}{11}$	$\frac{-40}{11}$
VI.		35	"	$\frac{?}{3}$	$\frac{+15}{3}$
I.		36	"	$\frac{?}{12}$	$\frac{-25}{12}$
II.		37	"	$\frac{?}{15}$	$\frac{-55}{15}$
III.		38	"	$\frac{?}{5}$	$\frac{-5}{5}$
IV.		39	"	$\frac{+}{0}$	$\frac{+30}{0}$
V.		40	"	$\frac{?}{14}$	$\frac{-25}{14}$
VI.		41	"	$\frac{?}{22}$	$\frac{-55}{22}$

The assumption that the dispersion (double the deviation) is large in this case is correct, although it is as much as three times as great as that given in the ordinary firing table. As a matter of fact, probable longitudinal deviations of 35 m. in actual fire under war conditions, are not uncommon. The assumed observation conditions must be regarded as hardly more than favorable; nevertheless, much more difficult ones will often be met with at such long ranges. The character of the observations as entered in the firing record conforms very closely to such conditions and circumstances as occur in actual firing.

At 3300 m. as many as five shots were not observed; it may be supposed, for instance, that they fell on ground particularly unfavorable for observation; only after the fire was dispersed did the character of the observation improve, In actual firing doubtful observations will occur, especially at the first range, but often later on also, in consequence of lateral deviation, which will make the determination of the short fork very much more difficult than was the case here.

The three shots not observed (numbers 7, 8 and 9) decided the director to give up trying to narrow down the short fork any further. He wished to take the space from 3200 to 3400 m. under shrapnel fire, but before doing so desired to determine whether the fork had been correctly established. This method is to be recommended. A fork of 200 m. that is established with *certainty* is preferable to one of 50 m. that is uncertain. In spite of this endeavor the fork limit of 3200 m. was not correctly determined, at least not with perfect certainty. *Both* shots fired at 3200 m. were observed *in front of* the target, although the actual distance was 3180 m. Shot four had a deviation of 40 m. short, shot eleven was falsely observed. It was a very extraordinary and unfortunate circumstance that this particular shot, the *only* one of seventeen, should have been observed falsely. Still, the error was not very great; for, had the fuses burned correctly, the probable mean distance of the points of explosion in front of the target would have been 30 m.

It may be asked whether in this case a volley would not have been in place. This question cannot be answered definitely in the negative; still, by this means the object would not have been accomplished any faster than it was by the method adopted. When black powder was still used in firing, the principal object of the volley was to facilitate the observation of the explosion cloud in the powder smoke surrounding the target (the enemy's firing battery). This object can no longer be attained in this way, therefore, in my opinion, the use of volleys will in future become less and less frequent.

After the limits of the fork of 200 m. as determined had been tested, the battery commander ordered the passage to shrapnel fire at the intermediate range—3300 m. Had he been so fortunate as to observe well the points of explosion of the shell set for this range, the limits of the space to be taken under fire could, at all events, have been reduced. In the present case three of the five shells were observed to burst beyond the target and more in front. The battery commander properly concluded that the points of explosion of all the shrapnel he might fire at

3400 m. would lie beyond the target, and could therefore limit himself to the ranges 3200 and 3300 m. Had the shells been all observed to burst *in front of* the target, the limit would of course have been advanced from 3200 to 3300 m.; had they been observed to burst partly in front of and partly beyond the target, 3300 m. would have been regarded as approximately the correct target distance, and the range would have been varied between 3250 and 3350 m.

On account of the great heights of explosion which normal fuses might give at long ranges, only a few explosion clouds are generally located at heights admitting of observation; at the first shrapnel range there were none at all.

At the next range two ground hits occurred, of which the first was observed doubtfully, the second as beyond the target. That the battery commander did not allow himself to be misled thereby and induced to insert a plate, was correct, for the other points of bursting at this range were none of them too low, and moreover, those of the preceding were either normal or else rather high. Furthermore, it was also quite correct, after observing shot 27 *beyond* the target, not to increase to 3300 m. On the other hand, neither did the fact of this observation justify the continuation of the shrapnel fire at 3100 m. Shot 27 was a *ground hit*, not a point of bursting in the air; but with the trajectory correctly placed ground hits must occur behind the target as well. Nevertheless, taken in connection with the shells fired at 3300 m., it had been made evident that even should 3200 m. be too short a range, the error could not in any case be very great. In the subsequent firing only one more point of explosion (number 35) was of such a height as to admit of observation, and only one more ground hit (number 39) occurred, but of these two only the latter was actually observed.

Whether the battery commander could conclude from this that he ought to go back from 3200 to 3100 m., or fire between these ranges as limits it is difficult to say, judging from the data of the firing record alone. It depends largely on personal impressions and judgment, and, in actual firing, it would depend on whether any definite effect on the target had been noticeable or not.

The shrapnel fired at 3300 m. were all without effect; of the 18 shots fired at 3200 m., on the other hand, shots number 26, 30, 32, 34, 36, 37 and 41, in sum total therefore seven, were, judging by the relation between height of explosion and distance in front of target, more or less effective. With all the other shots the effect, if any, was beyond the target proper, and may have come into play on the line of limbers or on the caissons. Any firing at long ranges, in which effective action can be expected from a third of all the shots must be regarded as decidedly successful. The mean point of explosion was at $\frac{-17}{10}$, certainly too near the target, so that the fragments even of the lower part of the cone of explosion of a shot of mean distance in front of the target, and mean height of explosion would pass entirely over the target.

In conclusion, be it remarked that had the firing with shell at 3200 m. been continued in order to determine the distance more accuratety, the result would probably have been the same. Since the distance was 3180 m., the probabilities were, as may be readily calculated, that two-thirds of the shots would be over and one-third short, and therefore this had to be regarded as the true distance. Indeed, 3200 m. is nearer the true target distance, 3180 m., than 3150 would have been. The fact that the fuses burned somewhat too long a time, of course, lessened the effective action considerably. Had the fuses burned correctly on the average, shots 25, 28 and 40 would also have been effective, hence, half the entire number.

2. FIRING WITH TORPEDO-SHELL AGAINST TROOPS OCCUPYING A FIELD FORTIFICATION.

Assumptions made by the director:

Distance—2870 m.

Trajectory of the torpedo-shell—about 20 m. shorter than that of shell c/82.

Longitudinal dispersion—medium.

Observation conditions— 1 to 60 correct (60 per cent.);
61 to 92 doubtful (32 per cent.);
93 to 100 false (8 per cent.).

The fuses burn about 30 m. too short (unknown to the battery commander).

Preparatory notes.

Position of the mean point of explosion of the torpedo-shell for elevation and fuse setting:*

$$2900\text{ m.}: \frac{-70}{16},\quad 2900\text{ m.}: \frac{-70}{7},\quad 2900\text{ m.}: \frac{-70}{3};$$

$$2950\text{ m.}: \frac{-20}{16},\quad 2950\text{ m.}: \frac{-20}{7},\quad 2950\text{ m.}: \frac{-20}{2};$$

$$3000\text{ m.}: \frac{+30}{17},\quad 3000\text{ m.}: \frac{+30}{8},\quad 3000\text{ m.}: \frac{+30}{-2}.$$

Record of the lottery numbers drawn for determining the range with percussion shell c/82.

Number. 1.	Lottery number. 2.	Deviation. m. 3.	Target distance minus deviation. m. 4.	Lottery number. 5.	Observation. 6.	Number. 1.	Lottery number. 2.	Deviation m. 3.	Target distance minus deviation. m. 4.	Lottery number. 5.	Observation. 6.
1	86	+40	2830	3	c	10	26	—25	2895	76	?
2	4	—70	2940	17	c	11	60	+10	2860	41	c
3	5	—65	2935	53	c	12	28	—20	2890	12	c
4	92	+50	2820	16	c	13	57	+ 5	2865	73	?
5	48	± 0	2870	35	c	14	78	+30	2840	22	c
6	27	—25	2895	60	c	15	72	+20	2850	44	c
7	13	—45	2915	2	c	16	2	—85	2955	85	?
8	48	± 0	2870	21	c	17	93	+55	2815	35	c
9	79	+20	2850	70	?	18	60	+10	2860	86	?

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* With fuses that burn correctly, when in addition, there is no difference in position between the trajectories of the percussion-shell and the torpedo-shell, the point of explosion for elevation and fuse at 2900 m. would have been at $\frac{-20}{10}$; on account of the difference in position of the trajectories it is at $\frac{-40}{10}$; on account of the behavior of the fuses at $\frac{-70}{10}$.

Number. 1.	Number on the firing record. 2.	Lottery number. 3.	Deviation. m. 4.	Lottery number. 5.	Observation. 6.
1	18	31	$\frac{-15}{+3}$	96	f
2	19	81	$\frac{+25}{-6}$	27	c
3	20	3	$\frac{-60}{+15}$	19	c
4	21	50	$\frac{\pm 0}{0}$	16	c
5	22	78	$\frac{+20}{-9}$	61	?
6	23	27	$\frac{-20}{+1}$	17	c
7	24	23	$\frac{-20}{+9}$	3	c
8	25	58	$\frac{+5}{-1}$	7	c
9	26	75	$\frac{+20}{-3}$	14	c
10	27	90	$\frac{+35}{-12}$	9	c
11	28	82	$\frac{+25}{-8}$	35	c
12	29	71	$\frac{+15}{-4}$	62	?
13	30	13	$\frac{-35}{+5}$	15	c
14	31	23	$\frac{-20}{+9}$	83	c
15	32	28	$\frac{-15}{+7}$	35	c
16	33	25	$\frac{-20}{+4}$	1	c
17	34	61	$\frac{+5}{-4}$	90	?
18	35	48	$\frac{\pm 0}{-1}$	39	c
19	36	47	$\frac{\pm 0}{+2}$	18	c
20	37	13	$\frac{-35}{+5}$	6	c
21	38	84	$\frac{+30}{-6}$	23	c
22	39	97	$\frac{+55}{-11}$	55	c
23	40	5	$\frac{-50}{+10}$	75	?
24	41	59	$\frac{+5}{-2}$	5	c
25	42	99	$\frac{+65}{-13}$	15	c
26	43	37	$\frac{-10}{+1}$	9	c
27	44	48	$\frac{\pm 0}{+1}$	82	?
28	45	96	$\frac{+50}{-10}$	65	?
29	46	54	$\frac{\pm 0}{+3}$	98	f
30	47	88	$\frac{+35}{-4}$	97	f
31	48	18	$\frac{-30}{+3}$	30	c
32	49	3	$\frac{-60}{+15}$	95	f
33	50	65	$\frac{+10}{-3}$	44	c
34	51	10	$\frac{-40}{+3}$	10	c
35	52	45	$\frac{-5}{-1}$	3	c
36	53	29	$\frac{-15}{+5}$	37	c
37	54	66	$\frac{+10}{-4}$	39	c
38	55	41	$\frac{-5}{+3}$	27	c
39	56	59	$\frac{+5}{-2}$	44	c
40	57	15	$\frac{-30}{+9}$	25	c
41	58	75	$\frac{+20}{-3}$	40	c
42	59	82	$\frac{+25}{-8}$	83	?

No. of gun. 1.	COMMAND. 2.	No. of shot. 3.	Fuse. Elevation. m. 4.	OBSERVATION. batt'y. 5.	OBSERVATION. target. 6.
I.	P. s., field int. on the green h't. quad. 2200, r. fl. F.!*	1	2200	—	—630
II.	. . . .	2	2600	—	—340
III.	. . . .	3	3000	+	+ 65
IV.	. . . .	4	2800	—	— 20
V.	. . . .	5	2900	+	+ 30
VI.	. . . .	6	2950	—	— 45
I.	. . . .	7	"	—	— 65
II.	. . . .	8	"	—	— 20
III.	. . . .	9	2900	?	+ 50
IV.	. . . .	10	"	?	+ 5
V.	. . . .	11	"	+	+ 40
VI.	. . . .	12	"	+	+ 10
I.	C. f., tor. s., t. f. by steps (50 or 100 m.), 2900, F. w. !†	13	"	+	+ 35
II.	. . . .	14	"	+	+ 60
III.	. . . .	15	"	+	+ 50
IV.	. . . .	16	"	?	— 55
V.	. . . .	17	"	+	+ 85
I.	(torp. s., t. f.	18	2900	? 19	—86 19
II.	. . . .	19	"	? 10	—45 10
III.	1 pl. l. !‡	20	2900	? 22	—130 22
IV.	. . . .	21	"	? 7	—70 7
V.	. . . .	22	"	? 0	—50 — 2
VI.	New elevation and fuse setting 2900!	23	"	? 8	—90 8
I.	A second plate lower !§	24	2900	? 6	—90 6
II.	. . . .	25	"	— 0	—65 — 4
III.	. . . .	26	"	— c	—50 — 6
IV.	. . . .	27	"	— 0	—35 —15
V.	New elevation and fuse-setting 2950!	28	"	— 0	—45 —11
VI.	. . . .	29	"	? 0	—55 — 7

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* Percussion shell, field intrenchment on the green height, quadrant, 2200, from the right flank fire!

† Cease firing, torpedo-shell, by steps (50 or 100 m. at a time), 2900, fire at will!

‡ One plate lower!

§ The command "one plate lower (or higher)" is not in the drill regulations. In the later firing regulations, however, it appears in place of the older form "one plate inserted (or removed)." Whether in the future the command "a second plate higher (or lower)" will be adopted, conforming in principle to the above, the author cannot say.

No. of gun. 1.	COMMAND. 2.	No. of shot. 3.	Fuse. Elevation. m. 4.	OBSERVATION.	
				batt'y. 5.	target. 6.
I.	(New fuse setting.)	30	2950	− 3	−55 3
II.	. . . .	31	"	? 7	−40 7
III.	. . . .	32	"	? 5	−35 5
IV.	. . . .	33	"	− 2	−40 2
V.	. . . .	34	"	? 0	−15 − 6
VI.	. . . .	35	"	− 0	−20 − 3
I.	New elevation 3000! (New fuse setting.)	36	3000	+ 0	+30 ± 0
II.	. . . .	37	"	− 3	− 5 + 3
III.	. . . .	38	"	− 0	± 0 − 8
IV.	. . . .	39*	"	+ 0	+85 −13
V.	. . . .	40	"	? 8	−20 8
VI.	New elevation 3000! Set all fuses at that.	41*	"	+ 0	+35 − 4
I.	1 plate higher!	42*	3000	+ 0	+95 − 5
II.	. . . .	43	"	? 9	+20 9
III.	. . . .	44	"	? 9	+30 9
IV.	. . . .	45	"	? 0	+20 − 2
V.	A second plate higher!	46	3000	? 14	+30 14
VI.	. . . .	47	"	? 13	+65 13

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* The positions of the ground hits in these cases were determined by the formula on page 137, and the corresponding entry made for observation in the battery.

No. of gun.	COMMAND.	No. of shot.	Fuse.	OBSERVATION.	
			Elevation. m.	batt'y.	target.
1.	2.	3.	4.	5.	6.
I.	. . . .	48	3000	$\frac{?}{20}$	$\frac{\pm 0}{20}$
II.	. . . .	49	"	$\frac{?}{32}$	$\frac{-30}{32}$
III.	. . . .	50	"	$\frac{?}{14}$	$\frac{+40}{14}$
IV.	. . . .	51	"	$\frac{?}{20}$	$\frac{-10}{20}$
V.	. . . .	52	"	$\frac{?}{16}$	$\frac{+25}{16}$
VI.	. . . .	53	"	$\frac{?}{22}$	$\frac{+15}{22}$
I.	. . . .	54	"	$\frac{?}{13}$	$\frac{+40}{13}$
II.	. . . .	55	"	$\frac{?}{20}$	$\frac{+25}{20}$
III.	. . . .	56	"	$\frac{?}{15}$	$\frac{+35}{15}$
IV.	. . . .	57	"	$\frac{?}{26}$	$\frac{\pm 0}{26}$
V.	. . . .	58	"	$\frac{?}{14}$	$\frac{+50}{14}$
VI.	. . . .	59	"	$\frac{?}{9}$	$\frac{+55}{9}$

The character of the foregoing firing with torpedo shell on covered targets is not at all an uncommon case in practice. Whoever has been present at such a firing practice, or has looked over the firing record of any *long-continued* firing, will admit that the firing usually proceeds in the same general way as is here indicated.

The determination of the range by means of percussion shell was undoubtedly successful; it is perfectly certain that the target lies between 2850 and 2900 m. In the continuation of the firing not a single false observation was made (in the case of shots 18, 46, 47 and 49, for which the lottery numbers gave false observations, the points of explosion were so high that they could not be observed at all). Nor was there any apparent violation of the firing regulations. And yet the firing proved unsuccessful; indeed, it must be so considered, since, among the twenty-four shots fired with a 3000 m. fuse only three (shots number 37, 40 and 51), or only one-eighth were effective, and if we leave out the first two shots because they were fired at an elevation lower by $\frac{6}{16}^\circ$ than that at which the firing was afterward continued, only a single shot produced any effect.

The battery commander correctly opens the fire with torpedo-shell at 2900 m. The points of explosion lay too high for observation and were therefore lowered. Even normally burning fuses would have given points of explosion so high (10 m.) that observation was not to be thought of; and, as the fuses burn 30 m. too short the mean height of explosion rises to 16 m. Lowering by one plate is not sufficient to give points of explosion admitting of observation; the mean height of explosion is still 7 m. +, and only about one third of all the shots can be counted on to have points of explosion having heights under 4 m.; but a considerable number of these are useless for observation because they are ground hits. Of the four shots fired with the points of explosion lowered by one plate, three have too great a height of explosion and one is a ground hit. The battery commander therefore again lowers and at $\overline{\overline{2900}}$ m. obtains one point of explosion, too high for observation however, and four ground hits in front of the target. Strictly speaking the battery commander cannot use his observation of the ground hits at all for the determination of the proper fuse setting. But let us put ourselves in his place; he either gets points of explosion so high that they cannot be accurately observed at all, or else they lie very low and many of them appear to be ground hits. That these last are really ground hits he cannot know with certainty; he might just as well regard them as low points of explosion. If it is difficult in case of shrapnel to distinguish ground hits from low points of explosion, it is much more so in case of torpedo-shell. While the ground hit in case of shrapnel can still be recognized occasionally by the admixture of more or less sand and dust in the white explosion cloud, this means of recognition is entirely wanting in the black explosion cloud of the torpedo-shell.

It may be thought that the unfavorable result was due to the particularly unlucky numbers that were drawn in case of shots 30 to 35 and 36 to 41. But that this was not the case can readily be seen if we consider how the points of explosion would have been located had the lottery numbers come in just the reverse way, *i. e.*, those of shots 36 to 41 for shots 30 to 35 and the reverse. The points of explosion of the shots 30 to 35 at $\overline{\overline{2950}}$ m., would have been in order, $\frac{-20}{0}$, $\frac{-55}{3}$, $\frac{-50}{8}$ (observed, therefore, $\frac{-}{0}$), $\frac{+35}{-11}$ (observed $\frac{-}{0}$, since the ground hit lies 20 m. in front of the target), $\frac{-50}{8}$, $\frac{-15}{-4}$. Evidently, no points of explosion beyond the target would have been obtained in this case either. By going up to $\overline{\overline{3000}}$ m. the location of the points of explosion would have been as follows: $\frac{-5}{3}$, $\frac{+10}{7}$, $\frac{+15}{5}$, $\frac{+10}{2}$, $\frac{+35}{-2}$ (ground hit 25 m. beyond the target, therefore observed, $\frac{+}{0}$), $\frac{+30}{1}$ (ground hit 25 m. behind the target). Of these six shots the second and third, on account of the fact that their points of bursting were too high, were not observed at all, the first one was observed as at $\frac{-}{3}$, the others at $\frac{+}{1}$ and $\frac{+}{0}$, respectively. Therefore, in this case just as in the preceding one, the firing would have been continued with 3000 m. elevation and fuse.

The mean point of bursting was to be expected, as stated, at $\frac{+30}{17}$; but with such a position for it not more than 7 per cent. of the shots can be counted on as effective, as may be readily shown by means of the diagram of points of bursting, which may be easily constructed from the data of column F in the table, bearing in mind the fact that the angle enclosing the effective shots is determined and limited by lines making angles, respectively, of 22° and 72° with the horizontal (compare appendix 2).

By adopting the elevation and fuse-setting 2950 m., the mean point of bursting would have been moved to $\frac{-20}{16}$, and the number of effective shots would have risen to 33 per cent., *i. e.*, the effect would have been about five times as great as at 3000 m.

It is also worthy of notice that the determination of the range was not really completed until after the expenditure of some thirty torpedo-shells, from which it is apparent how little value can be placed on results obtained from but a few shots.

We will have occasion to refer to these evils again further on.

3. FIRING ON A BATTERY; PASSING TO A BATTERY APPEARING ALONGSIDE THE FIRST TARGET.

Assumptions made by the director:

Longitudinal distance—2230 m.; the second target stands echelonned 60 m. to the front.

Longitudinal deviation—medium.

Fuses—burning 80 m. (in range) too long.

Observation—Lottery numbers 1 to 66, correct (66 per cent.);
67 to 92, doubtful (26 per cent.);
93 to 100, false (8 per cent.).

Preparatory notes:

Position of mean point of bursting for	1st target.	2nd target.
with elevation and fuse 2200 m.,	$\frac{\pm 0}{-4}$	$\frac{+60}{4}$
2200 m.,	$\frac{\pm 0}{+3}$	$\frac{+60}{+3}$
2200 m.,	$\frac{\pm 0}{+10}$	$\frac{+60}{+10}$
2150 m.,	$\frac{-50}{-4}$	$\frac{+10}{-4}$
2150 m.,	$\frac{-50}{+3}$	$\frac{+10}{+3}$
2150 m.,	$\frac{-50}{+10}$	$\frac{+10}{10}$
2100 m.,	—	$\frac{-40}{+3}$
2100 m.,	—	$\frac{-40}{10}$

Record of the lottery numbers drawn.

Percussion shell.

Number. 1.	Number on the firing record. 2.	Lottery number. 3.	Deviation. m. 4.	Target distance minus deviation. m. 5.	Lottery number. 6.	Observation. 7.	Number. 1.	Number on the firing record. 2.	Lottery number. 3.	Deviation. m. 4.	Target distance minus deviation. m. 5.	Lottery number. 6.	Observation. 7.
1	1	59	+ 10	2220	74	?	9	9	77	+25	2205	79	?
2	2	100	+100	2130	13	c	10	10	52	± 0	2230	80	?
3	3	93	+ 55	2175	10	c	11		23	—30	2260	44	c
4	4	54	+ 5	2225	24	c	12		44	— 5	2235	69	?
5	5	56	+ 5	2225	68	?	13		47	— 5	2235	93	f
6	6	69	+ 20	2210	39	c	14		64	+15	2215	73	?
7	7	94	+ 55	2175	75	?	15		31	—20	2250	44	c
8	8	34	— 15	2245	35	c	16		10	—50	2280	46	c

Shrapnel.

Number. 1.	Number on the firing record. 2.	Lottery number. 3.	Deviation. m. 4.	Target distance minus deviation. m. 5.	Lottery number. 6.	Observation. 7.	Number. 1.	Number on the firing record. 2.	Lottery number. 3.	Deviation. m. 4.	Target distance minus deviation. m. 5.	Lottery number. 6.	Observation. 7.
1	11	27	—15 + 2		42	c	13	23	18	—25 + 2		42	c
2	12	93	+35 — 6		90	?	14	24	69	+10 — 4		57	c
3	13	51	± 0 0		3	c	15	25	16	—25 + 4		9	c
4	14	6	—40 + 5		85	?	16	26	80	+20 — 3		13	c
5	15	29	—15 + 1		73	?	17	27	94	+40 — 3		39	c
6	16	77	+20 — 1		35	c	18	28	38	—10 — 1		60	c
7	17	36	—10 + 1		15	c	19	29	73	+15 — 2		48	c
8	18	38	—10 — 1		70	?	20	30	61	+ 5 — 1		43	c
9	19	98	+50 — 6		4	c	21	31	12	—30 + 4		77	?
10	20	51	± 0 0		22	c	22	32	77	+20 — 1		84	?
11	21	64	+10 0		25	c	23	33	90	+30 — 5		38	c
12	22	2	—55 + 7		10	c	24	34	78	+20 — 2		90	?

Firing Record.

No. of gun. 1.	COMMAND. 2.	No. of shot. 3.	Fuse. elevation. m. 4.	OBSERVATION.	
				batt'y. 5.	target. 6.
VI.‡	P. s., dir. on bat., l. of vil.. 2d p., 2000, l. fl. F. !*	1	2000	?	—220
V.	. . . .	2	2000	—	—130
IV.	. . . .	3	2200	+	+ 25
III.	. . . .	4	2100	—	—125
II.	. . . .	5	2150	?	— 75
I.	. . . .	6	2150	—	— 60
VI.	C. f., shr., by steps, 2150, F. w. !†	7	2150	?	— 25
V.	. . . .	8	2150	—	— 95
IV.	. . . .	9	2150	?	— 55
III.	. . . .	10	2150	?	— 80
II.	(Discharge loaded pieces.)				
I.	. . . .				
VI.	(Shrapnel, time fuses.)	11	2150	$\frac{-}{0}$	$\frac{-65}{-2}$
V.	. . . .	12	2150	$\frac{?}{0}$	—10 —10
IV.	1 plate higher !	13	$\underline{2150}$	$\frac{-}{3}$	$\frac{-50}{3}$
III.	. . . .	14	"	$\frac{?}{8}$	$\frac{-90}{8}$
II.	. . . .	15	"	$\frac{?}{4}$	$\frac{-65}{4}$
I.	New fuse 2150, set all at that !	16	"	$\frac{-}{2}$	$\frac{-30}{2}$

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* Percussion shell, directly on battery to left of village, 2nd piece, 2000 m., from left flank Fire!

† Cease firing, shrapnel, by steps (increasing gradually, 50 or 100 m. at a time), 2150 m., fire at will!

‡ On account of the fire beginning with left piece. these numbers are reversed with respect to their original order [note by translator J. W. P.].

No. of gun. 1.	COMMAND. 2.	No. of shot. 3.	Fuse. Elevation. m. 4.	OBSERVATION. batt'y. 5.	OBSERVATION. target. 6.
VI.	. . . .	17	2150	$\frac{?}{4}$	$\frac{-60}{4}$
V.	. . . .	18	"	$\frac{?}{2}$	$\frac{-60}{2}$
IV.	C. f., r., on the battery coming up, F. w.!*	19	"	$\frac{+}{0}$	$\frac{+60}{-3}$
III.	. . . .	20	"	$\frac{+}{3}$	$\frac{+10}{3}$
II.	2100!	21	2150 2100	$\frac{-}{0}$	$\frac{+20}{-4}$
I.	. . . .	22	"	$\frac{-}{3}$	$\frac{-45}{3}$
VI.	. . . .	23.	"	$\frac{-}{0}$	$\frac{-15}{-2}$
V.	. . . .	24	"	$\frac{-}{0}$	$\frac{+20}{-8}$
IV.	(New fuse setting.)	25	2100	$\frac{?}{7}$	$\frac{-65}{7}$
III.	. . . .	26	"	$\frac{-}{0}$	$\frac{-20}{0}$
II.	. . . .	27	"	$\frac{?}{0}$	$\frac{\pm 0}{0}$
I.	. . . .	28	"	$\frac{-}{2}$	$\frac{-50}{2}$
VI.	. . . .	29	"	$\frac{-}{1}$	$\frac{-25}{1}$
V.	. . . .	30	"	$\frac{-}{2}$	$\frac{-35}{2}$
IV.	. . . .	31	"	$\frac{?}{7}$	$\frac{-70}{7}$
III.	. . . .	32	"	$\frac{?}{2}$	$\frac{-20}{2}$
II.	. . . .	33	"	$\frac{-}{0}$	$\frac{-10}{-2}$
I.	. . . .	34	"	$\frac{?}{1}$	$\frac{-20}{1}$

* Cease firing; to the right on the battery coming up, fire at will!

DISCUSSION OF THE FIRING.

In determining the range with percussion shell the fork was not correctly established, because shot three in consequence of its large deviation struck far beyond the target. Since the target distance was 2230 m. and the elevation given to this shot was only 2200 m., it should have struck in front of the target. The short-fork distance became therefore, not 2200 (what it should have been) but 2150 m. As the short fork was established by three shots in front of the target and only one actually observed to fall beyond, it would have been better before passing to shrapnel fire to have fired a few more percussion shells at 2150 m.; then it would have become evident very quickly, as may be seen from the firing record, that 2150 m. was too short a range. That the passage to shrapnel fire in this particular case could follow without detriment immediately upon the establishment of the short fork, was due to the combination of two fortunate circumstances. In the first place 2200 m. was the actual approximate short-fork distance; the error made in its determination was *accidentally* not over 50 m.; it might have been however,—in consequence for example, of a false observation—very much greater. Moreover, the fact that the fuses burned 80 m. too long (in range) was exceptionally fortunate, since, after ground hits were avoided by inserting a plate, it so happened that perfectly normal distances of 50 m. in front of the target were obtained for the points of bursting. Had the fuses burned correctly bursting distances of 130 m. would have been obtained, and therefore certainly a very indifferent effect.

On passing to shrapnel fire the battery commander was soon obliged, on account of ground hits to insert a plate. In spite of the fact that the fuses burned 80 m. too long, it appeared as if the insertion of a single plate was sufficient to prevent ground hits. As a matter of fact the insertion of a plate increases the range by about 60 m.; the mean height of explosion would therefore be such as would correspond to fuses burning about 20 m. too long (about 3 m.).

As soon as the second target, the battery arriving on the right of the existing target, came up, the battery commander turned his fire in that direction. The first shot, a ground hit beyond the target did not as yet necessitate any correction, but upon observing in the next shot a point of explosion beyond the target the battery commander at once reduced the elevation by 50 m., *i. e.*, shrapnel with fuse set for 2150 m. were fired with an elevation of 2100 m. For this combination of elevation and fuse setting the director was not prepared. It is evident, however, that since the elevation 2100 m. is almost exactly the same as 2150 m., the position of the mean point of bursting for thse shots may be taken to be that assumed for 2150 m., viz: at $\frac{+10}{-4}$. These shots all lay in front of the target, those that gave ground hits as well as the one shot that burst in air.

From shot 25 on, when elevation and fuse setting were in accord again—2100 m.,—the first point of explosion was at 7 m., therefore somewhat above the normal height, and then followed two ground hits. The battery commander might have had another plate inserted at once. But, as the fuses of the shots fired against the first target burned approximately correctly, and the two ground hits (or possibly low bursting points) had been preceded by a high point of bursting, and as, moreover, he did not wish to leave a long interval before firing on the newly arrived target, he delayed inserting a second plate. The result justified his action; in the next seven shots there was but one ground hit, and he could hope, from the progress of the entire firing against this target, to obtain in a short time an annihilating effect.

4. FIRING AT A SKIRMISH LINE AT SHORT RANGE.

Assumptions of the director.

Target—skirmishers, kneeling, in open ground.

Distance—1170 m.

Fuses—burning 20 m. too long (in range).

Longitudinal deviation—medium.

Observation conditions—Lottery numbers 1 to 64 correct (64 per cent.); 65 to 91, doubtful (27 per cent.); 92 to 100, false (9 per cent).

Position of the mean point of bursting, with elevation and fuse 1100 m., at $\frac{-100}{2}$.

Record of lottery numbers drawn.

PERCUSSION SHELL.						SHRAPNEL.					
Number. 1.	Lottery number. 2.	Deviation. m. 3.	Target distance minus deviation. m. 4.	Lottery number. 5.	Observation. 6.	Number. 1.	No. on the firing record 2.	Lottery number. 3.	Deviation. m. 4.	Lottery number. 5.	Observation. 6.
1	31	−15	1185	56	c	1	9	23	−15 0	84	?
2	8	−55	1225	69	?	2	10	54	+ 0 − 1	23	c
3	87	+40	1130	74	?	3	11	80	+15 − 1	63	?
4	86	+40	1130	7	c	4	12	91	+25 − 1	71	?
5	96	+65	1105	29	c	5	13	12	−20 + 3	2	c
6	79	+30	1140	73	?	6	14	34	−10 − 1	43	c
7	74	+25	1145	55	c	7	15	25	−10 + 2	24	c
8	45	− 5	1175	98	f	8	16	20	−15 + 1	55	c
9	69	+20	1150	36	c	9	17	81	+15 − 1	31	c
10	55	+ 5	1165	71	?	10	18	95	+30 − 1	54	c
11	40	−10	1180	82	?	11	19	50	+ 0 0	48	c
12	75	+25	1145	29	c	12	20	54	+ 0 − 1	60	c

Firing Record.

No. of gun.	COMMAND.	No. of shot.	Fuse.	OBSERVATION.	
			Elevation. m.	batt'y.	target.
1.	2.	3.	4.	5.	6.
I.	P. s., skirmishers on the main road, 1000 !*	1	1000	—	−185
II.		2	1200	?	− 25
III.		3	"	?	+ 75
IV.		4	"	+	+ 70
V.		5	1100	—	− 5
VI.	C. f., shrapnel, 1100, F. w.!†	6	"	?	− 40
I.		7	"	?	− 45
II.		8	"	+	− 75
III.	(Shrapnel.)	9	"	$\frac{?}{2}$	$\frac{-115}{2}$
IV.		10	"	$\frac{-}{1}$	$\frac{-100}{1}$
V.		11	"	$\frac{?}{1}$	$\frac{-85}{1}$
VI.		12	"	$\frac{?}{1}$	$\frac{-75}{1}$
I.		13	"	$\frac{?}{5}$	$\frac{-120}{5}$
II.		14	"	$\frac{-}{1}$	$\frac{-110}{1}$
III.		15	"	$\frac{?}{4}$	$\frac{-110}{4}$
IV.		16	"	$\frac{-}{3}$	$\frac{-115}{3}$
V.		17	"	$\frac{-}{1}$	$\frac{-85}{1}$
VI.		18	"	$\frac{-}{1}$	$\frac{-70}{1}$
I.		19	"	$\frac{-}{2}$	$\frac{-100}{2}$
II.		20	"	$\frac{-}{1}$	$\frac{-100}{1}$

* Percussion shell, on skirmishers on the main road, 1000 m.!

† Cease firing, shrapnel, 1100 m., Fire at will!

Determining the distance of a line of skirmishers at short range by means of percussion shell, is the exception rather than the rule in practice. More commonly it will be necessary to pass to them from targets at greater distances, against which the battery is at the time engaged in firing shrapnel. If this is to be illustrated in the fire game a supposition to that effect must be made, and also as to how many guns of the battery are loaded when a particular gun is fired immediately after firing which the passage to the new target is to be ordered. We will illustrate such a firing by an example. Let us take the battery of the preceding example, standing as it was under fire and firing on hostile artillery at 2100 m. At the moment when the skirmishers arrive at the distance of 1170 m., suppose the fourth piece has just fired, and that the fifth, sixth, first and second are again loaded with shrapnel, set at 2100 m. Let the record as given for percussion shell in example four hold true as regards deviation and character of the observation in the case of these shrapnel, which will burst as ground hits by percussion.

The firing will then proceed as indicated in the following firing record:

No. of gun. 1.	COMMAND. 2.	No. of shot. 3.	Fuse. / Elevation. m. 4.	OBSERVATION.	
				batt'y. 5.	target. 6.
V.	C. f., l. skirmishers, 1000, F. w.*	1	$\frac{2100}{1000}$	—	—185
VI.	. . . .	2	$\frac{2100}{1200}$	?	— 25
I.	. . . .	3	$\frac{2100}{1200}$	?	+ 75
II.	. . . .	4	"	+	+ 70
III.	(New fuse setting.)	5	$\frac{1000}{1100}$	$\frac{?}{6}$	$\frac{-200}{6}$
IV.	(New fuse setting.)	6	$\frac{1200}{1100}$	?	— 40
V.	. . . .	7	"	?	— 45
VI.	. . . .	8	"	+	— 75

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* Cease firing to the left on the skirmishers, at 1000 m., Fire at will!

No. of gun.	COMMAND.	No. of shot.	Fuse. Elevation. m.	OBSERVATION. batt'y.	OBSERVATION. target.
1.	2.	3.	4.	5.	6.
I.	(New fuse setting.)	9	1100 1000	—	—150
II.	. . . .	10	"	?	—165
III.	. . . .	11	"	?	—185
IV.	. . . .	12	"	—	—145
V.	(New fuse setting.)	13	1000	? 2	—215 2
VI.	. . . .	14	"	— 1	—200 1
I.	. . . .	15	1000 1100	? 4	—185 4
II.	. . . .	16	"	? 4	—175 4
III.	. . . .	17	"	? 7	—210 7
IV.	. . . .	18	"	? 6	—215 6
V.	(New fuse setting.)	19	1100	— 1	—70 1
VI.	. . . .	20	"	— 1	—100 1

The comparison of these two firing records is very interesting. The first firing was quite successful; the last a complete failure. For, a battery which hurls it's first effective shot at a line of skirmishers at *less* than 1200 m. distance, only after firing eighteen shots, *i. e.*, at the expiration of about five minutes, cannot certainly count on any effective result after that.

In order at the beginning to prevent any misunderstanding, it may be definitely stated that this was not due to any mismanagement in directing the firing. How the effects of good work are combined with mere luck in firing is very clearly shown in these two examples. Had shot two been *correctly* observed, the firing in *both* cases would have been a failure; for, in that case 1200 m. would have been the short fork distance, and the position of the mean point of explosion would have become ±0, as in the other case. It was, therefore, an especially fortunate circumstance—namely, that a shot with a particularly large deviation short of the target (—55 m.) was not observed—which permitted the first firing to succeed so well. In the second firing record shot five was not observed, and it could not, even had the battery commander been aware of the fact, as he probably was, that it lay short of the target, be taken into consideration any way. The position of its point of bursting in front of the target was entirely the result of the fuse setting (1000 m.). This shot only served to show, what was already well known, viz: that the target was farther off than 1000 m. Then shots six and seven were not observed at all, and shot eight falsely, just as in the first firing record. In the latter (the first) it was without significance, because the fork of 100 m. had been already established and the passage to shrapnel fire already ordered. But in this (the second) case it was of *decisive* importance and value; for the result of the false observation was that the shrapnel bursting in air by the action of the fuse had too great a distance for the point of explosion in front of the target. Although the error was noticed as early as the second projectile which burst in air, it was still necessary to fire four more shrapnel with this false fuse-setting.

Whereas, in the first firing record the first effective shot fired was the ninth, *i. e.*, after about three minutes of firing, the first effective shot in the second case was the eighteenth.

The example also shows, however, how entirely different an order of firing may result from a change in a single observation. To make such a change is to be recommended whenever there is not much time for preparation. If, in the preparatory record, in the case of one of the first shots that serve to establish the fork, a correct observation is changed to a false one or the reverse, an entirely different firing record will be obtained, and all the rest of the preparations can be fully utilized.

[TO BE CONTINUED.]

ON THE DETERMINATION OF THE COMBUSTION-TEMPERATURE OF EXPLOSIVES.*

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Very few data connected with the theory of explosives up to date have been received with so much skepticism as the enormously high temperatures of explosion. For example, in accordance with the most recent experiments, that of black gunpowder lies between 3000° C. and 4000° C.; of gun-cotton, between 5000° C. and 6000° C.; and, finally, that of nitro-glycerine between 7000° C. and 8000° C.

The object of this investigation is to reduce on theoretical grounds, the temperatures of combustion of explosives to a trustworthy standard. For this purpose, in addition to the already existing black powder as standard of comparison, there will be considered besides nitro-glycerine, a few types of smokeless powders.

The most obvious objection to the high combustion-temperatures of powders depends on the consideration that these temperatures far exceed the melting points of the gun-metals, and that consequently guns ought to be destroyed far sooner than, fortunately, experience shows to be the case.

The above mentioned objection finds however in the extremely short duration of the influence of the glowing heated gases on the gun, an important if not complete invalidation, since to the exercise of this influence—here the alteration of the state of aggregation—a certain interval of time is necessary.

Accordingly, time for destruction is not given, in analogy with the idea first expressed by Rodman, that guns often withstand

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* Translated with the permission of the author, from *Mittheilungen über Gegenstände des Artillerie- und Genie-Wesens*, No. 2, 1891, by 1st Lieutenant C. DEW. WILLCOX, U. S. Artillery.

very severe strains without bursting, because time therefor is not granted.

Naturally the greater the intensity of the cause of destruction, the shorter is the time unquestionably necessary for completing the destruction.

The molecular theory of gases has also a word to say, although its foundations are not yet so secure, as to beget absolute confidence in the results of its computation. In accordance with this theory, between 2500° C. and 2800° C. molecular cohesion ceases to exist; that is, the molecules must separate into their unstable atoms.

Theorists, guided by the conjecture that, in analogy with solid bodies, the specific heats of gases must increase with the temperature, have maintained that the real temperatures of combustion are *somewhat* smaller than the calculated. In the meantime, however, experimenters have already furnished results exciting less astonishment. Experiments with the melting of platinum in the flame of gunpowder have indicated a surface alteration of the state of aggregation. Inasmuch as the melting point of platinum is 1775° C., the combustion-temperature of black powder could be put down incidentally at 2000° C., reckoned from the melting point of ice.

From pressures in closed vessels, as furnished by experiments with crusher-gauge, Noble and Abel have, indirectly, determined the temperature. In regard to this, I refer to my investigations published in 1888, in the *Mittheilungen*, on "The pressure relations in respect of the combustion of powder in closed vessels," and particularly to the formula on page 383:

$$p = R_1 T \frac{\varepsilon a \sigma_g D_1}{1 - \frac{\sigma_g}{\sigma_p} D_1}$$

in which:

p = pressure in atmospheres.

R_1 = characteristic constant for the products of combustion in Gay-Lussac—Mariotte's law (according to Noble and Able, = 0·00229).

T = the absolute temperature of combustion.

ε = the weight of gas in 1 kg. of powder.

a = the weight of powder burned per kilogram. of the charge, here = 1.

σ_g = weight of the volume of powder (*Kubiergewicht*).

σ_p = the specific weight of the mass of powder.

D_1 = the density of loading, according to the definition of both experimenters; that is, the ratio of the volume of the powder plus interstitial spaces, to the volume of the powder chamber.

If in the formula above, we put

$$R_1 T \varepsilon \sigma_g = A$$

then

$$p = A \frac{D'}{1 - \frac{\sigma_g}{\sigma_p} D'}$$

in which A may be computed as a mean from the system of pairs of values of p and D; according to Noble and Abel, $A = 2340$.

The numerical value of A being deduced from the pressures, we have

$$T = \frac{A}{R_1 \varepsilon \sigma_g}$$

By this procedure the temperature of combustion is found indirectly to be 2100° C., computed from freezing point. While this temperature is far more trustworthy than the purely theoretical one, yet we cannot but ask whether the pressures deduced from the data of the crusher-gauge are the correct ones, in regard to which a good deal might be said.

Finally, it may be remarked, in respect of Gay-Lussac—Mariotte's law, that,

$$\frac{1 - \frac{\sigma_g}{\sigma_p} D'}{\varepsilon \sigma_g D'}$$

is the specific volume of the powder gases, the value of which corresponding to the investigation above mentioned, becomes

$$\frac{1 - 0.6 D'}{430 D'}$$

These considerations premised, I turn to the real subject of my investigations, and begin with a glance at the cardinal error of previous methods of determining the temperature of combustion. This consists in assuming the specific heat to be independent of temperature, and in taking into account the specific heat determined for freezing. It is evident however that simple logic based on the phenomena of nature must lead to the conclusion that thermal capacity, of which specific heat is the numerical expression, decreases as the quantity of heat in a given body increases. That is, more heat must be imparted to a body, in order for example to raise its temperature from 1000° C. to 1001° C., than to raise it from 0° to 1°.

If we call Q_r the quantity of heat which one kg. of a composition gives out on explosion, and c_0 the absolute specific heat at 0° C., agreeing in the case of gases (there being no internal work done) with specific heat at constant volume, then heretofore the temperature t of combustion, counted from 0° C., has been defined by

$$t = \frac{Q_r}{c_0} \quad - \quad - \quad - \quad - \quad (1)$$

As an example take the black powder experimented with by Bunsen and Schischkoff. For this, the quantity of heat Q_r was found to be 620 calories (using the kilogram and centigrade scale). This value was deduced both from a practical reaction, furnished by a chemical analysis of the products of explosion, and from the data of a calorimetric experiment. The experimenters above-named, relying on the reaction of decomposition, found as an average value for the absolute specific heat of the products of explosion $c_0 = 0.18548$. With these data, we have in round numbers for the temperature of explosion

$$t = \frac{620}{0.18548} = 3340° \text{ C.}$$

With regard to this I remark that the quantity of heat, 620 calories, is decidedly greater than is accordant with the truth. It must be noticed in the next place, that chemical analysis is possible only after cooling takes place. In this process of cooling complicated combinations take place as subsequent reactions, that are not conceivable as occurring at the high temperature of explosion, but which nevertheless have been considered in the determination of the deduced quantities of heat.

Similarly, in calorimetric experiments time is given for subsequent formation of complex compounds, and for a partial change in the state of aggregation, giving rise to the emission of more heat, which has nothing to do with that given out at the moment of explosion.

Consequently, $Q_r = 620$ calories is far too great, and it is likely that the so-called theoretical formula of decomposition containing only simple combinations lies nearer the truth than those based entirely on chemical analysis.

The commonly given theoretical formula for the decomposition of black powder is as follows:

$$2KNO_3 + 3C + S = K_2S + 3CO_2 + 2N$$

to which corresponds $Q_r = 424$ calories.

The percentage composition of powder is in round numbers 75:13:12.

If we take the quoted value of Q_r as limiting value, then $\frac{620 + 424}{2} = 522$ may be regarded as a mean value lying nearer the truth.

To this mean value of Q_r we must also naturally join the mean value of c_0; and as, by my calculations $c_0 = 0.1282$ for the theoretical reaction, we have as mean for c_0:

$$c_0 = \frac{0.1282 + 0.18548}{2} = 0.15684$$

whence

$$t = \frac{522}{0.15684} = 3330^\circ$$

It is evident from this, that however the matter may be investigated, abnormally high temperatures are always obtained, as long as the specific heat is considered independent of the temperature. I shall therefore show how the temperature of combustion turns out, if we take the specific heat to be a function of the temperature.

In this matter, E. Wiedemann's experiments are of great value. According to these, we have for CO_2 at

0° 100° 200° C.

the absolute specific heats

0.1394 0.1549 0.1705.

Whence, the specific heat increases 0.000155 for 1°. We may therefore write for CO_2

$$c = c_0 + 0.000155t \qquad - \quad - \quad - \qquad (2)$$

As nothing more suited to my purpose is available, and as the average behavior of the products of combustion is quite similar to that of CO_2 (see the already quoted investigation, p. 346), I shall assume formula (2) throughout. It must however be borne in mind, that formula (2) offers only approximate results in the case of explosive compounds, particularly as I am applying to much wider temperature-limits, a formula applicable only to narrow (0°—200°) limits.

The question now is to determine the quantity of heat to be applied to unit-weight (1 kg.), in order to raise its temperature from 0° to t°.

If we put

$$c = f(t)$$

this means that to the mass of one kg., at the temperature t, must be imparted the quantity of heat $f(t)$ in order to increase the temperature by 1°.

Should the temperature be infinitesimally increased in a time dt,

$$cdt = f(t)dt$$

is the quantity of heat required.

Hence the quantity of heat, corresponding to t, absorbed by one kilogramme of the mass is defined by the equation

$$Q_r = \int_0^t f(t)dt = F(t)$$

and if, referring to (2), we write

$$f(t) = c_0 + at$$

then

$$Q_r = \int_0^t (c_0 + at)dt = c_0 t + \frac{a}{2} t^2 = F(t) \quad - \quad (3)$$

Hence, we have to determine the temperature of combustion

$$t = \frac{-c_0 + \sqrt{c_0^2 + 2Q_r a}}{a} \quad - \quad - \quad - \quad (4)$$

Substituting in this formula the values of c_0 and Q_r corresponding to the experiments of Bunsen and Schischkoff, and taking $a = 0.000155$, we have

$$t = 1874^\circ$$

that is, a value in tolerable accord with the confessedly few results of experiment.

In round numbers then, we may take the temperature of combustion as 2000° C.

If one wishes to deduce the coefficients of t in (2) from experiments made with powder, it is recommended to use in the calculation the temperature deduced from Noble and Abel's experiments.

If in

$$Q_r = c_0 t + \frac{a}{2} t^2$$

we put $Q_r = 620$, $c_0 = 0.18548$, and $t = 2100$
then

$$a = 0.0001$$

and

$$c = c_0 + 0.0001t$$

I now pass to the determination of the temperatures of combustion for a few of the modern explosive compounds, whose chemical constitution and conjectural theoretical decomposition will be next given.

This preliminary fundamental work I have carried out at the instigation, and in accordance with the valuable suggestions, of Major Johann Schwab, of the Artillery Staff.

Let us now take up four nitro-cellulose powders, distinguished from one another chiefly by different quantities of nitrogen.

A.—Powder, consisting of one molecule of trinitro-cellulose and two of binitro-cellulose (collodion-cotton):

$$C_6H_7(NO_2)_3O_5+2C_6H_8(NO_2)_2O_5=$$
$$CO_2+17CO+10H_2O+7N+3H.$$

B.—One molecule of trinitro- to one of binitro-cellulose:

$$2C_6H_7(NO_2)_3O_5+2C_6H_8(NO_2)_2O_5=$$
$$CO_2+23CO+15H_2O+10N.$$

C.—Reverse of **A.**

$$2C_6H_7(NO_2)_3O_5+C_6H_8(NO_2)_2O_5=CO_2+16CO+11H_2O+8N.$$

D.—Pure trinitro-cellulose.

$$2C_6H_7(NO_2)_3O_5=3CO_2+9CO+7H_2O+6N.$$

Besides these nitro-cellulose powders, will be investigated:

E.—Noble's nitro-glycerine binitro-cellulose powder, for which Krupp offers the following reaction:

$$10C_3H_5(NO_2)_3O_3+9C_6H_8(NO_2)_2O_5=$$
$$26CO_2+58CO+61H_2O+48N.$$

Finally:

F.—Nitro-glycerine:

$$2C_3H_5(NO_2)_3O_3=6CO_2+5H_2O+6N+O.$$

In constructing these reactions—which may always vary under the conditions of the explosion—it was assumed as basis, that the *H* and *C* are as far as possible completely burned. In the following table are given the percentages of the elements contained in the respective explosives, as well as those of the products of explosion:

Explosive.	Element.				Products of Explosion.					
	C	H	N	O	CO_2	CO	H_2O	N	H	O
A*	26.97	2.87	(12.24)	57.92	5.5	59.4	22.5	12.2	0.4	
B	26.23	2.73	(12.75)	58.29	4.0	58.7	24.6	12.7		
C	25.53	2.60	(13.24)	58.63	10.5	52.9	23.4	13.2		
D	24.24	2.36	(14.14)	59.26	22.2	42.4	21.2	14.2		
E	22.21	2.69	(14.81)	60.29	25.2	35.8	24.2	14.8		
F	15.86	2.20	(18.50)	63.44	58.2		19.8	18.5		3.5

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* If we suppose that all the hydrogen burns to water, then the reaction for **A** is:

$$C_6H_7(NO_2)_3O_5+2C_6H_8(NO_2)_2O_5=17.5CO+11.5H_2O+7N+0.5C.$$

The percentages of the products of explosion then are:

$$CO:H_2O:N:C=61.2:25.8:12.2:0.8$$

In order to be able to compute the combustion temperatures corresponding to the explosive compounds, we must first know the reduced quantities of heat Q_r, and the (corresponding to 0°) average absolute specific heats c_0 of the products of explosion; or more exactly, the absolute specific heats of the mixture of these products.

If we represent in general a decomposition by

$$K = k_1 + k_2 + k_3 + \dots\dots$$

then to get Q_r, we must have the quantity of heat Q, due to the chemical processes involved, and then divide this by the weight of the body K in kilograms.

Taking the gram. as unit of atomic and molecular weights, then, according to the decompositions above given, we have for

	A	**B**	**C**	**D**	**E**	**F**
the weights	0.801	1.098	0.846	0.594	4.538	0.454 kg.

The quantity of heat Q will be obtained by subtracting from the heat of combination of the explosion-products k_1, k_2, k_3, that absorbed in the separation of the given substance K into its elements.

The following table* gives, for one molecule of the substance concerned, the unit being the gramme, the quantities of heat of combination (or of separation) in usual (large) calories (kilogramme-degree C.):—

Substance.	Quantities of heat.
CO_2	94 calories
CO	25 "
H_2O	69 "
$C_6H_8(NO_2)_2O_5$	184 "
$C_6H_7(NO_2)_3O_5$	195 "
$C_3H_5(NO_2)_3O_3$	130.5 "

That is, in making 44 g. CO_2 94 large calories are set free; contrariwise, in separating 44 g. CO_2 into its elements, 94 calories are absorbed.

To illustrate the process of computing Q_r, we shall make the numerical calculation for compound A; as already pointed out, 0.801 kg. are taken into account.

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* From Berthelot.

1 CO_2 gives 94 calories = 94
17 CO gives 17 × 25 calories = 425
10 H_2O gives 10 × 69 calories = 690
whence 1209 calories are set free.

Since in the decomposition of one molecule of trinitro-cellulose, and in that of two molecules of binitro-cellulose, 195, and $2 \times 184 = 358$ calories, respectively, are absorbed, in all 563, we have for 0.801 kg. of the compound: $Q = 1209 - 563 = 646$ calories available, whence for one kg.:

$$Q_r = \frac{646}{.801} = 806 \text{ calories}^*$$

In this fashion I found for

	A	B	C	D	E	F
$Q_r =$	806	862	914	1010	1133	1427 cal.

It is now necessary to determine the specific heat c_0 of the products of explosion, i. e., the quantity of heat that—reckoning from the freezing point—must be imparted to one kilogram. of the products of explosion, in order to raise the temperature by 1° C. Supposing the weights $a_1, a_2, \ldots$ of the products of explosion to be determined corresponding to one kilogram. of the substance considered (see table, p. 415), and calling $c_0', c_0'', \ldots$ the absolute specific heats of the separate products of explosion, then in accordance with the law of nature that the absorption of heat always takes place in accordance with the condition of temperature equilibrium, we have,

$$c_0 = a_1 c_0' + a_2 c_0'' + \ldots \qquad (5)$$

as the quantity of heat that will increase the temperature of the products of explosion by 1° C.

Below are given the absolute specific heats for the products of explosion considered:

Substances,	Sp. heat.
CO_2	0.1581
CO	0.1752
H_2O (vapor)	0.3432
N	0.1717

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[*] If we take the reaction giving *free* carbon, $Q_r = 834$ cal.

O	0.1533
H	2.4046

The computation for preparation **A** is as follows:

From one kilogram. of the products of explosion we have:

CO_2	CO	H_2O	N	H
0.055	0.593	0.225	0.122	0.004 kg.

to which correspond the specific heats

0.1581	0.1752	0.3432	0.1717	2.4046

Multiplying, conformably to (5), the numbers in the upper by the corresponding ones in the lower line, we get (water-equivalents)

0.0087	0.1041	0.0772	0.0187	0.0096

whence by addition,

$$c_0 = 0.2183.$$

In this way I found for

	A	**B**	**C**	**D**	**E**	**F**
$c_0=$	0.2183	0.2146	0.2121	0.2064	0.2110	0.1971

In conclusion, the temperatures of combustion will be computed according to the usual method, and then according to mine.

By formula (1) for

	A	**B**	**C**	**D**	**E**	**F**
$t=$	3692°	4017°	4309°	4893°	5370°	7240° C.

By formula (4)

$t=$	2110°	2234°	2329°	2516°	2697°	3005° C.

A few considerations may be added connected with the reduced quantities of heat, Q_r. Starting from these magnitudes, we may compute the energy E_r given up by one kilogram. of a (compound) substance—and this we may call the reduced energy. Since one calorie is the equivalent (using the kilogram. and the centigrade scale) of 424 kgm., or of 0.424 mt. (metre-tonnes), we may obtain the reduced quantity of energy, by multiplying the number given above by 424, and 0.424 respectively.

Hence for

	A	**B**	**C**	**D**	**E**	**F**
we get						
$E_r=$	341744	365488	387536	428240	480392	605048 kgm.
and						
$E_r=$	341.744	365.488	387.536	428.240	480.392	605.048 mt.

respectively.

The quantity of energy E_r is a fundamental magnitude in interior ballistics, since—briefly—the solution of the problem of the motion of the projectile in the bore of a gun consists in distributing the energy of the charge—the potential energy—according to the laws of mechanics. By bringing the deduced values of Q_r and of E_r into relation with the data of the table, p. 415, the conclusion is drawn that Q_r (or E_r) increases with the quantity of nitrogen as well as with the quantity of oxygen present. And it is interesting to investigate whether in bodies of the same kind, a numerical relation may be determined between Q_r and the nitrogen.

Let us consider for this purpose, the nitro-cellulose powders (that is, **A, B, C, D,**), of which a greater number is available.

If we take the differences ΔN of N; next, the differences ΔQ_r of Q_r, and then determine the increase in Q_r for $\Delta N = 0.1$ per cent., we get the following:

Substance	N per ct.	ΔN	Q_r	ΔQ_r	ΔQ_r for $\Delta N = 0.1$
A	12.24		806		
B	12.75	0.51	862	56	11
C	13.24	0.49	914	52	10.6
D	14.14	0.90	1010	96	10.7

We may accordingly say, that within the limits of the considered quantities of nitrogen, an increase of 0.1 per cent. in nitrogen increases the reduced quantity of heat by 11 calories, and hence the reduced quantity of energy by $11 \times 424 = 4664$ kgm. For oxygen, we have as increases in Q_r for an increment of 0.1 per cent. in the oxygen of the series, 15.1, 15.3, 15.2, or an average of 15.2 calories. If we know ΔE_r, we may by means of the useful effect η determine approximately the increment ΔV in the initial velocity.

Since η indicates what proportional part of the energy contained in the powder charge (weight $= p$) was transferred to the projectile (weight $= P$), we have

$$\frac{P}{2g} V^2 = \eta p E_r$$

whence

$$V = \sqrt{2g\eta}\sqrt{\frac{p}{P}}\sqrt{E_r}$$

and

$$\Delta V = \sqrt{2g\eta}\sqrt{\frac{p}{P}}\,\frac{\Delta E_r}{2\sqrt{E_r}}$$

If, for example, starting from *A*, we put in this equation, $\eta = \frac{1}{3}$, $p = 2.75g$, $P = 15.8g$, $\Delta E_r = 4664$ kgm., then

$$\Delta V = 7\text{m}.$$

From the last two equations we get by division for the relative variation in initial velocity,

$$\Delta V = \frac{\Delta E_r}{2E_r} V.$$

To get the reduced quantities of heat, Q_r, reckoned from absolute 0 (−273° C.) we must add to Q_r the quantity corresponding to the absolute temperature of the substance before explosion.

As an approximation:

$$Q'_r = Q_r + c_0(273 + t)$$

in which t = temperature of the substance before explosion, reckoned from freezing point.

Neglecting *t*,

$$Q'_r = Q_r + 273c_0$$

This determination is approximate, only because the temperature −273° C. involves the assumption that Gay-Lussac—Marriotte's law holds good down to the absolute zero, while it is still further tacitly assumed that the specific heat suffers no change within the limit of negative temperatures.

For black powder $Q'_r = 670$ cal., and for

A	**B**	**C**	**D**	**E**	**F**
866	920	972	1066	1190	1480 cal.

The quantity of heat Q'_r may be taken as the measure of the dynamic effect of a compound, since—leaving out losses of heat—the pressure p' depends only on Q'_r, and is directly proportional to it, if unit-weight (1 kg.) of the substance is burned in unit-volume (1 m³); hence,

$$p' = mQ'_r$$

According to the mechanical theory of heat, and the molecular theory of gases, if p' is in atmospheres,

$$m = \frac{424}{10333}(k-1) = \frac{2}{3}\ \frac{424}{10333\beta}$$

in which

k = ratio of specific heats at constant pressure and at constant volume.

β = number by which must be multiplied the energy of the forward motion of the gas-molecules, in order to obtain the total energy. For perfect gases, $\beta = 1.625$.

With the known values of k, or β, tolerably plausible values may be obtained: it is more reliable to determine m from pressure-experiments. Taking those of Abel and Noble, and going back to the formula on page 410

$$m = \frac{p'}{Q'_r} = p\,\frac{1-0.6D'}{430D'Q'_r}$$

whence

$$m = \frac{2340}{430 \times 670} = 0.0081$$

This value of m may also be used in the determination of the values of k and β that are most likely to be true for the products of explosion; from the above formula,

$$k = 1.2, \quad \beta = 3.3$$

Since, as already pointed out in my investigations published in the *Mittheilungen* in 1888, the behavior of the powder-gases in guns lies between *isothermic* ($k = 1$), and *adiabatic* ($k = 1.2$), we have as a mean for k,

$$k = 1.1,$$

a value in remarkable accord with that (1.11) deduced by Krupp from velocity measurements.

NOTE.—I should like to express my thanks to 1st Lieutenant J. P. WISSER, 1st Artillery, for revising this translation. C. DEW. W.

ARTILLERY DIFFICULTIES IN THE NEXT WAR.[*]

By First Lieutenant JOHN W. RUCKMAN, First Artillery, U. S. A.

INTRODUCTION.

The attempt to discuss the artillery difficulties of the next war must, from the nature of the case, savor of prophecy. Perceiving this fact at the outset, and the indefinite and unsatisfactory results of such discussion, we plead in vindication of the act, that notwithstanding the involved nature of the subject there exist to-day among artillerists certain well defined lines of thought and movement which point out the direction in which future artillery problems are tending, and which enable us to see that while most of the circumstances of the future artillery battle will be novel, they will in many cases have been foreseen.

The manufacture of longer guns, heavier projectiles moving with higher velocities, and accurate devices for aiming, indicate that artillery fire will be certain and efficacious.

The scientific and practical care given to instruction and preparation indicate that the commencement will be sharp and effective. On all sides we see tendencies from the old toward the new which point out certain general modes of operation.

It is evident in the beginning that much will depend upon time, place, organization, and degree of preparation for these new conditions and that some definite limits must be assumed. Not being able to predict the time and place and not having the means to forecast the future, and to ascertain the effect of inventions during the intermediate years an attempt to arrive at exact conclusions would be useless.

Since we must select a future battle ground and since the question applied to our own country is an important and interesting one, we will assume our country to be the defender

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[*] Read before the officers of Fort Monroe, Va., June 17, 1892.

in this hypothetical war, and as it, judging from the present outlook, promises to have many difficulties, the discussion may also be profitable.

There is a wide-spread sentiment throughout the country that a sea-coast artillery is superfluous and useless; and that in case of war we would make short work of a hostile army which would dare "to set foot on the sacred soil of this grand and glorious Republic. Doubtless France puffed up with the same feeling thought in 1870 that she could similarly despise an invader, yet one short month sufficed to reveal her mistake."

As in 1870, war promises to come in future like an avalanche upon the unprepared and overwhelm them in its course. From the nature of our country, its government, and the traditions of the people, it will always be difficult to establish the necessity for a reasonable sea-coast defense, but does this alter our needs?

However this may be, so long as we as a nation remain so thoroughly satisfied with ourselves, and the demagogue and charlatan continue to have more influence than the military expert, we shall have little to hope for in the way of sea-coast defense. It is not here the purpose to discuss sociological questions, but simply to direct attention to this particular weakness which in itself is an inherent obstacle to artillery progress.

History shows that war like other human institutions adapts itself to the surrounding conditions and that the principle of the "survival of the fittest" obtains in a marked degree. By study a nation can ascertain these conditions and so control her preparations as to march with them or neglect all and permit her military establishment to fall behind or directly oppose them. The former insures success; the latter defeat. Other things being equal, it may be stated with certainty that the nation which adapts itself, in organization and preparation for war, and most thoroughly avails itself of the world's intellectual and material resources, will be the stronger at the critical moment.

In a general sense an artillery difficulty may be defined as any condition, social, organic, educational, or material, which will prevent the artillery from obtaining the highest results in war.

It is apparent that the state of proficiency of an artillery command will depend upon its instruction in its duties and its familiarity with the work required. Again when these qualifications are perfect there may still remain certain organic obstacles in the way of the highest results. From these different factors which enter a modern or future artillery problem there appear three classes of considerations. Those affecting *organization*, *personnel*, and *matériel*.

I. ORGANIZATION.

Under this head will be considered those causes which act to destroy our health as a body.

1. A WEAK ORGANIC STRUCTURE.

The general subject may be compared to a man who has a piece of work to perform. If he be strong, healthy, has a good constitution, and is well skilled in the use of suitable instruments, he will do it with intelligence and comparative ease. Given the requisite health, vigor, food, and tools, with a clear insight into the duty repuired, and few difficulties will appear.

But poor tools produce delay and fatigue, poor skill produces inadequate results, poor food destroys the health; but organic disease destroys the life. In the latter case there is no hope for the patient except through its permanent removal. As with the sick man, so it is with our artillery. As one already having a constitutional weakness may by indulgence in improper food and neglect of exercise so pervert his system as to render him incapable of taking proper sustenance, so it is with our arm, which through time misapplied and energies misdirected is so run down that it turns from a correct diagnosis of its case and hesitates to accept the only remedy which will restore it to efficiency. Keeping this fact well in view, the first thing to be done in order to obtain a strong artillery is to create a sound organic structure. Having once achieved this we shall have removed one of the greatest artillery difficulties that now oppresses us and will have paved the way for the removal of most of the others.

2. THE ABSENCE OF A CHIEF OF ARTILLERY.

On emerging from the Civil War we were practically field artillery. Since that time our history has been one of aimless drifting from one thing to another, but in all the vicissitudes through which we have passed we have never struck upon our legitimate coast artillery duties.

A few years ago an appreciation of the country's defenseless condition brought about a kind of reaction, and for once in our history we found ourselves beginning to take an interest in artillery questions. The habits and methods of years, however, could not be left off in a day, so that now though progressing, the movement is slow. Each regiment, post, and battery is following its own independent line of operation without concerted action or system from which alone valuable results can flow. In this work we are drifting pretty much as before, and the fact that we are showing interest in our own professional work must be regarded as more or less accidental, since a change in the present administration of our affairs may cut it off at any time. We have not yet been long enough at the work to have become imbued with it and it is by no means popular or fashionable. So long as each officer in charge can carry out a scheme of instruction or practice in his own way, do it in a perfunctory manner and hurry through it to engage in more agreeable duties we can make but slow progress. The instruction of a battery at target practice for example should be made "popular and fashionable." All these "go as you please" methods should be bridled and brought in with a strong hand, and made to move with uniformity and singleness of purpose. This will be the work for a Chief of Artillery.

A chief would obtain suitable instruments, see that they were in order, and uniformly and intelligently used. He would lay out practical and theoretical instruction and by a systematical course of artillery inspections see that they were carried out and made efficient. He would prescribe experiments to be made from time to time, to obtain necessary or useful data, collect and classify the results and disseminate them amongst his corps. More generally speaking, he would supervise artillery work, study its needs, coördinate its methods, supply information and encourage and develop artillery enterprise. Thus keeping himself ever abreast of his profession and awake to the progress of his arm he would institute and administer a system of reform, gather about him a staff of energetic assistants through whom he would command and educate the arm and prepare it for any emergency.

There is in this country no field so unoccupied and yet so full of promise as that of future artillery.

To develop this field we need a man at our head who can grasp this fact and the far reaching effects of a proper organization, and who can direct our movement toward the great opportunities before us.

3. UNION OF COAST AND FIELD ARTILLERY.

The dual nature of our artillery is a third point of weakness in our system. Officers are periodically transferred from heavy to light and from light to heavy service without regard to fitness or preference. While the manifest object of this course is to give instruction in both branches of artillery, we believe that the opposite effect is produced. Two years is certainly a short time in which to learn light battery duties, while a lifetime is not too long for those of the coast artillery. The two years avocation in the life of the heavy artillerist is not however the principal disadvantage resulting from this practice. It unsettles each one in turn, not only in place but in thought. Investigations in subjects of one service are unexpectedly broken up and all interest in it practically destroyed. Such practice is contrary to that of all other institutions, not one of which could for any time withstand such draughts upon its resources. In our case, however, held together with the artificial forces of law we cannot go to pieces however far our efficiency may fall. Instead of having these disrupting forces in our combined services, would it not be better to introduce into each, separately, natural central forces, which, acting with the artificial ones present, would tend to make each an inherently strong and efficient body. All causes we believe, looking to the highest development of both, require their separation.

4. DIVIDED RESPONSIBILITY.

Passing now from our own arm to its relations with the other technical corps we find that the three departments are practically independent of one another. Having no direct responsibility to the others, each may prosecute its work along its own line without coöperation. This may some day lead to friction and want of adjustability.

Forts are now in progress of construction and guns will soon be placed on them, yet we as artillerists, who will use these guns, have no settled policy as to their grouping with respect to tactical considerations.

A tactical system of controlling the guns will have to be developed in future to suit whatever combination happens to be adopted in the construction of the forts; the opposite of this should obtain. The parapets and emplacements may be ready before the carriages and appurtenances have been officially adopted, and so on throughout the list. Our whole scheme for defense seems to be wanting in coherence, harmony and systematic action. The artillery has no effective means of making its needs felt and having them attended to. A machine, when tried under service conditions, may fail; the artillery can neither correct it nor have it corrected. The routine method is long and tedious and great injury to the service may result from delay.

To be an efficacious arm we must know at all times the value of our weapons, and whether our material is in good order and will stand the tests of war. This can be known only by using it. When a piece of apparatus is found to be defective the remedy should be prompt and decisive. The present state of divided responsibility may some day cause disaster. History already furnishes many instances of disaster in war due to this cause, and will doubtless furnish many more. In the case now in question, although central authority is behind all of them, it is, we think, too distant and indefinite to give prompt and decisive action. There must be but one commander-in-chief to give directions in emergency.

The three departments to which the country's defense is intrusted have a common aim and object and it is in the interest of all to work in closest touch with one another; the sentiment of unity of purpose should not be discouraged, but cultivated and strengthened by the freest discussion of all subjects relating to sea-coast defense. The present state of affairs is unfortunate; nobody is to blame; it is a bad system. If in future these three departments must remain independent, could not all questions affecting them collectively be disposed of by a representative board of officers whose action would be authoritative and final.

II. INSTRUCTION.

Judging from present signs, the future coast artillery will consist of a personnel thoroughly instructed theoretically and practically in all that pertains to the preparation and use of heavy artillery.

I. THEORETICAL EDUCATION.

To clearly grasp the detailed functions required of a sea-coast fort a thorough understanding of the general object of the place becomes necessary.

This object being to repel a naval attack the first lessons should be devoted to a careful study of the navies of the world; the means of recognizing them; the effective strength of each, and their methods of attack. Without some information on these subjects the defense will know nothing of the forces against them and be ignorant of their probable course. The instruction should if possible be carried still further, so as to obtain a clear idea of the nation's war policy and views of its leading men. This information should be utilized in studying modern sea-coast fortifications in their various forms and the conditions to be fulfilled by them; and a thorough analysis made upon modern basis, of the attack and defense of sea-coast works. This analysis being worked out for one or more of our important harbors would develop the fundamental principles involved. We have nothing touching these important subjects in our present instruction, and yet it cannot be denied that the want of familiarity with them is a serious omission. The want of acquaintance with modern naval tactics, sea-coast fortification, tactical organization suited to given conditions, and the means of administering suitable instruction and drill, indicate a want of appreciation of some of the most important considerations in our profession. If the necessity for acquaintance with them does not present itself now it may some day, when it will be too late. While we are neglecting them it must be remembered that the necessity for them remains and that time should be given them in proportion to their importance.

Next in order would follow a course of theoretical study of all the minor problems of gunnery and considerations relating to defense. This is especially important with respect to artillery, since many of its problems admit of exact solutions. In all such cases theoretical study will save great labor and expense. As these facts become more pronounced and appreciated our officers cannot but feel that their facilities for study do not keep pace with the demand, and find themselves from day to day engaged in a struggle to obtain the necessary books and information. Artillery posts, furnishing facilities for theoretical investigations, are rare and, as a rule, officers are thrown upon their own resources and compelled to work along without aid or encouragement. Professional books are expensive, and unless he makes unusual efforts the officer cannot keep pace with the advance around him. Here once more is an unfortunate state of affairs, the direct result of having no head and no system. While this condition is a bar to all uniform progress, its amelioration in a great measure seems but a simple matter and requires remedies well within the power of our authorities. Briefly stated, we believe the following policy would accomplish the greatest improvement in this direction:

First.—The establishment of an efficient bureau of artillery information at the *United States Artillery School.* Such a bureau could be developed and organized in a few years so that an officer at any post investigating a special subject could obtain all relevant information in the bureau without difficulty or delay. This department, if energetically handled, would soon contain all the important results of artillery development of recent years and distribute its collections throughout the service.

Second.—Aid and encouragement as far as possible in obtaining books and professional papers by the War Department.

Third.—An efficacious means of discussion and interchange of opinions on doubtful or unsettled subjects. This proposition, if carried into effect, would collect useful data and fill the arm with new life and hope.

Fourth.—The principle of the "division of labor" should be adopted and applied to our work. The present artillery requirements are so varied and exhausting that one mind cannot become proficient in all. In scientific and business professions no one attempts to master all branches; on the contrary, the above mentioned principle is carried to its limit. Little progress was made in civilization, science or art until it was followed. It pervades and rules every human institution except our army. Nevertheless, when we consider the subjects comprehended in an artillerist's profession, it seems clear this principle should find double application.

Modern artillery, in order to secure maximum efficiency, exhausts the domain of *mathematics* with its applications to mechanics, ballistics and thermodynamics; embraces all the principles of *engineering*, with its applications of the strength of materials and other innumerable considerations, to gun construction, electricity, metallurgy and steam; and elicits from *chemistry* results with respect to powders and explosives immeasurable in value. In fact all physical sciences must be studied and used, and as the present phase of artillery makes these demands extensive in comparison with the past, so will future requirements be so in comparison with present. In addition to the above mentioned sciences, and in direct touch with the artillery profession we find the subjects of the armaments of the world, naval tactics, attack and defense of places, siege operations, mines and torpedoes, organization and administration of fortress artillery, and many others which are artillery necessities. According to our present methods the artillery officer is also required to keep himself proficient in the art and science of war, reconnaisance, surveying, grand and minor tactics, drills of all arms, practical exercises and use of all kinds of instruments. One can scarcely hope to master this array. It should be remembered that an artillery personnel are only men after all, whose minds are not infinite and who cannot, with reason, be expected to master all the parts of a profession whose scope practically embraces all the arts, sciences and material considerations in existence.

As now pursued our instruction is merely a smattering, which is scarcely retained until learned, and produces no permanent good to the service. Our methods are contrary to the practice of all progressive institutions and the great principle which actuates the movements and resources of the world.

Judging from these and many other relevant facts, we are forced to the conclusion that a great part of our work should be done by specialists.

A man having signified his intention to pursue a certain course of study should, as far as possible, be aided and encouraged by his fellow-officers, his arm, and by all who may be interested in his work. In this age new and original work can be done only by specialists, so that if we in ourselves hope to increase our stock of knowledge this is the only way. We cannot go on copying ideas after our past practice, and maintain even our present place, we must create; we must be pioneers in the work or fall still further behind. Even a mediocre standard will never be reached by borrowing old or obsolete ideas.

So far we have referred to officers only. We question the necessity for giving non-commissioned officers and cannoneers theoretical instruction. In cases where it is to be given, it should be according to a system and with a definite end in view.

2. PRACTICAL EDUCATION.

This is beyond question the important part of the instruction of an artillery personnel. Theoretical and practical men have wrangled and are still wrangling over the values of their respective methods and usually each has missed the true function of the other's work. Theoretical investigations may be considered a means, the practical application an end. In artillery science the former is invaluable, the latter indispensable; the one an essential, the other a necessity. It is only by reducing our fund of information to blows that we can accomplish our object. The weight, accuracy, and rapidity with which we can deliver them, and the skill with which we can mass them on a given point will show how well we have learned the lessons of modern artillery war. A complete mastery of all theoretic principles and a thorough and judicious turning of them to practical account, is therefore the result to be striven for and its achievement will demonstrate our readiness for war.

(1) *Reduction of scientific data.*—The results of all scientific researches, generalizations, and deductions should be reduced to practical form that they may be used, when needed, with celerity and certainty. This reduction we believe essential to success; its importance cannot be estimated. Every course of instruction should lead either directly or indirectly *to the solution of the problems which will actually arise in war.* Until now our arm seems to have been afflicted with tangential tendencies, and has suffered from a chronic state of missing the main issues. These are the inevitable effects of any system which is wanting in strong central forces necessary to keep the component parts in their proper orbits. If we wish in future to become a progressive, living arm of our service and carry respect and influence with us we must leave off amusing ourselves with these side issues and go straight to the main ones before us. The small arm must be relegated to the shelf and the artillery be armed, equipped and drilled as artillery. Artillery work must take its place at the front without apology and stand out in relief in proportion to its importance.

At this point we will bring forward, as of first importance, the determination of essential data. Range-tables must be computed and kept on hand for emergency; suitable tactics must be developed and a thousand smaller matters settled during peace, or be ignored in war. This may be considered preliminary work, as it is simply accumulated for use in drill and combat. At present the results of such work, if any exist, are in a hopeless condition. There is to-day scarcely a reliable range-table for our guns in existence, and the same may be said of all other ballistic data.

(2) *An Artillery proving ground.*—The Ordnance Department has in the past furnished us tables in a few cases, but this department being strictly one of supply and construction, has justly held aloof from that which was beyond all question artillery work. Furthermore, their proving ground being fully occupied

in testing guns, carriages, and making other experiments in ordnance, they have not time, had they the inclination, to construct our tables for us. Here then is a field, until now neglected by us, which must be occupied energetically and permanently. We need to commence with an exhaustive course in the solution of practical ballistic problems.

We are constantly learning how to do such work but are never doing it. The question here confronting us is not to know how to do artillery work, it is to do it. This most desirable result can only be attained at a well equipped artillery proving ground. The want of such a ground now bars, and until obtained, will continue to bar artillery development.

A type gun having been tested at the ordnance ground should go directly to that of the artillery and there be fired until all useful elements of fire have been ascertained. In this manner all ballistic theories would be tested, and from the actual results measured on the range complete gunnery tables should be constructed and arranged conveniently for use. When a gun had passed through this process no information, with respect to it, should be wanting. A complete record of the gun and its action would form a part of the gun's battery equipment.

The ground would be commanded by an artillery expert and operated by a number of officers who would at the end of a definite term be replaced by others, and return to their batteries to put into application the information gathered from their experience at the proving ground. This policy would bring artillery officers into their true sphere of action, keep them in touch with scientific gunnery and introduce into the arm a vast amount of theoretical and practical information.

In addition to the preceding results all carriages and varieties of mechanism would go there and be thoroughly tried under service conditions and their suitability and efficacy determined before assignment to the troops. Gun tactics would then be developed at the ground and ready to put into execution at the earliest moment.

With these data on hand their application remains. This brings us to the last stage of the instruction and in touch with the gun.

The preceding work must be done in peace, or remain undone, for when once the battle is on it will be too late; this will not be the time to figure, but the time to fight.

In many experiments in the instruction of a battery, observations with nice instruments will be necessary. It must be clearly understood that they will not be used in time of attack. During drill, measurements of range, deviation, and other elements become essential to a complete study of results with view to future corrections, and mark an important distinction between *drill* and *war*.

(3) *New methods of drill.*—Our whole system of drill at the gun must be replaced by new methods. As now carried out, a great deal of time is spent in teaching the detachment nothing. The instructor prescribes with minute accuracy how the staff shall be grasped and inserted in the bore but he does not insist on its uniform insertion, to the same point. While the former is insisted on and the latter neglected, it makes comparatively little difference in a ballistic sense how the staff is put into the bore, provided it goes to the same place each time. Again our continued drilling without cartridge or projectile renders it impossible to attend to uniformity of loading and other important details. Every drill should be performed with a perfect cartridge and projectile and the greatest care given to the above considerations. Correct allowances for the day should be ascertained and made for the assumed range, and repeated until they can be made without hesitation. The exercise should include instruction in handling fuzes, powder and shot, and progress as if engaging the enemy. We must remember that "fancy movements" are very well in their place, but they form a very small part of the instruction of a battery. We must not drop the bone to grasp at its shadow. Æsthetic considerations of drill should be set aside for special occasions and so conducted that there would be no possibility of being mistaken for serious work. For, if, in this discussion, there is one thing that is clear to our mind, it is that the future successful soldier must put away his gay dress, quit posing for effect, take up the stern

realties of his profession and pursue them according to business principles. It cannot be too strongly emphasized that business with us will mean work and that our work is war.

(4) *Permanent assignment of batteries to guns.*—Batteries should during peace, be permanently assigned to particular groups, and platoons and detachments to particular guns. Excepting drills to familiarize cannoneers with the duties of other guns, all drills should take place at the guns assigned and the battery made thoroughly proficient in their use, since it would man these guns in time of war. In this scheme the cannoneers would be trained to fall in at their own guns ready for conflict at a moment's notice and exercised in target practice and battle exercises. In this manner the cannoneers would learn their guns as the infantryman learns his rifle. When this had been well mastered, further drill should be given with fixed numbers, with view to giving each *man the maximum preparation for his duties in emergency.* Each battery would care for its own material and be responsible for its condition at all times. Weekly and monthly inspections at the guns, advantageously replacing the present infantry inspections, would determine a battery's standing and elicit progress made.

As things now stand, were an alarm to sound, interminable confusion would prevail, orders would be given and countermanded, batteries would get in each others way and valuable time would be lost. This difficulty can be avoided by settling beforehand what must be done, in case of susprise, and doing it until each man knows his post and duties.

Portions of a harbor will be directly controlled by certain batteries and definite orders concerning them could be prescribed, for contingencies, and laid down in the general scheme of defense. This would enable the commander of a group of guns to make his general arrangements without further instructions. This implies on the part of the officer a thorough acquaintance with the harbor, the scheme of defense and the details of the part his guns are to play.

(5) *A definite scheme of defense.*—For a thorough and intelligent coöperation of the whole defense, all officers must understand the ultimate end to be obtained. To this end the commanding

officer should have the scheme of defense always on hand and instruct his command in its details. It should always be ready for study and criticism. So far, instruction in our army has been limited to lieutenants and non-commissioned officers. This is unquestionably a mistake, for in time of war captains, majors and colonels will have duties to perform, These duties should within limits be prescribed and considered by their respective grades. This system contemplates the theoretical and practical education of each officer in those duties which will probably be demanded of him in war. Thus would lieutenants be instructed in the duties of lieutenants, captains in those of captains, colonels in those of colonels, and generals in those of generals.

(6) *A thorough course of target practice.*—When the drill at the guns reaches the highest standard the command is ready for a thorough course in target practice. In this exercise we apply all our previously collected information and in its combination we ascertain our ability to hit. This is the branch of our work which must not fail. This practice, as far as possible, should be devoted to the ascertainment of rules and methods which will serve as future guides for the gunners. It should also be utilized in supplementing the proving ground work, especially with those guns which have not been tested. Too much time and attention is given to tentative methods of hitting the target, allowances being made first to one side and then to the other without any intelligent reason for doing so. It would be better to miss the target a score of times and learn the deviating causes, than to hit it accidentally. On account of this tentative method we have and shall continue to have practice without results. The main object of the practice—the determination of rules and processes to be used in war—seems to have been lost, and in its place spectacular effects are sought, it being considered of more importance to splash the target than to demonstrate a principle. To rush it through and pass to more agreeable duties seems to have been the order of the day. It is greatly to be regretted that this sentiment prevails and that in many cases it takes refuge under the pretext that it is useless to waste time in attempting to accomplish anything with our old guns and that it will be time enough to commence work when the new guns

arrive. This shows that we are not yet ready to give to our profession the plodding labor which it deserves and which it exacts for profitable returns. It was so when our present guns were new and will obtain in future with new guns, unless a complete change takes place first in the present conception of the object of target practice, and second in regard to the intelligence and motive with which it is carried out. We must not deceive ourselves into thinking that when we have new guns it will be an easy and simple matter to use them. The science of gunnery, like geodesy, requires the most painstaking attention to details, in order to secure valuable results. The prevailing sentiment until now pervading our work is wrong, and we here record an urgent protest against it. Gunnery is not changed by the kind of gun any more than astronomy by the kind of telescope. The principles of loading, aiming and firing remain the same whether the gun be a muzzle or breech loader. For the old guns the error will be greater and the target struck less often, but that is all. The above argument would disarm the infantry and stop all practice, because that arm expects soon to be armed with a small-caliber rifle. And yet, is not the continued practice with the old weapon preparing them for the use of the new? Will not the use of the old ammunition, after the adoption of the new, make these men better able to use their new gun effectively? These questions admit, we believe, of an affirmative answer only. If this answer be true for infantry it must be many times more true for artillery.

Our present scheme for target practice needs further extension and development.

Judging from present tendencies, the following conditions will be elicited in future war and should as far as possible be considered during peace and embraced in a well digested system of target practice:

a. Practice at fixed targets.

When ballistic machines are present *they should always be used* and data for the following exercises determined.

b. Practice at a target moving at different speeds, both in daylight and at night. For this work some kind of tracking instrument is necessary to show the continuous path of the moving object.

The observing telescopes of such an instrument, if furnished with an open sight alidade, will enable the observers to stop turning their telescopes as the shot strikes and plot it with the independent sights. The target's position being marked by the stopping of the path, the impact of shots can be plotted on the same map. A transit behind the gun, constructed for continuous motion and carrying a movable hair, would measure all deviations and check the preceding observations. The results should be carefully plotted on the original map and critically studied. This study should seek causes of error, defects in apparatus and suggest improvements. When this practice had been completely analyzed and mastered and methods corrected, all apparatus with view to preliminary instruction should be thrown aside and the experiment repeated as if in actual battle. In this case the instruments of battle only should be used, and the fact impressed upon all. Time spent on this drill will never be wasted. If it be impracticable to have such drill at all artillery posts the officers and non-commissioned, at least, should be annually concentrated at central points where the practice can be held.

c. Practice by indirect laying at fixed and moving targets.

In future this kind of fire must under certain circumstances be used, especially when the enemy can be seen from points of observation, but not directly from the battery. In such cases direct fire becomes impossible. Basing the statements on some experience, we believe that this kind of fire can be made more accurate and efficacious than any other and it should be developed to its extreme limit.

In the final adoption of a target system and other subjects connected with our theoretical instruction, it must be remembered that in regard to these questions there is no such thing as "peace footing." All movements during peace must look to ultimate war.

The preceding remarks in reference to organization and education we believe cover the most important considerations embraced under these heads. In the good organization the sick man is made well, in the proper education he obtains food which gives him the mental strength and will to grasp and handle his tools; the latter remain to be considered.

[TO BE CONTINUED.]

NOTES ON ARTILLERY.

The Angle of Jump and its Measurement, by Colonel Siacci, Royal Italian Artillery. Translated from *La Revue de l'Armée belge*, by Laurence V. Benét, Artillery Engineer, Hotchkiss Ordnance Company, Ltd.

I.

It is well known with all descriptions of guns, that the angle of departure does not coincide with the angle of elevation of the piece before firing. This was formerly attributed to the balloting of the projectile in the bore, but since the development of breech-loading guns and banded projectiles this explanation has lost all value, and the recoil is now indicated as the cause of the difference between the two angles. As a matter of fact, the recoil (by which we mean the complex motion of translation and rotation imparted to the gun and carriage by the discharge) commences while the projectile is still in the bore, and when it reaches the muzzle, the axis of the gun is no longer in its original position. It cannot be inferred, however, that the projectile leaves the muzzle in the direction of the axis of the piece at this instant, for although the center of gravity of the projectile describes a straight line along the bore, it actually describes a curve in space on account of the rotation of the gun, and leaves the muzzle in the final direction of this curve.* This direction corresponds to the resultant of the initial velocity, and the velocity of rotation of the axis of the piece at the moment the projectile leaves the muzzle.

In the case of small-arms, the difference between the angles of elevation and departure was, and is still attributed, to a certain extent, to the vibrations of the barrel.† In the case of artillery, however, such vibrations have never been observed, and if they do occur they cannot exert as great an influence as does the recoil. This is demonstrated by the fact that the greater the recoil, that is the greater the ratio of the weight of the projectile to that of the gun, the greater the angle of jump. The 15-cm. (Italian) shell, for instance, according as it is fired from the gun, howitzer, or mortar, gives angles of jump which vary between the respective limits of 5′ to 12′, 18′ to 23′, and 34′ to 57′.

The object of this paper is not, however, to explain the cause of the angle of jump, but to review the methods employed for its measurement, and to propose a new method which is more exact than those heretofore followed.

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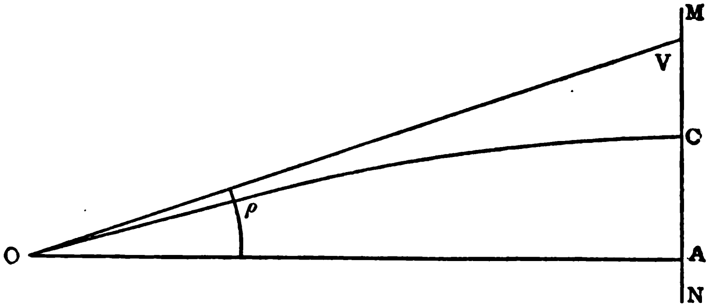
* See *Journal of the U. S. Artillery*, Vol. I, page 386.—EDITOR *Journal*.

† Didion, *Balistique*, 1860, page 389. See also *Mémorial des Poudres et Salpêtres*. Vol. IV, Paris, 1891, page 79.—(Note of translator.)

II.

The method universally followed for determining the angle of jump is the following:



A number of rounds are fired at a vertical screen *MN*, and the distance of the center of impact *C*, from the point aimed at *A*, is measured A distance *VC* equal to the space through which the projectile would fall under gravity while transversing the distance *OA* is laid off above *C*, and the angle of jump is computed by the formula:

$$\tan \rho = \frac{AV}{OA}$$

It is readily seen that while this method is more or less approximate, it is not exact. As a matter of fact it supposes that when the projectile leaves the muzzle, the gun has not moved, that is that the muzzle is still at *O* as before firing.

It is undoubtedly true, that in the very short time employed by the projectile to traverse the bore, the gun will be displaced by a very small amount, but however small this may be, the error arising from the supposition that the muzzle has remained at *O*, will be more or less negligible according to the distance *OA*.

The Prussian *Handbuch* says that this distance should be such that the blast will not damage the screen.[*]

The French *Aide-Mémoire* calls for a distance of fifteen metres.[†]

Colonel D. Diego Ollero, of the Spanish Artillery, proposes not less than 100 metres.[‡]

The French Marine Artillery employs from 400 to 500 metres,[§] but as at these distances the resistance of the air is already sensible, the measure of the angle of jump is combined with a special determination of this resistance.

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[*] *Handbuch für die offiziere der Königlichen preussischen artillerie. Zehnte Abtheilung*, page 16.

[†] *Aide-Mémoire à l'usage des officiers d'Artillerie.* Fourth edition, chapter XV, page 37.

[‡] *Balistica.* Madrid, 1890, page 415.

[§] Hélie. *Balistique expérimentale*, 1884, vol. II, page 265. In the trials of the Hotchkiss 10-cm. rapid firing gun at Gâvre, June 11th, 1889, the angle of jump was determined at a range of no less than 1325 metres.—(Note of translator.)

We have already recommended from 20 to 60 metres,* but in the presence of the distance employed by the French Marine Artillery, the former figure may appear too small, although greater than the distances proposed by the *Handbuch* and the *Aide-Mémoire*.†

III.

In order to obtain the angle of jump freed from the error which may arise from the displacement of the muzzle, the following method may be employed, which requires no special determination of the resistance of the air. This method is quite as simple as that usually followed, and utilizes the rounds fired for the measurement of initial velocity. It also affords a means of determining the amount of the displacement of the muzzle at the moment the projectile leaves the bore.

The gun being mounted for taking velocities, place a card-board target of convenient size close behind each of the velocity screens. Mark on these targets the points P_1 and P_2 where the natural line of sight intersects them, and fire.

Let x_1 and x_2 be the distances from the muzzle to the targets;

a_1 and a_2 the distances between the centers of impact O_1 and O_2 and the points P_1 and P_2;

V the instrumental velocity as given by the chronograph;

ρ the angle of jump;

b the vertical displacement of the center of the muzzle;

r the vertical distance of the line of sight from the axis of the bore.

Then we shall have:

$$\left.\begin{aligned} \tan\rho &= \frac{g}{2V^2}(x_1+x_2)+\frac{a_1-a_2}{x_2-x_1} \\ b &= r-\frac{gx_1x_2}{2V^2}-\frac{a_1x_2-a_2x_1}{x_2-x_1} \end{aligned}\right\} \quad - \quad - \quad - \qquad (A)$$

Demonstration:—Before firing (Fig. II), let A be the muzzle of the piece; P, P_1, P_2 the natural line of sight which we suppose parallel to the axis of the bore, and making an angle α with the horizontal. At the moment the projectile leaves the bore, let O be the muzzle of the piece, and O, O_1, O_2 the trajectory, and finally let Q_1, Q_2, and R_1, R_2 be the points in which horizontal lines through O and A would intersect the targets.

The distances x_1 and x_2 being very small, the trajectory O, O_1, O_2 will differ very little from a parabola having for its equation

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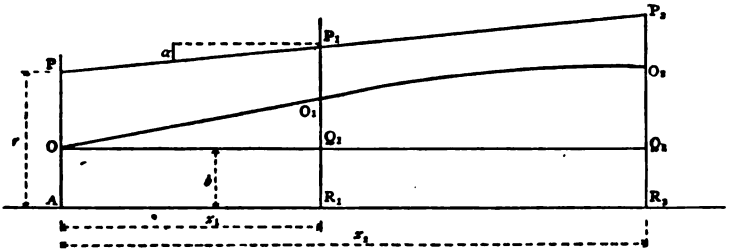
* *Balistica.* Turin, 1889, page 141.

† For the determination of the angle of vibration (*vibrations-winkel*) of small-arms, Mieg is satisfied with 10 metres (*Aussere Balistik*, Berlin, 1884, page 100). This officer makes the hypothesis that the barrel revolves as a rigid system about its rear end, and also that the bullet leaves the muzzle in the direction of the axis of the bore. We must observe, however, that the hypothesis of rigidity is in contradiction to that of vibrations of the barrel. In addition it cannot be admitted that the bullet leaves the bore in the direction of the axis. In reality, as we have explained, it leaves the muzzle in the direction of the resultant of the initial velocity and the velocity of rotation of the gun barrel.

$$y = x\tan\phi - \frac{gx^2}{2V^2} \qquad \text{- - - - -} \qquad \text{(B)}$$

wherein ϕ is the angle of departure. For the point O_1 we have from the figure:



$$y_1 = Q_1O_1 = P_1R_1 - P_1O_1 - Q_1R_1 = x_1\tan\alpha + r - a_1 - b$$

and for the point O_2

$$y_2 = Q_2O_2 = P_2R_2 - P_2O_2 - Q_2R_2 = x_2\tan\alpha + r - a_2 - b$$

Substituting for y_1 and y_2 their values from (B) we have:

$$\left.\begin{aligned} x_1\tan\alpha + r - a_1 - b &= x_1\tan\phi - \frac{gx_1^2}{2V^2} \\ x_2\tan\alpha + r - a_2 - b &= x_2\tan\phi - \frac{gx_2^2}{2V^2} \end{aligned}\right\} \qquad \text{- -} \qquad \text{(C)}$$

α and ϕ being very small, we may write $\tan\phi - \tan\alpha = \tan(\phi - \alpha) = \tan\rho$, and from equations (C) we readily deduce the formulas (A).

The above method was tested last May at our School of Application for Artillery and Engineering, with the 12-cm. bronze B. L. gun ($r = 0.135$ metres), mounted on the light siege carriage. The following table gives the results of the experiments:

Charge.	Number of rounds.	x_1	x_2	a_1	a_2	V	ρ	b	ρ_1	ρ_2
kgs.		metres.	metres.	metres.	metres.	metres.		metres.		
0.500	8	11	23.1	0.112	0.131	143.6	22′	—0.020	16′	19′
0.900	6	11	31	0.119	0.131	217.2	13′	—0.013	9′	12′
1.700	7	11	41	0.075	—0.031	321.2	21′	0.000	21′	21′
3.600	6	11	56	0.092	—0.026	457.8	14′	0.000	14′	14′

The values of ρ_1 and ρ_2 in the last two columns are the angles of jump that would have been found had a single target been employed. These values of ρ are computed by means of the following equations:

$$\tan\rho_1 = \frac{gx_1}{2V^2} + \frac{r-a_1}{x_1}$$

$$\tan\rho_2 = \frac{gx_2}{2V^2} + \frac{r-a_2}{x_2}$$

From the experiments we find that in firing with the two lower charges, the muzzle of the gun was displaced downwards by twenty mm. and thirteen mm. respectively, small amounts it is true, but which cannot be neglected. If they were neglected as when the usual methods are followed, we would find angles of jump considerably below the truth, as is apparent from the table.

IV.

The displacements of the muzzle were so small, that it may be thought that they were more apparent than real, that is that they are numerical results due to an insufficiently exact measurement of the velocity V, or to leaving out of account the resistance of the air. This doubt is immediately dispelled, however, if we compute the errors we must admit in the measurement of V, to account for the displacements of twenty mm. and thirteen mm. found with the first two charges. It is only necessary to make $b = 0$ in equations (A) and determine the value of V; we find:—

$$V = \sqrt{\frac{\frac{1}{2}gx_1x_2}{r - \frac{a_1x_2 - a_2x_1}{x_2 - x_1}}}$$

whence we find for the charge of 0.500 kgs.:—

$V = 176.4$ instead of 146.3, a difference of 30.1 metres, and for the charge of 0.900 kgs.:—

$V = 269.6$ instead of 217.2, a difference of 52.4 metres.

The magnitude of the differences shows conclusively that whatever may have been the actual errors in V, the computed displacements of the muzzle cannot be attributed to them.

The displacements are therefore real; but how then explain the angle of jump? It is apparent that the downward displacement of the muzzle can only take place through a downward rotation of the chase, the more so if the carriage turns, as it apparently does, about the point of contact between the trail and the ground, the wheels rising and with them the axis of the trunnions. This downward rotation of the chase must therefore be due to the reaction of the elevating screw, when struck by the breech of the gun. But if the projectile left the muzzle while the chase was descending, or when it had its maximum displacement, the angle of jump would be negative. As it is on the contrary positive, we must conclude that the projectile leaves the muzzle while the chase is rising after its downward movement.*

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* If we admit that the axis of the trunnions has returned to its original height (from the ground) when the projectile leaves the muzzle, we may readily compute the vertical velocity of the latter. This velocity v will be given by:

$$v = V_0\left(\tan\rho - \frac{b}{l}\right)$$

V_0 being the initial velocity, and l the distance from the axis of the trunnions to the muzzle. In the experiments just cited, $l = 1.778$ metres, and we find for the four charges respectively $v = 2.5$ metres, 2.4 metres, 2.0 metres and 1.9 metres.

Whatever may be the explanation of the facts, it is certain that sensible movements of the muzzle take place, or may take place, and that consequently the old method of determining the angle of jump should be abandoned, or solely reserved for firings at considerable ranges wherein the resistance of the air is measured and taken into account. At all events the employment of two targets will always be more exact as well as simpler and more convenient. It gives in addition data (the displacement of the muzzle), which the old method cannot give, and which may throw some light on the obscure phenomena of recoil.

Report of tests of The Brown Segmental Tube Wire Gun.

Trustees Brown Segmental Wire Gun,
Gentlemen:

I have the honor to submit the following report of the preliminary firing, of the completed five inch B. L. Experimental Rifle.

The firing consisted of a private and a public test, at each of which three rounds were fired.

PRIVATE TEST, APRIL 12th, 1893.

First round.—Charge, 19.79 lbs. of DuPont's Brown Prismatic Powder W. F., lot 2. Specific gravity, 1.810. Granulation, 24 to the pound., being 7 prisms of black and 468 prisms of brown powder. Weight of shot, 62½ lbs. Pressure obtained, 26382 lbs. per sq. in.

Second round.—Charge, 24.54 lbs. of the same powder, being 7 prisms of black and 582 prisms of brown powder. Weight of shot, 62½ lbs. Pressure obtained, 34,231 lbs. per sq. in.

Third round.—Charge, 30.83 lbs. of the same powder, being 7 black and 715 brown prisms. Weight of shot, 62½ lbs. Pressure obtained, considerably in excess of 60,000 lbs. per sq. in.

The coppers used had an initial compression of 40,000 lbs. per sq. in. Estimating on the basis of the tabular difference for coppers of this initial compression, would indicate a pressure of 66,200 lbs. per sq. in. Two gauges were used.

PUBLIC TEST, APRIL 15th, 1893.

First round.—Charge, 19.79 lbs. of the same powder as in private test, 7 black and 468 brown prisms. Weight of shot 62½ lbs. Pressure obtained. 25,200 lbs. per sq. in.

Second round.—Charge, 24.54 lbs. of the same powder, 7 black and 582 brown prisms. Weight of shot. 60 lbs. Pressure obtained, 33,800 lbs. per sq. in.

Third round.—Charge, 30.83 lbs. of the same powder, 7 black and 715 brown prisms. Weight of shot, 60 lbs. Pressure so far above 60,000 lbs. per sq. in., that it was impossible to estimate its approximate value.

In order to give the artillerist an idea of the character of the phenomenal pressure obtained, I give the following extract from the pressure table furnished by the Ordnance Department from the Watertown Arsenal, also the record of the pressure gauges.

Lieutenant E. St. John Greble, 2nd Artillery, kindly consented to assist in making the test, and brought with him from Sandy Hook one of the government gauges. This gauge was used, together with one of our own at each discharge. The pressure records obtained by the two sets of gauges were practically the same, the pressure given in this paper being the mean of the two gauges.

PRESSURE RECORD OF LAST ROUND.

Three gauges were used. Gauge No. 1 contained a copper compressed to 40,000 lbs. per sq. in. Gauge No. 2 a copper compressed to 50,000 lbs. per sq. in. Lieutenant Greble's gauge, a copper compressed to 40,000 lbs. per sq. in.

	Gauge No. 1.	*Gauge No.* 2.
Initial compression	40,000 lbs. per sq. in	50,000 lbs per sq. in.
Original length	0''.3276	0''.2782
Final length	0''.1620	0''.1918
	0''.1656	0''.0864

The copper in the government gauge was so distorted that the compression could not be measured.

EXTRACT FROM PRESSURE TABLE.

Pressure.	Corrected Compressions.	
lbs. per sq. in.	I. C. 40,000 lbs. per sq. in.	I. C. 50,000 lbs. per sq. in.
59,000	0''.0812	0''.0333
59,200	0''.0818	0''.0339
59,400	0''.0823	0''.0344
59,600	0''.0828	0''.0349
59,800	0''.0835	0''.0356
60,000	0''.0841	0''.0362

It will be seen at a glance that the compression of the copper in gauge No. 1, 0''.1656 is nearly double the compression corresponding to 60,000 lbs. per sq. in. for a forty thousand copper. And the compression of the copper in gauge No. 2, 0''.0864 is more than double that for a fifty thousand copper for the same pressure. Therefore the pressure in the gun greatly exceeded 60,000 lbs. per sq. in.; how much, it is impossible to estimate.

I have, however, forwarded the compressed coppers, together with others, to the Chief of Ordnance, with a request that experiment may be made at Watertown Arsenal, in order to determine the probable pressure.

The copper in Lieutenant Greble's gauge also indicated a phenomenal pressure, although it could not be measured.

CONDITION OF THE GUN AFTER PRIVATE TEST.

After each round the gun was carefully examined. The only thing noticed was a slight movement of the liner, and movement of the chase jacket.

After the test was completed the gun was carefully examined and star-gauged. It was found that precisely as in the case of the test cylinder, the entire bore had become slightly smaller, due to the settling together of the segments; there had also been a slight movement of the liner, otherwise the gun was found intact and in splendid condition.

The movement of the liner had been expected; the same thing occurred in the cylinder and is of no consequence, as it can readily be prevented.

The movement in the chase jacket consisted of a very slight opening of the joints, which closed again as soon as the gun became cool.

AFTER PUBLIC TEST.

Nothing of importance was noticed after the first two rounds, except a slight movement of the liner and the opening of the chase jacket. At the last discharge a few unimportant bolts were broken in the hinge plate of the breech mechanism by the terrible shock, otherwise the gun appeared to be in good condition.

After the test the gun was carefully examined. *No enlargement* of the bore was detected, in fact, at one point the bore was found to be, if anything, perceptibly smaller.

The breech action worked well and was readily opened after each discharge.

A fact worthy of note is that the breech bushing was unscrewed with ease by one man after the public test.

The movement of the liner is entirely unimportant. It was assumed that the friction would be sufficient to hold it in place without other locking device. It will now be set home and locked before the gun is turned over.

The movement of the chase jacket is of a character to demonstrate the free action of one of the essential features of the system. The segmental core becoming heated, elongates; this opens out the several layers of wire like so many spiral springs, and as the several hoops of the chase jacket are shrunk upon the outer layer of wire, they necessarily move with the wire. The fact that they close as soon as the gun cools demonstrates how freely the several layers act in unison and resume their normal condition as the gun cools down.

THE PHENOMENAL PRESSURE.

It is a fact that every time an attempt has been made to obtain high pressures in our gun we have had phenomenal results.

On the first occasion with but a small charge of sphero-hexagonal powder, a pressure of 60,000 lbs. per sq. in. was obtained. This being incomprehensible it was attributed to the roughness of the bore.

At the private test, 30 lbs. of Brown Prismatic Powder gave phenomenal results. This was attributed to drying out of the powder. At the public test every precaution was taken. The cartridges were carefully loaded from a new lot of powder just received from the manufacturers, the copper bands were turned off reducing them 0''.02 in diameter, and great care was taken to wash out the gun after each discharge; nevertheless 30 lbs. again gave us phenomenal results.

The only explanation seems to be that for all powders there is a "*critical pressure*;" when this is reached the powder is rapidly converted into gas, and phenomenal pressures produced.

This has not been noticed before as no such pressures have ever been used in guns. In other words, it is probable that the enormous pressures used in our gun has developed a new principle, not before known.

In conclusion I would call attention to the fact that the phenomenal pressure obtained at the last discharge, was far beyond anything that has ever been thought of in a gun. It has in a most effectual manner demonstrated the truth of our claim as to elastic strength.

The three copper gauges used in the last discharge proclaim in a language far more powerful than any I can use, that the Brown Segmental Wire Gun is a phenomenal gun.

Very respectfully,
G. N. WHISTLER,
1st Lieutenant 5th Artillery,
Engineer for Trustees.

A New Torpedo Circuit Closer.[*]

Thornfield,
Bitterne,
Hants,
12 April, 1892.

To the Under Secretary of State for War.

Sir:

A foreign government torpedo department having enquired last December concerning the circuit closer with mechanical retardation designed by me and described on page 126 of my book on Submarine Mines and Torpedoes (London, 1889), I replied saying that I had designed an improved apparatus of the kind in which the glycerine cylinder and piston are replaced by a valvular air arrangement which is far simpler.

Having considered the matter during January and February, I sent the said department a design on 3rd March, which I shall now describe.

A is an india rubber pear-shaped chamber like the squirt which can be bought in any chemist's shop. It is closed at the top by an ebonite or bone mouth *M*, bored with a central hole in which fits the spindle *Y*, and this carries a contact-ring for connecting the springs *S S* electrically, and therefore the terminals *T T* to battery and fuze. A small vertical slot is cut in *Y* by which air can enter *A* gradually. The bottom of *A* is fitted with an india rubber flap valve *D*, which allows air to escape freely but not to return. The cord *H* connects *Y* to a bridge of tape over the orifice leading to *D*.

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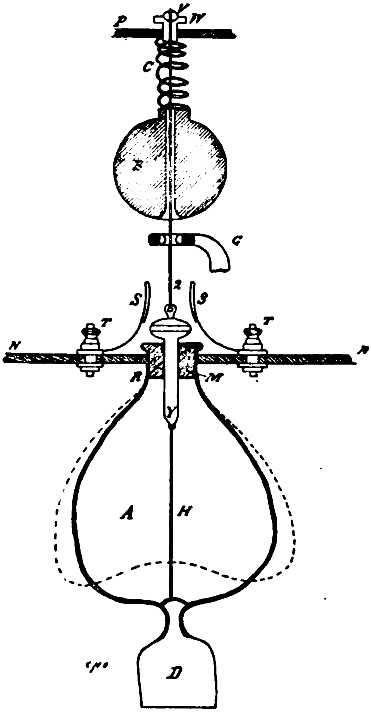
[*] Received through courtesy of Captain E. L. Zalinski, 5th U. S. Artillery.



A is fixed at *M* to the table *N N*, which also carries *T T*.

The action is as follows:

When the ship strikes the buoyant body carrying the apparatus, the inertia of *B* (which may be a ball of lead) causes it to swing aside on its hanging support *C* (a spiral spring) and thus to pull the cord *Z* vertically upwards through the guide hole in the arm *G*. *Y* is consequently raised also, and the cord *H*; the chamber *A* taking the shape in dotted lines, and air being expelled through *D*. The contact-ring is thus brought against the springs *S S* and remains there during the time air is leaking back into *A* by the vertical slot in *Y*, the length of the time of such retardation being regulated by the size of the said slot in *Y*.

Mines of secondary importance which it may not be convenient to fit with the elaborate electrical contrivances for electrical retardation, may thus be retarded mechanically by this pneumatic arrangement, and therefore be somewhat protected from counter-mining, as experts will understand.

This apparatus is now being manufactured by the torpedo department before referred to. The Royal Engineers may like to do so too.

Hence this letter.

I have the honor to be, Sir,
Your obedient servant,
J. T. Bucknill,
Lieutenant Colonel.

Trial of Armor Plates at Gâvre.

Trial of a Vickers Harveyized steel plate has been made at Gâvre in France, with results not equal to those obtained in England, the United States, and Russia. The plate in question was 26.8 cm. (10.55 in.) thick, and it was attacked by a chromatized steel projectile of 24 cm. (9.44 in.). It resisted the first shot, which had an initial velocity of 580 mètres (1,903 ft.), but was deeply cracked in three places. A second projectile, with a velocity of 700 mètres (2,296 ft.), however, perforated it, and buried itself at a distance of 1,300 yards beyond, and a third projectile, with a velocity of 650 mètres (2,132 ft.), also passed through, but its impact had been upon one of the cracks. Finally, a fragment of the plate showed better power of resistance to a projectile with 20 mètres less velocity, which broke up without injuring it. Whether the inferior results obtained by the plate in France were due to special defects or to superior hardness of the projectiles is difficult to determine. But it will be seen that the plate succumbed to the attack of projectiles with an initial velocity between 600 and 700 mètres; and, as M. Weyl points out in the *Débats*, France is about to mount naval guns with a velocity of 800 mètres (2,624 feet). This velocity has been reached by lengthening the gun, and by the employment of slow-burning powder. But, with a bound, a much greater success has been attained recently at Ruelle, where a gun of 16 cm. (6.29 in.), 90 calibers in length, has given a velocity of more than 1,200 mètres (3,936 feet). With this piece several hundred rounds have already been fired under satisfactory conditions, and we learn that it is now about to be despatched to Gâvre to be tried against Harveyized plates, so that we may expect further interesting particulars. Of course a gun 47 feet in length can be mounted only in a ship specially constructed.—*The Army and Navy Gazette.*

BOOK NOTICES.

The Influence of Sea-power upon the French Revolution and Empire. By Captain A. T. Mahan, U. S. Navy. Two volumes, Pp. xxii., 380, 428. Boston—Little, Brown & Co., 1892.

In these volumes Captain Mahan continues the labors begun by him in his "Influence of Sea Power on History," published in 1890. As this work was general in character, so is his later one special, in that it deals with a special period. But the one is the continuation of the other. Together, they constitute the most valuable contributions yet made to naval history. To regard them however as merely naval histories would be to lose sight of their chief value. For it may be justly said of these works, that whatever the point of view, whether of naval history, of strategy, or of history as a science, their importance is of the first order. There have been writers on naval operations; on sea wars, but until these works appeared, no writer had ever developed the *principles* of sea-power and assigned them their place in the system of forces, the resultant of which we see in the civilization of to-day.

So true is this, as to leave in the reader's mind the impression that Captain Mahan has discovered an unexplored field in the domain of history. And this will be found to be the fact. In most histories, land wars have ever been regarded as the chief factors in the development of modern history, so far as this is controlled by war. The results of naval operations, when taken into account, have been thought to be too scattered, too casual, if that expression may be used, to exercise a measured, not to say measurable, influence in shaping the destinies of the world. Of course the destruction of his fleet in Aboukir Bay made Napoleon's tenure of Egypt impossible. Of course the battle of Trafalgar rendered impossible his invasion of England. But if marked cases like these be excepted, the general proposition laid down will command belief, that until the publication of Captain Mahan's works, the influence of sea-power as a force of incessant application, was, if not unknown at least ignored, in those estimates and records of national effort that we call history. It is a matter of just national pride then, that an American naval officer should have filled up, as we now know that he has, a breach in the continuity of history. For rightly considered, Captain Mahan's works are positive contributions to the philosophy of history. This is saying a great deal, but it is not saying too much. Captain Mahan everywhere traces the influence of a force; he shows how the force is continually applied to secure definite results and how events shape themselves in consequence. The conclusion forces itself upon the mind that this force, dormant in peace, is bound up in the essence of a great nation's existence, and is to-day as much a factor in the possibilities of the future, as it was in the realities of the struggle that began at Valmy and ended at Waterloo. If such conclusions are not contributions to the philosophy of history, then there is no meaning in the term.

Limitations of which it is unnecessary to speak in detail, make it impossible to do full justice to the work, the title of which heads this notice. To give anything more than a brief statement of its scope would require an article foreign to the purposes of the *Journal.* The aim of Captain Mahan is perfectly described by the title he has chosen. Volume I covers the period between 1783 and 1800–01. From a sketch of the state of affairs in Europe after the treaty of Versailles, we pass to a description of the various European navies, and in particular of that of France. The chapter dealing with the causes that led to its ruin is one of the most striking in the whole work. Under the influence of revolutionary ideas discipline disappeared, and with it trained officers and men. To this disappearance may be attributed the disaster that finally overwhelmed Napoleon. The remaining chapters of this volume are devoted to the development of operations in the Mediterranean and in the Atlantic, on the coasts of France, and against Ireland. Volume II carries on the thread, discusses the proposed invasion of England, the events leading up to Trafalgar, the Trafalgar campaign itself, and the terrible struggle set on foot by Napoleon's continental system. The last chapter analyses the British policy during the Napoleonic wars. At the risk of repetition it must be stated that the point of view throughout is not that of naval operations as such, but of history as influenced, as controlled by naval operations. It is this point of view which, by its novelty and importance, lends such interest and value to Captain Mahan's labors.

We should, however, be unjust to the author if in this notice we omitted to mention the admirably clear accounts of the various purely naval events. No landsman need fear to read this work lest it should prove of too technical a nature. And in general praise is freely due, and will be freely given for the author's skill in marshalling facts, in assigning just weights to the conditions involved, in drawing conclusions and in estimating results. His skill in respect of these matters nowhere stands out more clearly than in his description of the confessedly intricate events growing out of the Orders in Council, and of the Berlin and Milan Decrees. On the same plan of excellence rests his analysis and defense of the British policy as shaped by Pitt. Nor must we fail to speak of the convincing argument against commerce destroying as an element of war, deducible from the losses of British commerce by French privateering. These for the whole war did not exceed two and a half per cent. of the capital invested.

We close this notice, not with the feeling that justice has been done to its subject, but with the hope that it may serve to bring to the attention of artillery officers a work, the value of which can scarcely be overestimated.

C. DeW. W.

Nouveau Dictionnaire Militaire, par un comité d'officiers de toutes armes. Pp. viii, 854. Paris, L. Baudoin, 1892.

The object of this work as set forth in the preface is two-fold. In the first place, there is to-day no encyclopædia that fully reports the progress made of late years in military science. In the next, such encyclopædias as do exist are so voluminous as to be found in general only in public libraries. Hence it has seemed to the authors "that a military dictionary containing all words whose military meaning should be accurately understood, and cast into such a form as to make a sort of *Aide Mémoire général* . . . . would satisfy a real need."

The authors are to be congratulated on the success of their efforts. They have compiled a work that cannot but be of great general utility. While omitting details, either as being too technical or as being out of place in a work of general application, *i. e.*, intended to meet the wants of all arms of the service,—they have yet treated the principal subjects concerned with a fulness sufficient for most purposes of reference. It must not from this be inferred that details are lacking; on the contrary many subjects are fully developed. What is meant is that the limits adopted have in some cases forbidden the introduction and description of all the component parts of the subject considered. To illustrate, only general considerations are given in respect of gun-carriages; a detailed nomenclature of the various types would have extended the work beyond the limit of general reference.

A feature of the work lies in the fact that questions of what may be called the archæology of the science of arms, hold an altogether subordinate place. It is upon the questions of the day, upon the present state of development of the art military, that the authors have fixed their attention. For example, the principal high explosives and small calibre magazine rifles using smokeless powders are described; other examples might be given. The advantage of having in one compact volume, data that otherwise must be sought in periodicals of many languages needs no comment. The subjects of administration of interior economy and of organization, are concisely and accurately treated. And these are just the matters in regard to which it is frequently so hard to get definite information without great trouble and even expense.

The make-up of the book is satisfactory. By using double columns, and type, which though small, is clear and easily read, the authors have compressed their work within 850 octavo pages. Figures to the number of 310 serve to illustrate the subjects that admit of illustration, while reference is made easy by heavy-faced type of different fonts for the various headings and their subdivisions.

C. DeW. W.

Handbook of the Hotchkiss 75-mm. Rapid Firing Field Gun. London: Harrison and Sons, 1893. Pp. 23, with plates.

Under this title the Hotchkiss Ordnance Company describes the latest product of its shops, a R. F. field gun. Like all of Hotchkiss' work, it is good. We do not agree with some artillerists who insist that high initial velocities giving tremendously long ranges are necessary for field artillery, for the reasons that the country ordinarily moved over would not admit of their use; neither would the eye, even with assistance, give the desired accuracy. The ammunition, hauled over the country at the expense of horseflesh, would be thrown away at such ranges only to be longed for when fighting at the closer ranges commenced.

We are of the opinion that the ranges at present accepted are amply sufficient: and while in the outer zone the ammunition could be expended with more than sufficient rapidity for accomplishing the desired work from the field guns now in use, there is no question but that at closer ranges the problem changes, and in order to keep pace with the infantry, the artillery must provide itself with a gun which will pour in such a dense fire that its work will be more rapidly and effectively done than with the present field gun for light and horse artillery.

It is at the shorter fighting ranges, and in cavalry combats, that the artillery must make its best effort, and the consumption of ammunition will be very great in order that the troops may be saved from decimation. It therefore behooves us to obtain a field armament fulfilling practical conditions that are possible, and which will best satisfy the requirements of the future.

Such a weapon must be within the limit of weight and at the same time capable of very rapid work when called on. We note the following extract from conditions contained in a pamphlet by Nordenfelt:

1. Fixed metallic ammunition will be used.
2. The breech mechanism must work rapidly enough not to cause more delay in the firing than the time necessary for preparing the fuze and aiming.
3. The breech mechanism must combine simplicity, security and facility of manipulation.
4. The carriage should be supplied for giving proper deviation and elevation.
5. The force of recoil must be so absorbed, as to avoid change of position of the carriage when the piece is discharged.
6. The weight of gun, carriage and limber must be so distributed that the limber will carry about fifty projectiles.
7. The total weight of the light field piece should not exceed about 3630 pounds, or about 605 pounds per horse.

Artillerymen have been longing for such a weapon for some time past: and now the Hotchkiss Ordnance Company puts forward its claim, after long study and careful practice, to having finally solved the problem.

We shall now give short descriptions of the principal parts of this weapon.

THE GUN.

As described in the pamphlet, the 75-mm. gun puts the total weight for each horse at 580 lbs. and permits a supply of forty-eight rounds to be carried in the limber chest. With a charge of French BN_4 smokeless powder weighing 1.76 lbs., the projectile of 13.2 lbs. weight has an initial velocity of 1740

f. s. and, at a range of 6000 yards, the remaining velocity is 668 f. s. The pressure obtained for the above I. V. is not indicated.

The shrapnel breaks into 231 pieces and the canister contains 200 balls.

Eight aimed rounds, and at short ranges fifteen unaimed rounds, may be fired per minute.

The body of the gun is built up of three forgings of oil-tempered and annealed steel, and the breech-block is a hollow prismatic forging, with rounded corners, having a vertical movement in a mortise cut completely through the jacket.

The front face of the block is perpendicular to the axis of the bore, whilst the rear face is slightly inclined. The upper front corner is cut away to allow for the motion of the extractor; and the firing mechanism is contained in the hollow part of the block. The part of the breech-block which supports the head of the cartridge consists of a removable hard steel plate, which is dovetailed into the face of the block, and secured by two screws.

By means of a crank the breech-block is moved down or up, thereby opening or closing the breech, extracting the empty cartridge case and cocking the firing mechanism. The hammer of this mechanism is in the axis of the breech-block and carries a detachable point or firing-pin which acts on the primer of the cartridge through a hole in the face plate.

Without detailing the various parts of the mechanism we shall remark that "the extractor is a single piece of steel working in a longitudinal groove in the left cheek of the breech housing. Its forward end is formed into a hook to grasp the head of the cartridge."

Simple rules are given for mounting and dismounting the breech mechanism, and also for the care and preservation of the gun.

THE CARRIAGE.

The gun carriage is made of steel and is of the rigid type. It combines simplicity, lightness and resistance.

Lateral pointing is done by means of the trail handspike, instead of training gear. This avoids increased weight; and as with training gear the axis of the gun would generally make an angle with the axis of the carriage thereby disarranging the aim on the discharge of the gun, the method adopted seems satisfactory until the perfect rapid-fire gun is found. The trail consists of two brackets which are built up of steel plates and angles, and properly braced; a feature of the design being that a line drawn from the centre of the trunnions to the point of contact between the trail and the ground almost coincides with the axis of the trail.

The axle is a single forging of mild steel rectangular in section, but hollowed between the collars to reduce the weight; and the trail is attached to it by means of two strong steel castings, which are riveted on the inside of the brackets, and to the axle plates; and in these pieces are formed the trunnion beds.

The wheels are of the Archibald type. Recoil is checked by means of a powerful spade on the end of the trail, which is forced into the ground on firing. In general one or two rounds are necessary to give the spade a firm bearing, but after these have been fired the recoil is completely checked.

As the wheels leave the ground at each discharge, the carriage is simply fitted with one traveling brake on the left side; and the one indicated is not such as, in our opinion, leaves nothing to be desired. We cannot consider it as being a good traveling brake.

The elevating gear consists of a hollowed arc attached to lugs on the breech of the gun and gearing lodged in the elevating transom. It is worked easily and rapidly by means of a crank handle, and is relieved from the shock of discharge by a friction clutch.

THE LIMBER AND CAISSON.

The limber body is a rigid steel frame carrying a wooden ammunition chest covered with water-proof canvas and stoutly ironed. The chest opens to the rear and contains six compartments, in each of which eight rounds can be placed. The cartridges are carried horizontally, and are supported at the center of gravity of the projectiles and near the heads of the cases in loose racks fitted in the compartments, so that each cartridge is held securely irrespective of the number contained in the chest. The caisson, carrying ninety-six rounds of ammunition, consists of two limbers similar to the one described. On the rear one the pole is replaced by a stock, on which is secured the spare wheel.

Under the foot-boards are receptacles for the necessary stores and spare parts.

We do not like the position of the spare wheel, high in air: nor of the picket rope and prolonge, below the axle.

We would also substitute the canvas watering buckets, to be carried in some position above, instead of below, the axle. The total weight of the caisson is 3663 lbs., being 187 lbs. more than the weight behind the gun team.

The pole yoke and single-trees are of metal, and no double-tree is used, the single-trees being attached directly to the splinter-bar; a position which finds some advocates.

THE AMMUNITION.

The ammunition is assembled in a manner similar to that employed for small arms, and consists of a primed aluminum cartridge case containing the powder charge and a wad, in which is inserted the projectile.

The combination fuze, having a range of fifteen seconds, consists of four main parts, all of which are made of aluminum to economize weight.

The base percussion fuze is well known in our service.

There are also given a short drill for the gun detachment, consisting of six active and three reserve cannoneers: a range table, a table of weights and measures, several photographs and nine plates of drawings.

In conclusion we will call attention to the fact that our present light field battery on a war footing consists of six guns and nine caissons, thereby allowing 231 rounds of ammunition to each gun.

A four-gun rapid-fire battery, with twelve caissons, would call for one team more and would provide 336 rounds per gun.

Total number of rounds in first case 1586.

Total number of rounds in second case 1344.

We are however getting entirely beyond our limits in entering on the subject of ammunition supply and shall therefore close by calling attention to the fact that our Ordnance Department is now, we understand, either manufacturing, or contemplating the immediate manufacture of, metallic ammunition for our present light field piece.

A. B. Dyer,
1st Lieutenant 4th Artillery.

Aide-mémoire de l'Officier de Marine, by Edouard Durassier, chief of bureau to the Minister of the Navy, and Charles Valentino, late officer of the navy, librarian to the Minister of the Navy. Pocket edition. Address L. Baudoin, 30 Rue et Passage Dauphine, á Paris, France. One vol., 12mo, in English cloth: price, 3 fr. 50, postpaid 3 fr. 80.

This pocket companion is brought up to its sixth year. It opens with a table giving in net the force of the new naval structures of the maritime nations (with true French politeness arranged alphabetically, not in order of strength), classified by tonnage and speed.

It discusses maritime international rights; gives the grades of the different navies, with their pay. Here our own navy stands out remarkably: an American cannot understand how the European officers live on their pay; the only answer appears to be, they do not. Then follows a description in detail of the armored vessels of England, Germany, Austria and Italy; these are either those imposing special study on the French officer, or the only ones worth his study. Next comes a list of the war vessels of all nations, armored or plain: here is given the material of construction, length, breadth, draft, displacement, H. P., speed, number of propellers, coal capacity, thickness of armor, armament, style of armor, crew, torpedo arrangements, and date of launching.

The fourth chapter should be the most interesting to our arm. In the words of the prospectus, in it is given a descriptive nomenclature of the principal models of guns now in use, either for the armament of ships or for coast defense. It courteously gives the United States *a system*. It appears that we have breech-loading rifles in steel; breech-loading rifles in cast-iron; muzzle-loading rifles in cast-iron; and smooth-bores in cast-iron. In this chapter are given name, caliber, destination (ship or sea-coast), metal, length of bore in calibers, weight of gun, class of powder and weight of charge, weight of shell, initial velocity, energy by circumference of missile and of weight of gun, and penetration of armor at muzzle: it also gives the revolving systems, and the systems of small arms.

The succeeding chapters are on torpedoes, a navy list of the French navy, and a list of the submarine cables of the world.

Nothing in its space could be more complete than this work, perfected as it has been under the careful revision of so many years by men having every advantage and fully alive to progress and to the wants of every navy officer of the world. J. H.

Extended Order of Drill. An arrangement of rules prescribed in Infantry drill regulations, with explanations. By 1st Lieutenant John T. French, Jr., 4th Artillery, late Recorder of Tactical Board. 23 pages. Army and Navy Register, Washington, D. C. Price 25 cents.

This is a small pamphlet containing the general principles of the new infantry drill regulations with elucidation of many points relative to their practical application. The author's official connection with the tactical board renders him particularly qualified to treat of the subject, and one is thus enabled as it were to read between the lines of the regulations. It is safe to say that these explanations will be of great help to those who are studying the new drill regulations. J. W. R.

Alternating Currents of Electricity: Their Generation, Measurement, Distribution and Application. By Gisbert Kapp, C. E., with an introduction by Wm. Stanley, jr., 1893. The W. J. Johnston Co., Ltd., 41 Park Row, New York City. Price $1.00.

A small book of one hundred and fifty-six pages, reprinted from the *Professional papers of the Corps of Royal Engineers*, and devoted to the subject of alternating currents. Owing to the present and increasing importance of this subject the work is timely. The subject is treated in a clear and enticing style, and elucidates the elementary but fundamental principles of the subject. The author's name alone is sufficient recommendation for the character of the contents, so that it is only necessary in a brief notice to convey to the readers an idea of their scope.

Beginning with an introduction to the elementary conceptions of alternating currents, one is carried along through the chapter without much help from mathematics, except where equations are necessary to aid in grasping the relations existing between the quantities. The reader who is able to read the book intelligently will not fail with respect to the formulas. The measurement of pressure, current and power forms a chapter which deals with the necessary instruments involved, and leads up naturally to the subject of the condition of maximum power.

Having thus paved the way for the consideration of the generator, the author proceeds to the construction, advantages and disadvantages of the alternator, and briefly touches upon that of Ferranti, Westinghouse, Mordey, Kapp, Kingdon and Kennedy. The alternator being avowedly a high voltage machine, it is necessary for economical reasons to transform the current into one of suitable low voltage by means of *transformers*. These are clearly set forth in construction and principle. The part relating to central stations and their operation with the transformers, either in separate houses or in sub-transforming stations, is probably one of the most useful to the practical man.

The advantage of using alternators in parallel is considered practically, and it is shown that a direct-coupled engine with even angular speed represents the condition for success. The remainder of the book contains chapters on *motors*, *self starting motors* and *multiphase currents*. Each of these subjects is so extensive that but little can be given under them. In connection with motors, the principal part of the chapter is given to necessity for and means of synchronizing, with some experience of the author. Under self starting motors we find Zipernowsky's motor mentioned. The closing chapter treats of multiphase currents, which is probably the most important subject treated in the book, since it relates directly to the construction of alternating current motors which have unbounded promise before them. Commencing with the discovery of Ferraris and Tesla, and its application to the production of rotary motion, we follow the writer through resulting motor development and its defects. Dobrowolsky recognized the cause of the defects, substituted three currents for the two in the Tesla-Ferraris motor, and finally "re-arranged the winding of the field in such a way as to attain the effect of six distinct currents, though still using only three wires in the line transmission." These developments are told in a way that holds the attention of the reader, and takes him through a remarkable period of electrical development.

J. W. R.

Index to the Literature of Explosives, Part II. By Charles E. Monroe, Baltimore Deutsch Lithographing and Printing Co., 1893. Price $1.00.

In publishing Part II of his index, Professor Munroe has given a valuable aid to those who are interested in the investigation of modern explosives. The literature on this subject is so widely scattered and is so constantly being added to, that without some such compendium, the effort to keep up with the development of the subject would be almost hopeless.

The value of the index would, however, be greatly enhanced by the addition of an index of subjects treated. As it now stands, in looking up a subject it is necessary to run through the entire pamphlet.

W. W.

BOOKS RECEIVED.

Extended Order of Drill.—An arrangement of rules prescribed in infantry drill regulations, with explanations by *1st Lieutenant* JOHN T. FRENCH, JR., *4th Artillery*, late recorder of the tactical board. Army and Navy Register, Washington, D. C. Price 25 cents.

Electro-Chemical Effects due to Magnetism, by *Lieutenant* GEORGE OWEN SQUIER, Ph.D., *U. S. Army*. Reprinted from the London, Edinburgh and Dublin Philosophical Magazine, June 1893. Same, reprinted from American Journal of Science.

Aide-Mémoire de l'officier de Marine, by E. DURASSIER and C. VALENTINO L. BAUDOIN, Paris, 1893.

Course of Instruction for Artillery Gunners, prepared for publication under direction of *Major General* JOHN M. SCHOFIELD, *Commanding U. S. Army.* Artillery Circular. B—Gunpowder and high explosives, *1st Lieutenant* WILLOUGHBY WALKE, 5*th U. S. Artillery.* D—The use of meteorological instruments, *Captain* CHARLES E. KILBOURNE, *Signal Corps, U. S. Army.* E—Range and position finding, *Lieutenant* HENRY L. HARRIS, 1*st U. S. Artillery.* Government printing office, Washington, D. C.

SERVICE PERIODICALS.

Revue d'Artillerie.

JANUARY.—The Souchier Prism-Telemeter.

This range-finder was adopted for the Russian Army after a competitive trial, in which many models of range-finders were considered. Each commandant of a company or troop will be provided with it. The description is illustrated and considered under the heads (1) Theory of the Apparatus, (2) Method of using it.

The fire of field artillery.

An abridged translation of article by Captain W. L. White, R. A. *Proceedings of the Royal Artillery Institution*, 1892, Nos. 4 to 8.

The Roknic apparatus for indirect field fire.

The instrument enables giving direction to pieces when other methods (procédés de repérage) are not applicable, as when the object is covered by woods, a farm, etc. The method is described in detail and results of the inventor's experiments given.

Mountain exercises executed in Switzerland.

FEBRUARY.—Methods and formulas of experimental ballistics.

Chapter III. Solution of problems of fire. Consisting of nine problems of fire; formula for correction and discussion of the drift of a projectile.

Field artillery fire. Schlæpfer system of automatic brakes (for field gun).

Treated under the heads of description, operation, advantages and disadvantages of the brake.

MARCH.—Artillery in the United States in 1892 (continued).

Description of the material and organization of our field and mountain artillery, illustrated by plates showing guns, fuzes, shells, primers, etc.

Methods and formulas of experimental ballistics (continued). Experiments made at Krupp's shops upon 6-cm. rapid fire field guns.

This is an analytical investigation of the experiments made with 6-cm. R. F. field guns of 30 and 38 calibers. The discussion consists chiefly of a comparison with the 8-cm. German field gun in regard to efficacy. Dimensions and weights are first given, with brief mention of new features in construction; after which comes a thorough review of the ballistic qualities of these new guns compared with the old German field gun. The projectile has great sectional density, so great in fact that the old range tables apply almost exactly. Shrapnel fire reaches 3000 m. Experiments were made upon three ranks of screens 2.7 m. high and 30 m. long, with intervals in depth of 20 m. The results are tabulated. The comparison of the two types of gun is carried out with respect to the following considerations: (1) The efficacy of the projectile considered separately.

a. The number of bullets contained within it.
b. Their force of penetration.
c. Flatness of trajectory (angle of fall).
d. Range interval covered by the burst.
e. Opening of the sheaf.
(2) Precision. (3) Rapidity.

Drill regulations for the German field artillery (continued).

A revision of the drill regulations of 1889 and known as those of 1892.

The Military Academy of West Point.

APRIL.—Principles of pointing in field artillery fire. The new magazine guns before the Chilian Commission. Developments relative to certain particular cases of the methods of fire of siege artillery.

MAY.—Exercise regulations for the German field artillery. Developments with respect to particular cases of the methods of fire of siege and position artillery. Warfare executed by a mixed detachment of the XIV German Corps. J. W. R.

Revue Militaire de l'Etranger.

JANUARY.—Tactical observations of General Dragomirov upon the maneuvers and exercises of the troops of his command. The mobilization of the English army. The war budget of Norway. The military utilization of a railroad in Spain.

FEBRUARY.—The recent armor plate trials in the United States. The new military law of Bulgaria. The Norwegian railway system.

MARCH.—Reorganization of the general staffs of the surrounding military frontiers in Russia. The new Krupp field artillery.

This article treats of the recent experiments at the shops of Krupp with respect to rapid fire guns. (1) Twelve guns have been constructed varying in caliber from 6 cm. to 8.7 cm.; they are probably nickel steel. All of these twelve types are intended for metallic cartridge cases. The wedge opens to the right. (2) The fermeture is an entirely new model. (3) The carriage of the 6-cm. is without recoil; that is, it is intended for rapid fire. To accomplish this it is divided into two parts, a small carriage carrying the piece and a large one carrying the whole. (4) Powder, projectiles, fuzes. The powder is C/89 smokeless. Three kinds of shells are used. The fuzes are discussed and illustrated by cuts.

Results of experiments with the 6-cm. rapid fire gun during 1891 and 1892 are given. Number and kind of shots are given, with the nature and dimensions of the target.

The railway troops of the Austro-Hungarian army.

APRIL.—Instruction of the German foot soldier in varied ground. Strong places and fortress troops in Russia. The new Spanish 7-mm. gun.

MAY.—The German war budget for 1893-94. The reorganization of the Swedish army. The combat and investment of Fredericia. Military news. J. W. R.

Revue du Génie Militaire.

JULY-AUGUST, 1892.—An application of graphical statics to the computation of the metallic arcs of the bridge of the Cerveyrette. Detachable constructions and their military uses. Experiments upon the rupture of metallic bridges. Apparatus for testing cements. Narrow-gauge railways.

SEPTEMBER-OCTOBER.—Upon the processes of construction employed in the dunes of El-Oued.

NOVEMBER-DECEMBER.—Note upon a new bridge material for advance guards. The conditions ot visibility of two distant points. Military telegraphy and telephony. The Teilloux sounding call relay. General Faidherbe.

JANUARY-FEBRUARY 1893.—The fortress of Küstrin under the French occupation, 1806-1814. Upon a new system of rolling platforms for rapid transportation for docks, shops and arsenals.

MARCH-APRIL.—Lighting of barracks by electricity.

The subject is treated thoroughly; commencing with a statement of a few general principles the writer, Captain E. Dubois, of the Engineers, considers the following questions connected with the problem: I. Cost of present illumination. II. Net cost of a lamp-hour for electricity, gas and petroleum, in which it is concluded that when the troops occupying the barracks take charge of the plant and run it, electric light in France can be supplied cheaper than other illumination. III. Illumination necessary for the service, in which is found a detailed discussion and tabular estimate of the needs of barracks and auxiliary buildings. IV. Economical and practical conditions for electrical illumination of barracks, V. Cost of electric light. (a) Cost of installation. (b) Cost of maintenance. Conclusion.

Note relative to the size of gauge for colonial railways. The fortifications of Sicily. The defense of the German coasts explained to the Reichstag. J. W. R.

Revue Maritime et Coloniale.

NOVEMBER, 1892.—The disembarkation of a body of troops. Balloons and the exploration of Africa. Vocabulary of powders and explosives. The German navy (continued). Former troops of the navy (continued). History of the French military marine (contiued).

DECEMBER.—The civil war in Chili. Study upon the mechanical theory of heat. Coal in the extreme east. Ideas upon the Seine wave action.

JANUARY, 1893.—English war-ships. Experiments made on board the *Naïäde* upon the quieting effect of oil on waves. The cyclone of the 18th of August, 1891, at Martinique. Description of an apparatus for counting the number of turns and the direction of motion of a machine. The contemporaneous navies of European states—their elements of strength. Artillery and armor. The civil war in Chili in 1891. Succinct résumé of the results of the voyage of the despatch-boat *La Manche* to the island of Jan Mayen and Spitzbergen during the summer of 1892. Abacus for the determination of points at sea.

FEBRUARY.—Note upon a graphic representation of the diurnal movement of a chronometer. Canada and the French interests. A new system of mounting light weight compass needles. In the country of the Kanakas. The civil war in Chili. Mechanical theory of heat. Fishing section.

APRIL.—English war-ships. Note upon a provisional installation of electric light made on board the *Japan*.

MAY.—Study upon the theory of the great war. Auxiliary apparatus permitting pointing and loading simultaneously.

This article gives a solution of the important problem in gunnery, of preventing any delay in aiming on account of the operation of loading, and thus enables the cannoneers to keep the gun constantly directed upon the enemy. Rapidity of fire will in this manner be enormously increased and at the critical moment may be the one important element of fire. The details are worked out with great care. The feasibility of adapting the apparatus for a fixed telescope and the Deport telemeter is considered.

Mechanical solution of navigation problems. The circulation of the winds and rain in the atmosphere. Note upon the *Capitan Prat*—the armored Chilian cruiser.

The note gives a complete history of the early negotiations which led to the order for the ship of the La Seyne works up to its completion. The dimensions, construction, system of protection, armament and all that relates to this remarkable ship are given. The electrical manipulation of the towers, means of signaling and transmitting orders, etc., are the most prominent of the many interesting features of the ship. J. W. R.

Revue du Cercle Militaire.

JANUARY 1.—The Army School of Portugal (continued). Archipelago of the New Hebrides (continued).

JANUARY 8.—The travels of Commander Monteil.

JANUARY 15.—War a hundred years hence (continued). Infantry combat.

JANUARY 29.—Field hospitals (continued). A new law proposed for recruiting in the Italian Army.

FEBRUARY 5.—The new decree upon the interior service of infantry (continued).

FEBRUARY 12.—The Military Society of Berlin.

FEBRUARY 26.—The war game and means of perfecting it. The new organization of the Spanish army.

MARCH 12.—Our regulations of maneuver and their application. Winter tents in the Russian army. The small arm of the future.

APRIL 2.—The arming of infantry according to the formula of Professor Hebler (continued). Italian railroads. The state of preparation of the Russian army for war.

La Marine Française.

JANUARY 8.—Admiral Saint-Bon. Tables of advancement.

JANUARY 15.—Short guns. The loss of the *Rosales*. A celebrated paper (continued).

JANUARY 22.—The new ministry.

JANUARY 29.—Discussion upon the naval budget.

FEBRUARY 5.—Recruitment of crews.

February 12.—Twenty years ago.

February 19.—The army and the colonial navy. Oceanic circulation. Administration and accounts of the crews of the navy.

February 26.—Discussion of the marine budget.

March 15.—The navy and the great works (continued). Artificial smoke.

April 15.—The senate and the navy. The chamber of deputies and the navy.

May 1.—The Bosphorus and the Dardanelles. The cannon of 90 calibres.

This is a 16-cm. cannon which has just been finished at Ruelle. It consists of four independent parts: the first 50 calibers, which is lengthened to 90 calibers by three sections being screwed on in succession. The reported initial velocity is 1,214 metres (3,983 feet) with a 45-kg. projectile. The gun is an experimental model, in which it is proposed to study ballistic advantages of long guns in addition to the mechanical problems involved. The gun is reported to be a success. J. W. R.

Journal de la Marine—Le Yacht.

January 7.—War navies in 1892 (continued). Technical Maritime Association—analysis of papers presented (continued).

January 21.—The national marine.

January 28.—The French torpedo vessel *Corsair*.

February 4.—The naval budget in the chamber of deputies. The Japanese armed coast guard ship *Itsuku Shima*. English naval constructions in 1892.

February 18.—The United States navy.

February 25.—Sailor's Home. Firing with heavy oils.

March 4.—The English naval budget. The American ram *Katahdin* (continued). The Italian torpedo-cruiser *l'Aretusa*.

March 11.—The actual condition of war navies. Foreign naval news.

April 8.—The loss of the *Bourdonnais*. The application of low density aluminum alloys to naval construction.

April 15.—The institution of naval architects in England.

April 29.—Guns and armor.

A review of the recent achievements of guns as compared to former design, strength and velocity of projectile, and also considerations relative to improvements in armor. The writer looks forward to still greater improvements in guns and gunnery, greater speed for vessels and continued advancement in the resistance of armor.

MAY 13.—The Italian submarine boat *Audace*. J. W. R.

Revue d'Infanterie.

JANUARY.—Treatise on the exercises and maneuvers of infantry. History of infantry in France (continued). The Russian army—artillery (continued). Notes on combat formations and methods of instruction for infantry. The march from the military point of view. Manner of applying the rule for suppressing inconveniences inherent in the dispersed order in the combat of the battalion.

MARCH.—A page of history: defense of Châteaudun.

MAY.—Infantry fire. Infantry instruction.

Revue Militaire Universelle.

JANUARY.—Tactics applied to the terrain (continued). Explosives (continued). The Dahomeyan expedition in 1890 (continued). The Chaplain of Saint Cyr (continued). General study upon the contemporaneous geographical movement.

FEBRUARY.—The principal explosive factories.

MARCH.—The South Orange States.

APRIL.—Tactics applied to the terrain. The war of the future. Strategy and mobilization in Algeria.

MAY.—The two guns—the German model of 1888 and the French of 1886. Notes on smokeless powders.

JUNE.—German foot artillery regulations. The siege of Méziéres, 1815.

Mémoires de la Société des Ingénieurs Civils.

Revue Militaire Suisse.

JANUARY.—Complement of the mountain fortifications, especially that of the St. Gothard.

FEBRUARY.—Study upon the Swiss Landsturm: organization, employment and use. Society of officers of the Swiss Confederation.

MARCH.—The judiciary organization: upon the mode of punishment. The combat sword. The task and actual condition of the Swiss army.

MAY.—The German emperor and empress in Switzerland. Reorganization of the Spanish army.

Revue de l'Armée belge.

JANUARY.—Study of the defense of the lower Scheldt.

The writer, after laying down the general principles which should be applied to the problem, passes to the different subdivisions of the defense in detail. The history, efficacy, and present use of torpedoes is considered; also the control of fire, range-finding, and other considerations which pertain to the problem.

General Le Clément de Saint Marcq. Application of the processes of stationary and mobile ærial navigation to the art of war.

This discussion is a continuation of the subject begun in an earlier number and treats the subject of ærial navigation analytically, and considers the value and effect of the solution of this problem upon the art of war.

Note upon the formation of cannoneers in field artillery.

A careful, thoughtful argument in reference to the instruction of recruits: I. Instruction in the service of the piece. II. Pointing with the sight.

Historical, political and military study of Constantinople and the peninsula of the Balkans (continued). Note in reference to field artillery fire. Study upon powders and explosives considered from the point of view of military demolition. Second part.

The author deprecates the general tendency of men using explosives for destructive purposes to over-charge the mine or work to be destroyed, frequently wasting large quantities of precious explosive and also obtaining a result quite the contrary to what was desired. He argues for the use of these agents according to theoretical and experimental formulas, and with some intelligence as to what is to be done. Following these general remarks are several tables giving comparative data with respect to all the principal military explosives. These data refer to temperature, time and velocity of detonation and pressures produced compared to a standard powder. Formulas for computing these data are given. An appendix follows which contains all the most reliable practical formulas for destroying different kinds and shapes of material with the rules for their application.

Study upon the destruction of ice.

This study relates to the obstruction of rivers by ice and means of breaking and clearing it away.

MARCH.—The tactics of former times. Repeating fire-arms now in use. Souvenirs of Mexico. Study upon powders and explosives considered from the point of view of military destructions.

This article, in continuation of the subject, considers the following questions: § 3. General study of the effects of an explosion. (A) Upon the phenomenon of explosions—exterior effects. The first part of this section is devoted to the theoretical action of an explosive detonated in a uniform medium; after which comes the effect in media of limited dimensions and with results, such as the effect within the mine, the transmission of the wave and the crater formed. (B) Definitions and notation. Here are defined the terms used in practical mining. (C) Research relative to the form of intumescence produced by a charge of powder or explosive. This part of the paper consists in an analytical investigation of the intumescence of a mine, in which enter the elements of time, velocity and displacement of the particles in terms of known quantities. The formulas for maximum height and extension, etc., enable one to construct the sheaf point by point. Practical examples with computations follow the deduction of the formulas. The article is illustrated by photographs of land and water mines and by curves and plates showing the progress of explosion. J. W. R.

Memorial de Artilleria.

DECEMBER, 1892.—Combustion of grains of powder.

A discussion by Lieutenant Colonel Onofre Mata, Commandant of the Central School of Fire, Madrid, relative to the generality of certain formulas for the combustion of grains of powder given in his *Tratado de balistica interior*. The article is in the main a reply to the criticisms expressed by the *Revue de l'Armée belge* doubting the applicability of the formulas to all forms of grains. The first part is devoted to general reasoning in which is found an elucidation of mathematical principles involved. The volume of the grain burnt at any time is expressed by Al^3+Bl^2+Cl, in which l is the thickness of the grain burnt. A and B are functions of the primitive surface of the elementary pyramid considered and the radius of curvature of the normal section, and C is the primitive elementary surface of the grain. The first differential coefficient of this function becomes the burning surface for any given value of l.

The discussion and application of these formulas is exceedingly interesting. The paper closes with two tables which contain the values of A, B and C for all the ordinary forms of grain of smokeless and black powders.

A provisional system of projectors.

The author in advocating the installation of a plant for projectors does so, not so much with respect to its use in war as to the establishment of a provisional system for immediate instruction and drill. The argument which follows consists mainly in showing the advantages which would flow from a provisional system and the manner in which it can be cheaply constructed. The writer advocates the use of engines already existing in the artillery parks at Barcelona. The plan is thoroughly worked out and estimated cost given.

Military maneuvers in Spain (continued). Coast artillery, (warships continued). Material of the Schneider 45 caliber 15-cm. rapid-fire gun.

JANUARY, 1893.—Field harness. Experiments with smokeless powders in the factory of Granada.

This article gives the results of a series of experiments carried on at the factory with different kinds of smokeless powders. Tables giving conditions, velocitiies and pressures accompany the discussion.

Points upon the military organization of Great Britain in 1893 (continued). The progress of ærial navigation.

FEBRUARY.—Observations upon the rules of field artillery fire.

An analytical treatment of the subject under the following heads: 1. Upon fire by regular increments in elevation. This relates to the question of finding the range by firing successive guns with regular increments or decrements in elevation; it also covers the cases of depth and motion of target. 2. Upon shrapnel fire. (a) Laws of dispersion of explosions in which the principles of probabilities are applied. (b) Operations of correcting shrapnel fire, given in shape of six rules for procedure.

The form of small-arm bullets.

MARCH.—Treatise upon a special form of hollow projectiles.

An analytical discussion of the form and length of hollow projectiles.

Cartridges of the Lee-Metford gun. Modern fire-arms and their ammunition.

APRIL.—A proposed system of pack-saddles for mountain artillery. Marches and fire exercises executed by the third Battery of the fifth Battalion of fortress Artillery.

The march was from Pamplona to the Central School of Fire at Madrid. The events and experience of the march of sixteen days are given. The details of the fire exercises are interesting. The firing represented an attack upon a siege battery emplacement with traverses, parapets, etc. The first exercise was an indirect enfilade fire; the details, with plates representing the effect of a definite number of shots, are shown. The method of correcting for range and deflection are described and tables of deviations, etc., accompany the article.

Points upon the British militia organization. Military maneuvers. Coast artillery (warships). J. W. R.

Revista Cientifico Militar [Barcelona].

January 1.—Lieutenant General D. Marcelo de Aycánaga as minister of war. The health of the soldier (continued). Importance of communications across the Pyrenees. The defense in military operations. Review of the press and of military progress (continued).

January 15.—The service of subalterns. The Spanish-American military congress (continued). The valley of Andorra.

February 15.—The military problem (continued). Nitramite.

March 1.—Fortifications applied to the defense of Spain. Moral education of the soldier (continued). Work descriptive of an historical military episode.

April 15.—The military problem. The small-arm for our infantry.

May 1.—Classification of belligerents and combatants in civil wars.

Revista General de Marina.

May.—The right of search. The actual condition of war navies. The hydrographic service of England. A vocabulary of powders and explosives. The voyage of the *Santa Maria*.

Boletin del Centro Naval.

November 1892.—Tactics of torpedo vessels.

December.—Modern constructions—project of a rapid cruiser (continued). Naval school.

January and February 1893.—The naval military school. Monitors considered as a coast guard. The recovery of wrecked boats in general (application to the *Howe*). Compendium of the instructions for the artillery and torpedo school boats in the Italian navy.

Circulo Naval, Revista de Marina.

December 1892.—Discrepancy between the duties and pay of a few sea sergeants in our fleet. Cyclonic and anti-cyclonic storms in the southern hemisphere. European navies. Vocabulary of powders and explosives. The great war of 1892, a prophecy.

Revista Maritima Brazileira.

JANUARY.—Steel in France (continued). The battle-ship. Portable fire-arms. The naval maneuvers of 1892.

FEBRUARY.Autobiography of a Whitehead torpedo (continued). Powders and explosives. Naval maneuvers in 1892.

Revista da Commissao Technica Militar Consultiva.

JANUARY.—Repeating fire-arms—the new German and Belgian guns. Reorganization of the military schools. Artillery notes.

Revista Militar.

DECEMBER 15, 1892.—Questions of alimentation. Points in reference to the history of the arsenal of the army.

DECEMBER 31.—Service of information for cavalry.

JANUARY 15, 1893.—The army and politics. Instruction for companies. Notes upon the recent military and technical inventions and discoveries.

JANUARY 31.—The army officer.

FEBRUARY 28.—The army and the finances.

APRIL 15.—Reward and punishment. Excerpts of studies upon military education and organization. A military velocipede in Spain.

APRIL 30.—Military reforms. Infantry and field trenches of battle.

Rivista di Artiglieria e Genio.

JANUARY.—Present fortification—transformation of existing works. Miscellaneous notes.

FEBRUARY.—The progress of modern map making in Europe (continued). Instruction of the foot artillery of the German army. Considerations upon the probabilities of fire of coast and marine artillery (continued). Miscellaneous notes.

MARCH.—Method of indirect pointing for field artillery. Notes.

APRIL.—Brief consideration of the regulations for field artillery fire. Temporary fortification and the new means of offense. Fuzes and primers proposed for the German artillery service. Instruction for the execution of the school of fire.

MAY.—Minimum small-arm caliber. Temporary fortification and the new means of offense. Observations and remarks in respect of siege artillery fire. Proposed modification in the present attachment of the traces to the collar. Notes.

Archiv fuer die Artillerie- und Ingenieur-Offiziere.

OCTOBER-NOVEMBER, 1892.—The most recent photographic surveying instruments. Photographic record and theory of projectile-oscillation. Recent regulations for the Spanish artillery and engineer arms.

JANUARY, 1893.—The construction of tables for curved fire (translated from the Italian).

FEBRUARY.—The first quarter-century of the Engineer Commission.

MARCH.—Long-distance rides.

This is a sort of record of long-distance rides, both past and present. With the exception of one case, American examples are not reported.

Fortifications and field armies: considerations upon the campaigns of '48 and '68 in upper Italy, and upon the first operations of the last war with France.

APRIL.—A new French range-finder. Description of the Paschwitz telemeter.

MAY.—Practice against captive balloons.

Mittheilungen ueber Gegenstaende des Artillerie- und Genie-Wesens.

No. 11, 1892.—Summary of technological experiments. Summary of experiments in the domain of artillery and arms.

No. 12.—Theory of artillery practice.

No. 1, 1893.—Considerations on the theory of the behavior of projectiles (continued in No. 3). Conclusions respecting R. F. guns (continued in No. 2, 3; concluded in No. 5) More recent opinions on mountain fortifications.

No. 2.—Experiments on a new pole for field piece. Upon means of observing shots.

No. 4.—Artillery range-finders. On compressed air.

No. 5.—Experiments with explosives by the engineer regiment in 1892.

Jahrbuecher fuer die deutsche Armee und Marine.

November, 1892.—The maneuvering and fire of artillery in battle. Considerations on the behavior of the small-calibre bullet.

December.—Military reflections upon the suppression of riots in large cities. The recent Italian regulations in combat exercises.

January, 1893.—The fall maneuvers of the 9th against the 12th French Army Corps in Poitou, 1892 (continued in February). The French fleet maneuvers in 1892. Armor-plate fortification illustrated in its economical aspect by the examples of Liege and Namur.

March.—The employment of belt-roads for tactical purposes. The speed of modern armored ships. The care of our wounded in a future war.

April.—On the wounds caused by the small-caliber rifle.

May.—The land fortification of Switzerland. The history of siege warfare since the introduction of fire-arms until 1892.

Internationale Revue ueber die Gesammten Armeen und Flotten.

October 1892.—German armor-plate construction and French imitation. Germany's coast-defense.

December.—On the use of R. F. and machine guns in the field (continued in January, February and March, 1893).

March, 1893.—New small-arms, by General R. Wille (continued in April and May). Shall we build coast-defense ships, and of what kind (concluded in April)?

April.—Attack and defense of places (continued in May).

May.—American plan and policy of defense.

Marine-Rundschau.

January.—Prussian naval policy since 1836 (continued in February). English naval maneuvers, 1892.

April.—Russian fleet maneuvers in 1892.

Organ der Militaer-Wissenschaftlichen Vereine.

No. 1, 1893.—A word on the application of field artillery.

No. 2.—The work of the German general staff in 1870-71.

No. 3.—Moltke and his influence on the operations of 1864.

No. 4.—The field-gun of the future. The defense of the bridge-head of Presburg.

No. 5.—Cavalry to the front! a study in war history.

No. 6.—Infantry fire in battle. On the formation and leading of larger artillery masses in battle.

Schweizerische Militaerische Blaetter.

JANUARY.—The Swiss artillery. Trial of a 7.5 cm. R. F. Skoda gun. French battle tactics for artillery. Experiments with aluminum. The war of the future.

FEBRUARY.—Implement for setting time and double action fuses.

MAY.—Infantry against artillery.

Mittheilungen aus dem Gebiete des Seewesens.

No. 12, 1892.—Relation between offensive and defensive powers of state. R. F. guns of large caliber.

Nos. 1 and 2, 1893.—Fleet maneuvers in 1892.

No. 3.—On stability of rotation, with special reference to Howell torpedo.

Beiheft zum Militaer-Wochenblatt.

Nos. 8 and 9, 1892.—Remarks on the Russo-Turksh war, 1877-78.

No. 1, 1893.—My long-distance ride, Berlin-Vienna.

No. 2.—Epitome of the history of the Royal Prussian Engineer Committee, during the first 25 years of its existence.

No. 3.—Impressions of a military tour in the Caucasus and South Russia.

Militaer-Wochenblatt.

APRIL 26.—On the history of the German general staff, from 1806 to 1870 (continued).

Allgemeine Schweizerische Militaerzeitung.

FEBRUARY 11.—Attack and defense of modern armored forts (continued). Investigation of the tactical consequences of the introduction of the small-caliber rifle and of smokeless powder.

MARCH 4.—Reorganization of our field artillery.

Allgemeine Militaerzeitung.

APRIL 12.—Tactics of the three arms (continued).

MAY 27.—Charts and plans of the city of Metz.

Die Reichswehr.

APRIL 23.—The ersatz-officers of Germany.

APRIL 30.—The ram-cruiser *Maria-Theresa.*

MAY 20.—The naval review in New York.

MAY 26.—The Roumanian Mannlicher rifle, M. 1893.

Kriegswaffen.

PART 12, 1893.—Compressed air gun (pneumatic dynamite gun). Aiming contrivance for guns.

Artilleriskii Journal.

JANUARY, 1893.—Preparation of field artillery for war (continued). Manufacture and character of different smokeless powders and those of little smoke (continued). The measurement of high temperatures.

FEBRUARY.—Exercises with double-action fuzes. The artificer, the pointer and the chief of piece. The settlement of a few practical questions with respect to lighting by means of electrical projectors.

MARCH.—The one hundred years existence of the Russian horse artillery. Notes upon the execution of field artillery night firing exercises. The apparatus adopted in Germany for masked field artillery fire.

Razviedtchik.

NO. 122, 1893.—Organization and service of velocipedists in foreign armies (continued).

NO. 127.—The lance in the German cavalry.

NO. 128.—Individual instruction of the new soldiers of the guard.

No. 133.—What are our neighbors doing?

No. 136.—The Chicago exposition.

Russkii Invalid.

No. 29, 1893.—Review of artillery in foreign armies in 1892 (continued).

Nos. 41 and 42.—War fire maneuvers with masses of artillery.

No. 58.—A few remarks on the organization of the order for combat.

No. 59.—Smokeless powder viewed as to the absence of danger,—fire and transportation.

No. 71.—Notes on small-arms.

Nos. 72 and 73.—The means of lighting, taking care of, and maintaining communications upon the battle-field.

Nos. 90, 91 and 92.—Special works of the engineer field troops in 1891-92.

Nos. 102 and 103.—Summer exercises for the troops in 1893.

No. 107.—Summer work for the field engineer troops in 1893.

No. 108.—Instruction as to the classification of the sick and wounded in war.

Norsk Militaert Tidsskrift.

PART 1, 1893.—The society for voluntary assistance of the sick and wounded in the field. The attack of the enemy by an infantry battalion, armed with the small-caliber rifle and smokeless powder.

PART 3.—Smokeless powders and small-calibers.

PART 4.—Fire discipline and fire leading.

Militaert Tidsskrift.

PARTS 1 AND 2, 1892.—Military retrospect for 1891.

PART 3.—Military sanitation.

PART 6.—The soldier's moral training. The fall maneuvers of 1891 and the report of the Minister of War made up from reports on the maneuvers.

PART 1, 1893.—What has been the role of the lance in cavalry during different periods (continued in part 2).

Artilleri-Tidskrift.

PART 1, 1892.—Field artillery firing over its own troops. About the deviation (scattering) of projectiles. The fire of field artillery at concealed objects (with plates). The reorganization of the German field artillery firing school. Rapid-fire cannon in comparison with ordinary field guns. Notes about the manufacture of cannon in America. Notes from foreign countries: Reorganization of the German field artillery material; a new field gun in France; effects of the new ammunition in Italy; experimental firing at captive balloons in Russia; Maxim's automatic rapid-fire gun; aluminum bronze as a material for cannon and small-arms; from the 9th German field artillery's history. Announcement: "Fire game for the field artillery."

PARTS 2 AND 3.—The field gun of the future—a study. Schleswig's field artillery regiment No. 9 in the battle of Gravelotte-St. Privat. Fiske's range-finder—with plate. What value for war ought to be given to the present divisional exercise of the field artillery? Malmström's concussion fuze. Pressure gauge for muskets. Horse-shoes in the German army. News from foreign lands: Experiments with mortar batteries in Germany; experiments with observation ladders in Germany; reorganization of the English field artillery; changes in the Austro-Hungarian field artillery; a new rifle in Roumania; Graydon's torpedo gun; the newest artillery material in the United States.

PART 4.—Field artillery's advance guard duties. German field artillery firing school. Fire rules for the German field artillery. 6.5 mm. repeating rifle, Mannlicher's system.

PARTS 5 AND 6.—Our new army organization. Growth of field artillery in France. Notes on the pressures generated by some of the new propulsion agents (motors). Target practice of the three arms by the XIV German Army Corps. Attempt at firing regulations (firing instruction) for the German field artillery, 1892. A few American notes on the last German fall maneuvers. News from foreign lands.

The Journal of the Royal United Service Institution.

JANUARY 1893.—Ventilation of ships. Notes on infantry tactics. An old log. Army and Navy of Japan. Recent progress in marine machinery. Cavalry divisions and divisonal cavalry.

FEBRUARY.—The system of mounting and placing guns on board ships of the royal navy. Foreign war offices. Brief account of the return march to India of the army in Afghanistan under General Sir Donald Stewart, G. C. B. &c., in 1880. The Turkish Janissaries. France and her marine (mercantile and war). Recent progress in marine machinery. A Spanish view of the Spanish Navy. Moltke's tactical exercises, 1858–82.

MARCH.—Electric balloon signalling. Tactical employment of engineer field companies in combination with other arms. Different systems of signalling in the field. German field-artillery exercise. The Buonaccorsi Automobile torpedo. Bohmayer's electric bell. Electrical transmission and indicator for the movements of the tiller. The magazine rifle of 6.5 mm. caliber.

MAY.—The military organization best adapted to imperial needs. Modern warfare as affecting the mercantile marine of Great Britain. The contemporary navies of the world; their elements of power, guns and armor. Battle-ships of England. The Russian official report on the Ochta competition. Experimental firing with 6 cm. quick-firing guns at the Krupp works in Germany.

Journal of the United Service Institution of India.

AUGUST 1892.—On repairing and constructing war railways. The most effective tactical use that can be made of signalling on a modern battle field. A revised scheme for a government mule farm in the hills. Penetration and effects of magazine rifles.

SEPTEMBER.—Plevna with tactical considerations of defense. Revolver training. Jungle fighting. Suggestions on the train- of cavalry leaders and remarks upon pace in manœuvre, and the use of succor squadrons in battle. The volunteer force in India. The civil war in Chili, with special reference to the employment of small bore rifles. The combined tactics of infantry and artillery.

OCTOBER.—The bearing of recent developments in the means of destruction on the medical service in time of war. The bearing of cavalry for reconnaissance. Warfare in mountainous countries.

NOVEMBER.—A suggestion for the improvement of horse breeding in India. Smokeless powder as affecting tactics. Instructions for field firing of detachments of the three arms of the Russian Army, 1886.

DECEMBER.—Burma, 1885–1887.

JANUARY 1893.—The organization of the native cavalry. The armaments of the three arms and their effects in war. Continental regulations on attack and defense.

FEBRUARY.—An estimate of the probable losses in the frontal attack of infantry. The curved sword in the native cavalry. A tactical retrospect of the years 1859 and 1890 with special reference to infantry; see page 157.

MARCH.—Section columns from parade to battle. Infantry attack formations. A tactical retrospect of the years 1859 to 1890.

The Military Society of Ireland.

MAY 1, 1891.—Reconnaissance.

DECEMBER 8.—Slavish discipline.

JANUARY 6, 1892.—The physical training of the recruit and drilled soldier.

JANUARY 27.—Soldiers life in the army and how to improve it.

FEBRUARY 10.—Military horses and their management.

MARCH 2.—Barracks.

APRIL 13.—Woods: their tactical importance in battle.

NOVEMBER 2.—Mobilization for home defense.

NOVEMBER 16.—The artillery in 1870–71, from a general army point of view.

NOVEMBER 30.—Field manœuvres and camp of instruction.

JANUARY 4, 1893.—Army organization.

Aldershot Military Society.

NO. XXXIX.—Synopsis of lecture on the horse for military purposes.

NO. XL.—The importance of the American war of 1861–65 as a strategical study.

NO. XLI.—Lecture on modern infantry fire tactics (offensive).

NO. XLII.—The command of the sea and its effect upon military operations [Vice Admiral P. H. Coulomb, R. N.].

Transactions of the East of Scotland Tactical Socicty.

1892–93.—Discussion on some needful reforms. Field firing of 5th V. B. R. S. at Camp Aberlady, 1892. Discussion on musketry instruction. "The Defense of the Forth." Scottish military bodies and their territorial traditions. Discussion Military Medical Organization. Suggested improved method for dismounting troops in the field. "Marching power." The effect of smokeless powder on the attack and defense.

Proceedings of the Royal Artillery Institution.

JANUARY 1893.—Achievments of field-artillery (continued). Defense of a coast fortress. Instructions for the conveyance of troops by rail on the field service scale. Recent development of armor and its attack by ordnance [continued].

FEBRUARY.—Soldiering and sport in Mashonaland. Saddlery.

MARCH.—Okehampton experience, 1892.

APRIL.—The strategical geography of Europe. Notes on optical instruments. The value of a high site for coast artillery.

MAY.—The effect of the rotation of the earth on the motion of projectiles. The modern batteries. Modern gun-powder and cordite.

Engineering.

JANUARY 13, 1893.—The gun trials of the armor clad ram *Libertad.*

JANUARY 20.—The strength of torpedo boats; the effect of a collision.

FEBRUARY 10.—Electric balloon signalling.

FEBRUARY 17.—The Dredge-Steward omni-telemeter. Gunnery trials of a battle ship. Ordnance manufacture in America. H. M. S. *Grafton.*

FEBRUARY 24.—The Argentine Cruiser *Neuvo de Julio.*

MARCH 24.—The position of cruisers in warfare.

Summary of subject matter of papers read before the Institution of Naval Architects, by Lord Brassey, Admiral Coulomb and others, the above and kindred subjects.

MARCH 31.—Quick-firing guns in the field.

APRIL 7.—The Institution of Naval Architects.

MAY 19.—The power trials of H. M. Battleship *Ramillies*.

MAY 26.—Explosions.

A review of Colonel Majendie's report on the subject of explosives for 1892.

The manufacture of small arms (continued).

JUNE 3.—The Russian Torpedo Cruisers *Wolwoda* and *Possadnik*. The engines of the first class cruiser *Crescent*.

J. W. R.

The Engineer.

JANUARY 6, 1893.—War material.

JANUARY 13.—Electricity in the United States. The gun trials of the twin-screw armor clad ram *Libertad*. Gas power for electric lighting.

JANUARY 20.—The Harvey plate trial.

JANUARY 27.—Engineers in the U. S. Navy. Mounting heavy guns afloat.

FEBRUARY 3.—Complication in gunnery.

FEBRUARY 10.—Harvey-Vickers plate. Cordite.

FEBRUARY 17.—The "*9 de Julio*." Smokeless powders. Nickel steel.

FEBRUARY 24.—Armored cruiser *Brooklyn*, U. S. Navy.

MARCH 3.—Bridging the Bosphorus. The trial of H. M. S. *Hood*. Battleship *Iowa*, U. S. Navy.

MARCH 24.—The bearing of recent plate trials on future warfare. The Russian official report of the Ochta competition.

An illustrated article showing photographs of the recent armor trials, and the effect of the attack at each stage of the experiment.

MARCH 31.—The Russian barbette battleship *Sinope*.

APRIL 7.—The American Nickel Harveyized Plate trial.

APRIL 21.—The U. S. Dynamite Cruiser *Vesuvius*.

MAY 5.—Trials of H. M. S. *Ramillies* and *Alarm*.

June 2.—The Naval Annual for 1893. The *Dimitri Donskoi*.

J. W. R.

The United Service Gazette.

January 7, 1893.—A calendar of British land victories. The reorganization of the French Army (continued). A French reply to Sir Thomas Symonds. The training of engineers and artillery. A naval retrospect, 1892. The army, 1892.

January 21.—Offensive tactics of infantry. Guns on board ship.

January 28.—Ammunition for field guns. Electric balloon signalling. Training troops for action. The next naval programme.

February 4.—Lord Roberts on artillery. Engineers in the field. Our naval supremacy.

February 11.—Sea power. Field maneuvers and camps of instruction.

February 18.—Army organization. II. Sea power. The battle of Gettysburg.

February 25.—Our swordsmanship. Lord Roberts on the duties of cavalry in the field. Egypt and the Red Sea.

March 4.—The *Royal Arthur*. The navy estimates. Proper professional pride. Strategy in the American civil war.

March 11.—The navy estimates.

March 18.—The art of marching. The state of the navy.

March 25.—French army maneuvers. The navy maneuvers of 1892—I. The manning of the navy.

April 8.—Naval supremacy.

April 15.—The value of the torpedo-boat. Imperial defense. Mobilization of the volunteers. Conscription statistics.

April 22.—Our position in the Mediterranean. The invasion of England.

April 29.—The future of the torpedo.

May 6.—Employment of artillery in masses. The new defenses of France. Our relative strength at sea. The function of artillery. Continuity of the effective service of warships.

MAY 13.—The personnel of the navy.

MAY 20.—Our naval strength. The new defenses of France. The eastern frontier—II. The phonograph and its military use.

MAY 27.—Our naval requirements. Our position in India.

The Army and Navy Gazette.

JANUARY 7.—Musketry in India. Our naval literature.

JANUARY 14.—The defenses of Constantinople. The reorganization of the yeomanry.

JANUARY 21.—The efficiency of the Italian army. Naval engineering.

JANUARY 28.—The armies of Europe. Sea power and the French revolution. Artillery fire. Electric balloon signalling.

FEBRUARY 4.—Quick-firing guns. The French navy in 1789. The tactical employment of the Royal Engineers.

FEBRUARY 11.—The yeomanry reorganization scheme. Army signalling.

FEBRUARY 18.—Cavalry and mounted infantry. The ventilation of ships.

FEBRUARY 25.—The army service corps. Young soldiers and enteric fevers. The shipbuilding programme.

MARCH 4.—Balaclava (continued). Sandhurst and Woolwich. The soldiers ration. The Military Society of Ireland.

MARCH 11.—The localization of the forces.

MARCH 25.—The state of the army. The Canadian Militia. Field guns.

APRIL 1.—A war cloud. The ordnance corps.

APRIL 8.—Cruisers, monstrous or otherwise (continued).

MAY 13.—State-craft and sea-power. Defenses of Constantinople.

MAY 27.—Cordite.

Review of paper by Orde Brown in the Naval Annual, in which he treats of cordite as compared to the black powders with tests as to its stability, made upon it in Canada and also in the hot stations.

JUNE 3.—Foreign policy and naval program. Our naval literature.

J. W. R.

Journal of the U. S. Military Service Institution.

JANUARY 1893.—Artillery service in the rebellion. Hot air balloons. Russian view of the Pamir question. Comments on military specialists. The knapsack. Musketry training. Place of the Medical Department in the army.

MARCH.—Prize essay. The army organization best adapted to a republican form of government. The evolution of modern drill books. Telegraph in war. Artillery service in the rebellion.

MAY.—The evolution of modern drill books. The knapsack and the army shoe. Military misconceptions and absurdities. The post mess. Cavalry drill regulations. The flag of truce. Apprentice schools for the army. Military uses of photography. Target practice.

Proceedings of the U. S. Naval Institute.

No. 64.—Naval signaling (A. P. Niblack, Lieutenant Junior grade, U. S. N.).

The author here adds a very interesting and valuable contribution to his previous investigations on the subject of signaling. The subject is considered from the present status of signaling and the different methods now in use. The following general heads indicate the nature and scope of the paper. Theory of signaling. I—Messenger service. II—Day and night squadron and distant visual signaling. III—Phonetic signaling. Under these heads are included sub-heads covering all kinds of signaling problems and the apparatus used in solving them. A discussion filling several pages follow the main article. The comments on the propositions of the paper are in general very complimentary to the writer and confirm his statements in reference to the signaling question.

Crusher and cutter gauges for explosives (W. R. Quinan).

This is an article of eighty pages and four large plates. The paper opens with the apparatus used by the author in his experiments. The most important machines described are the pressure gauge, foot pounds machine, calipers and lead cylinders. The author has taken a very prominent part in the development of these machines and their application to the measurement and test of explosives. He lays before the reader a vast amount of data of his own production, and with this and other data obtainable proceeds to an analytical investigation of the very questionable status of *crusher and cutter gauges.* In the beginning a step is taken with view to the determination of an expression for work in foot pounds in terms of known constants, and the amount of compression of the lead cylinders used.

It is inferable from the context that the writer does not consider the investigation entirely successful. It is impossible here to follow the steps in the analysis of the subject. It is found that the first formula deduced which results strictly from theoretical considerations does not agree with the results of experiment, and it becomes necessary to ascertain coefficients, exponents, etc., which will obviate the discrepancy. The reasoning then becomes a search for an empirical formula. The deduction and illustration of the final equation is interesting and well worth reading by all who may be interested in this part of the subject of high explosives. The principal points raised in this part of the paper is the shape of the cylinders after compression and the old question as to whether compression of lead causes any change in *density* and *volume*. In reviewing other experiments much attention is given to those of General Abbot who, it is safe to say, founded the present schools of research with reference to the physical properties of high explosives. Care is also taken to correct statements made in other magazines with respect to the direction of action of an explosion

Considerable space is given to discussion of the "anomalous sub-aqueous action of nitro-glycerine," as recorded by General Abbot. In this connection the writer considers the question of two waves the *explosive* and the *pressure* wave, which some hold, accompanies explosion. In attempting to follow the reasoning here, one soon gets into deep water—for example: "*The velocity of the pressure wave is simply the velocity of sound.*" Why? Does not the velocity of such a wave in its initial stages depend *entirely* upon the impulse behind, which is urging it forward. Is not the rate of elastic propagation an after and secondary consideration? Is this wave propagation likely to be greater in nitro-glycerine than the velocity of detonation, assumed as moving from one end to the other of an elongated charge. Briefly stated will nitroglycerine under any circumstances transmit an elastic wave more rapidly than that of the detonation producing it? One of the most interesting suppositions connected with this discussion is that some of the nitro-glycerine may not have been exploded, which is supported by the author's own extensive experience in reference to nitro-glycerine explosions.

Under the head of *lead as a register of work* we find its advantages and disadvantages mentioned; and the form of compressed plugs for both soft and hard lead under explosive and impulsive forces. The statement as to the difference in time and action of these two kinds of forces involves some very nice physical problems which are not easily answered. That an *explosive force* ever begins its action at zero and develops to a maximum may well be questioned. May it not in many particular cases begin its action at its maximum intensity?

Copper as a register embraces quite an extended discussion covering the physical properties of this metal and the different methods of using it. The subject is treated both experimentally and analytically and great quantities of data presented. These data and in fact all those of the paper are shown graphically. It is impossible to mention even the various heads which are considered in this thorough and able paper. The subject of *Strength of Explosives* in itself demands extended study and thought. The same may be said of its application to High Explosives.

In his closing remarks he says that, "It is possible that no explosive used in fire-arms is capable of writing a record of work which will agree in two such instruments as the cutter and crusher gauges." The questions may also be asked in connection with his closing remarks on smokeless powders, are *they* high explosives and is the velocity of combustion independent of the pressure? Does the difference mentioned with respect to external reaction amongst molecules in case of gunpowder and internal reaction amongst atoms in smokeless powders really exist? The most recent experiments in these matters, it may be ventured, show no radical difference either in manner and rate of combustion, or in the reactions which result therefrom.

One of the most interesting and valuable parts of the paper is the clear way in which all the different problems and their attendant difficulties are brought to the surface and stated. The statistics also form an invaluable contribution to the subject. For all these parts to the general subject all interested in the physical problems treated will find the discussion most instructive and useful.

No. 65.—Automobile torpedoes.

Enters into a thorough discussion of the general uses of such weapons and their efficiency, the Howell torpedo and the probable type of the future torpedo cruiser and destroyer.

Chemical analysis of the three Corean guns. Notes on the literature of explosives. Naval signaling (discussion continued).

J. W. R.

Journal of the U. S. Cavalry Association.

MARCH.—Cavalry upon the field of battle. Smokeless powder in its relation to cavalry efficiency. Conversations on cavalry. Gaits and gaiting of horses.

Journal of the American Society of Naval Engineers.

FEBRUARY.—Method of running the lines for the shafting and boring out the stern tubes and brackets of the U. S. S. *Cincinnati*. Marine boiler furnaces. Steel castings. Economical speed and coal endurance of war vessels as affected by the relation of the coal expended for all other purposes. The contract trial of the U. S. S. *Monterey*. Commerce of the great lakes.

The Army and Navy Journal.

JANUARY 7.—Russian trial of armor plates.

MARCH 11.—The inaugural parade. The navy appropriation.

MARCH 25.—The effect of new army legislation.

The Army and Navy Register.

JANUARY 28, 1893.—Ranging the *Vesuvius*.
FEBRUARY 11.—Status of naval vessels building.
FEBRUARY 18.—Rifles in European armies.
FEBRUARY 25.—The army bill.
MARCH 11.—Report on the guns of the *Vesuvius*.

Cassier's Magazine.

JANUARY.—Life and inventions of Edison (continued). Three million horse power in winter. The governing of steam engines. Electric traveling cranes. Gauges for registering high pressures. The Canadian Society of Civil Engineers. Influence of patents on American industries. The steam engine in modern civilization. A new form of condenser. Notes on new and patented inventions (continued). Machine shop construction. Some interesting machines. The milling machine in place of the planer.

FEBRUARY.—Mechanical flight. Leading American engineers. Economy of a non-condensing engine. Electric transmission of power for mills. Steel for forgings. Some new pumping machinery. Heat movement in steam engine cylinders. Valuable speed power transmission. A new sectional water-tube boiler.

MARCH.—Electricity and our coast defenses. Long distance transmission of power. Modern gas and oil engines. A new method of storing power.

APRIL.—Traveling cranes. Power transmission for central stations.

This is a valuable paper added to the literature on electricity by Dr. Louis Bell. In it he discusses the general question of electrical power transmission under the following three heads: 1. The transmission of single units. 2. The transmission of power to a centre of supply from which point it is to be distributed. 3. The supply of power for light and motors throughout the transmission line. He then proceeds to discuss the special considerations involved in each of these classes. His remarks relating to incandescent lighting with multiphase systems deserve special notice. In this connection speaking from experience and in contradiction to the popular notion, says that lamps can be as successfully operated on multiphase systems, as on an ordinary single phase circuit, provided equal pains be taken with the distribution of the copper in the lines and the regulation of the voltage in the dynamos. The article is extremely interesting and valuable.

Modern gas and oil engines. Steam engines at the World's Fair. J. W. R.

Hammersley's United Service.

JANUARY 1893.—The National Guard of Iowa in 1892. A story of Gettysburg. The battle of Copenhagen.

FEBRUARY.—The rennaissance of war.

MARCH.—Ship canals. The Vermont National Guard.

APRIL.—Moltke.

MAY.—A new system of drill regulations for infantry. Oliver Cromwell as a soldier. Army clothing and equipage.

The Iron Age.

JANUARY, 1893.—U. S. armored cruiser *Brooklyn*. British naval forced draft rules.

JANUARY 26.—Machine for rolling electrically heated bars.

FEBRUARY 2.—The Shaw 80-ton Gantry transfer crane.

This crane is to be used in mounting, dismounting and transferring heavy guns at Sandy Hook.

FEBRUARY 16.—The small arms of the great powers. The development and transmission of power from central stations.

FEBRUARY 23.—New armor specifications. The new Edison Station, New York.

MARCH 2.—Unfreezable dynamite.

MARCH 9.—Hydraulic power plant for the U. S. coast-defense vessel *Monterey*. A new mitrailleuse for cavalry. Trial of the 14-inch Harvey plate.

MARCH 16.—Hydraulic machinery and heavy guns.

A quotation from the *London Times* with comments on the fact that the recent cold weather had very disastrous effects upon the hydraulic machinery for the heavy guns upon the *Benbow*. After discovery of the injury, a careful inspection of the machinery was made and the necessity for taking apart most of the machinery was reached. It became necessary to send it to the original makers for reconstruction and repair. The Admiral of the fleet, Sir Thomas Symonds, suggested in this connection. the possibility of the best English ships being unsuited for service in such waters as the Baltic.

Schneider gun mount. Machinists in the navy.

MARCH 30.—Trials of the dynamite gun-boat *Vesuvius*. Notes on British armor and ordnance.

APRIL 6.—The Merriam percussion fuse.

APRIL 13.—Car for conveying heavy guns.

APRIL 20.—The manufacture of rifles.

MAY 4.—The new Western Electric Generator and Motor.

J. W. R.

The Scientific American.

JANUARY 14, 1893.—The manufacture of small arms. Fast torpedo boats.

JANUARY 21.—The Russian Warship *Ruric*.

JANUARY 28.—Warship *Chicago*. Military cycling. The advance in armed cruisers.

FEBRUARY 4.—Snow-shoe exercise in the German army.

FEBRUARY 11.—Trial of an American armor plate at Portsmouth, England. Trial of the pneumatic cruiser *Vesuvius*.

FEBRUARY 18.—The harbor defense ram *Katahdin*.

MARCH 4.—The manufacture of dynamite.

MARCH 11.—The coming naval review. The Uniten States steamship *Iowa*.

APRIL 11.—An improved camera lucida.

APRIL 18.—Krupp's exhibits at the Columbian Exhibition. The first war steamer of the world.

Engineering Magazine.

JANUARY 1893.—The choice of an architect. The anthracite coal industry. Fire losses and the age of clay. Pan-American railway surveys. Liquid fuel in steam making.

FEBRUARY.—The World's Fair and industrial art. The great wall of China. Progress in pneumatic tube transmission. Railroad development in Africa. Practical farming by electricity. Fire proof buildings. Modern uses of windmills.

MARCH.—America's need of the Nicaragua Canal. Relation of architect and engineer. The increase of speed on railways. Locations for the pig-iron industry. American railway progress in 1892. Value of long distance telegraphing. American annexation of Hawaii.

The American Engineer and Railroad Journal.

JANUARY 1893.—The new Manlicher rifle. Naval notes.

FEBRUARY.—Recent inventions in armor. The Ochta armor trial. An English torpedo cruiser. The manufacture of rifles. Naval notes.

MARCH.—The trials of the *Vesuvius*. Trial of Harvey steel armor plate. The Ammen ram *Katahdin*. Naval notes. War ships under construction.

APRIL.—Shells and high explosives. Fletcher rapid fire gun mount.

The Engineer (N. Y.).

JANUARY 7, 1893.—Hot work in naval vessels.

JANUARY 21.—Krupp's steel works. Machinists in the navy.

FEBRUARY 18.—The *Ann Arbor* as a coast defense ship.

The Electrical Review.

JANUARY 28, 1893.—An electric torpedo detector. The naval search light.

MARCH 18.—Power transmission for central stations.

The Western Electrician.

JANUARY 7, 1893.—The 120-ton electric traveling crane at Watervliet.

FEBRUARY 18.—Electricity in the French navy.

MARCH 11.—Electric shot firing in mines.

Marine Review.

JUNE 22, 1893.—Plans for submarine boats.

This relates to a call by our navy for designs for a submarine torpedo-boat. It appears that George C. Baker and Captain McDougall will probably submit designs. The French it appears have taken the lead in submarine navigation, having built several vessels of this class recently. The *Gymnote* is now said to be successful and is attached to their navy. This vessel has remained below water forty minutes, and during early trials maintained a steady course eight metres below the surface for 500 metres at a speed of four knots. She is propelled by electricity and contains compressed air for supplying the crew. Spain has a similar boat, and Russia and Italy are experimenting in the same direction. The article closes with a summary of a recent report of our Navy Department with respect to the great value of such navigation in coast defenses.

J. W. R.

El Porvenir Militar.

Electrical Engineering.

Technology Quarterly and Society of Arts.

BOOKS, EXCHANGES, ETC.

American Journal of Mathematics.
Annual Report Bureau of Ethnology.
Annual Report Smithsonian Institution.
Annual Report American Iron and Steel Institute.
Annual of the Office of Naval Intelligence.
Institution of Mechanical Engineers.
Journal of the American Chemical Society.
Journal of the Franklin Institute.
Popular Science Monthly.
Proceedings of the American Philosophical Society.
Proceedings of the Royal Society N. S. Wales.
Transactions of American Institute of Electrical Engineers.
Transactions of American Institute of Mining Engineers.
Transactions of the American Society of Mechanical Engineers.
Transactions of the Canadian Society of Civil Engineers.
Transactions and Journal of the Photographic Society of Great Britain.

JOURNAL

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NOTES ON ARMOR.*

BY FIRST LIEUTENANT ERASMUS M. WEAVER, R. Q. M., SECOND ARTILLERY, U. S. A.

I.

INTRODUCTION.

There is no question connected with the work of coast artillery of greater importance than that of armor. War ships in the future will carry armor covering a larger area of their sides than ever before, and the latest phase of the question, introduced by the employment of shells carrying within them bursting charges of high explosives, makes the armor on many old-type vessels of more service, relatively, than it was ten years ago. It is easy to understand, for example, that a ship of the *Hercules* type (1866) is better able to meet the fire of 8-inch guns and smaller calibers firing shells with gun-cotton charges than one of the *Impériuse* type (1881).

At all events, the targets to be fired at in time of war are of primary interest to the coast artillery. What will be the character of these targets? How do the powers of resistance of

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* It is the intention of the writer, after a brief review of the subject of armor in general, to present in the *Journal*, from time to time, such facts and information pertaining to armor as may come to his notice and be suitable for publication. To the end that the notes may be full, he asks contributions from all those who may be interested. Information in this line addressed to him at Fort Adams, Newport, Rhode Island, U. S. A., will be gratefullv received and duly ackhowledged. E. M. WEAVER.

the sides of armored battle-ships compare with the penetrating powers of our sea coast guns? These questions must always be up before us as perhaps the most fundamental and practical ones we have to deal with.

It is desired in this series of notes to traverse the ground covered by these questions, indicating the leading features of the targets presented in the sides of the type ships of the principal naval powers, and considering the powers of resistance offered by these ships to the attack of our 8-inch, 10-inch, 12-inch and 16-inch B. L. sea-coast guns.

A brief review of the gun-armor question may be given here with advantage:—

THE GUN-ARMOR CONTEST.

For almost forty years this contest has been going on. The advent of modern armored ships may be considered to date from the bombardment of the Kinburn forts by the French men-of-war in 1854. In this action the iron-clads *Lave*, *Devastation* and *Tonnante* took a leading, if not decisive part, and their success on this occasion determined the future use of armor protection on war vessels. France was led to lay down her first armor-clad battle ship, the *Gloire*, in 1858; England followed with the *Warrior* in 1859; Italy, with the *Formidable*, in 1860; Russia, with the *Petropalovski*, in 1861, and, finally, our own country with the *New Ironsides* and the *Monitor* in 1861. These ships, respectively, constituted the germs of the great fleets that to-day sail the seas under the flags of these countries. With the appearance of iron-clad war vessels began the struggle between armor and artillery.

The advantage in this competition has oscillated from the gun to armor and back again so often that it has been difficult to predict at any one stage the character of the next one. At no time during the entire period has the rivalry been more keen than during the past two years, and at no time has the advantage appeared to be more positively on one side than it does at present on the side of the plate. Yet, in view of what has heretofore happened, it would be a rash thing to say that the prolonged contest has at last been brought to an end. The entire metallurgical horizon is being scanned with a watchful eye by projectile makers, and any new promising process, or principle, or treatment introduced in iron or steel manufacture will be seized upon by them and tested to the fullest extent with a view to restoring to the projectile the leading position from which it now appears to have been displaced.

The train of improvements which has led up to the present status of the relation between the plate and the projectile was initiated about 1875. The contest previous to this had been between wrought-iron armor, on the one hand, and cast-iron projectiles on the other. A short time before, the cast-iron projectile had been improved by chilling the ogive in casting; but, with this exception, there had been no material innovation in the manufacture of projectiles since the introduction of rifled projectiles.

Step by step, however, guns had been increasing in caliber and power. The only way wrought-iron armor could meet this increased power of the attack was by increasing the thickness of armor to correspond with the increased power of the guns. In this way, little by little, the thickness of armor increased on the sides of battle-ships until, finally, this phase of the contest may be said to have terminated with the twenty-four inches of armor placed along the water line of the English ship *Inflexible*, in 1874.

In 1875 the French designed the *Furieux* to carry steel armor. The Italians two years before had planned the *Duilio* to have steel armor, and this ship, launched in 1876, was the first battleship to float steel armor. In the same year the Wilson patent for compound armor was taken out. Two new types of armor, thus, made their appearance at about the same time. Both gave much higher powers of resistance than wrought-iron and this fact enabled war ships to reduce the thickness of armor carried by them, and, with the same relative defensive powers, gave them greater buoyancy and allowed more space between decks—considerations which were of great importance because of the encroachments that had been forced by the necessity of carrying great thicknesses of wrought-iron armor.

A contest at once sprang up between the compound plate made in England, chiefly, and steel armor made principally in France.

This battle of the plates was fought out on the testing grounds of Europe with varying advantage. As long as chilled-iron projectiles were used the compound plate had the better record in that it broke up in better form iron projectiles, but, with the appearance of the steel projectile, the weak point of the compound plate—the weld between the face and body—began to become apparent, and the steel plate, after this, was considered the better type. The rivalry continued however very warm down to the Annapolis and the Ochta trials of 1890. After these trials there remained no doubt as to the supremacy of the Schneider all-steel plate over the compound plate of the English manufacturers. But these same trials, which established the superiority of the all-steel plate, also marked its downfall in the introduction of an alloy of nickel and steel as armor-plate metal.

In consequence of the fact that cast-iron projectiles were broken up with ease by both steel and compound plates there arose a lively competition among European metallurgists in efforts to produce an efficient armor-piercing projectile. Krupp, Armstrong, Firth, Whitworth, the Terre Noire works, the St. Chamond works, Hadfield, Holtzer and others gave the matter close study and worked diligently to arrive at a solution. Forged-steel, cast-steel, specially treated steel and alloys of steel were all tried as projectile metals in many competitive tests in the period between 1882 and 1886. The results of the tests established in a definite way the superiority of the projectile made by Holtzer in France and Hadfield in England of an alloy of chromium and steel.

These chrome-steel projectiles were first developed in France by M. Brustlein, the metallurgist of the Holtzer Company. M. Brustlein had noted as far back as 1875 the success that had attended the efforts of Mr. Julius Baur, of New York, in the manufacture of chromium-steel for commercial purposes. Based on Baur's work he began experiments in France with projectiles made of this alloy, and ultimately succeeded in producing the now famous Holtzer armor-piercing shell, which has become the standard projectile, the world over, for attacking armor. In England, the projectiles made by the Firminy process, and those made by Hadfield, both understood to be chrome-steel alloys, possess about the same qualities as the Holtzer projectiles.

These projectiles have remarkable hardness associated with a high measure of tensile strength. To such a degree do they possess these properties that, as a rule, they are not disintegrated by impact against ordinary steel or compound plates, even with velocities above 2000 f. s,, and often they undergo impact without material deformation. By thus holding together they expend the full amount of their energies in producing changes in the plate, *i. e.*, in penetration, cracks, etc. There is on record the performance of a 6-inch Hadfield projectile which was fired three times from the same gun against armor,—the first time, it perforated a 9-inch compound plate and its backing; the second time, it perforated, similarly, a second 9-inch compound plate; the third time, it was fired at a specially treated plate which broke it up. When fired at simple steel or compound plates chrome-steel projectiles, with rare exceptions, either perforate without deformation, or rebound entire from the plate, or remain in the plate unbroken gripped by the metal.

The introduction of these projectiles had the effect of restoring the attack to the same relative position it held ten years before when cast-iron projectiles were pitted against wrought-iron armor; the increase in gun-power that had occurred in the meantime made about the same calibers effective against the same thicknesses of compound or steel armor as formerly obtained with cast-iron projectiles against wrought-iron armor.

This improvement in projectiles gave an impetus to the arguments of a certain class of officers abroad who advocated the abandonment of vertical armor. At first armor covered the entire hull of the ship as in the case of the *Gloire* and *Formidable*, but, in order to keep pace with the increased powers of the attack, it became necessary to make side armor thicker and thicker until, about 1865-7, when six to eight inches of wrought-iron were found to be insufficient, tonnage considerations placed a limit to this manner of meeting the attack. At this stage naval constructors were forced to leave certain portions of ship's sides uncovered in order that the requisite thickness could be placed along the water line and in the wake of the vital parts of the ship. England and Italy led the way in this movement as evidenced, for example, in the *Inflexible* and *Duilio*.

It was claimed by the anti-armor school that ships could fight and live even though projectiles should pass with freedom through the unarmored parts; that while, of course, it would be desirable to keep them out, if possible with a moderate thickness of armor, this could not be done, and, therefore, it would be better to have the increased flotation and interior ship space than the incomplete protection of the armor, especially as this armor, while failing to stop the projectiles, would, through the resistance offered, develop in blind shells sufficient heat to explode the charge between decks, which, if the armor were not there, would probably pass through these parts without exploding. It was further claimed that it would be better to give attention to increasing the flotation power of the ship by providing a belt of light elastic material like cork or cellulose along the water line, which, while permitting projectiles to pass, would, to a certain extent, close after them, and prevent the ingress of water, and, also, by employing many water-tight compartments in the structure of the ship's bottom filled with this same material, the effect would be to give the ship what was called a "raft body" and make her practically unsinkable; furthermore, that the development of the ram and the torpedo threatened to make all armor above water useless.*

These views were making great headway in naval circles and it seemed at one time that coast defenders might see all vertical side armor vanish, and that our sea-coast armament would have to deal chiefly with "wooden walls" again. But, at this epoch, an event occurred which arrested at once all progress in this direction, and caused a complete cessation to this line of argument.

Originally armor was placed on ships to keep out explosive projectiles, but as the resistance offered by armor became greater, the walls of the shell had to be made thicker. In course of time these conditions reduced the explosive charge within the shell to almost insignificant proportions. About 1880-5, however, it was shown by experiments that gun-cotton and other

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* It is probable that the sinking of the *Victoria* will revive some of these arguments.

explosive nitro-compounds could be fired with safety in shells with high velocities, and it was further revealed, especially by the experiments on the *Resistance* at Portsmouth, England, in 1889, that the destructive effect of shells so charged was appalling. "None but those who had witnessed the trials could picture the wholesale destruction caused by these shells. Of dummy men, scarcely one in the vicinity of a bursting shell escaped; but one of the most remarkable features was the terrible smoke and fumes after each explosion, which set fire to the ship and prevented any one approaching the spot, in some cases for twenty minutes after the shell had burst."* Also the use of forged steel shells enabled thinner walls to be used and thus increased the charge capacity of armor-piercing shells.

It is now generally admitted by all powers, including England and Italy, that it is absolutely necessary to keep these shells from entering to the interior of war ships. Practically, therefore, the same conditions obtain, at present, in this matter, as existed in 1854-5 in consequence of the introduction of the first explosive projectiles by General Paixhans of the French service, and we find in the latest designed ships a reproduction of the distribution of armor found in the *Gloire* and *Formidable*, as, for example, in the new *Dupuy de Lôme* French ship (named suggestively after the constructing engineer of the *Gloire*) and the modified design of the Italian war ship *Re Umburto*. Designers of war ships now provide, therefore, not only a belt of water line armor and turret armor but also arrange to have the entire midship section, where is placed the secondary battery of smaller caliber guns, covered with four to six inches of steel armor, with a view to excluding shells with high explosive charges from the fighting portion of ships.

But, to return to the plate, we have seen how, in the Annapolis and Ochta trials of 1890, the supremacy of the homogeneous steel plate was established over the compound plate with steel face and iron body, and reference was made to the introduction of an alloy of nickel and steel as a metal for armor. This was the first public test of a plate of this character and of a thickness as great as 10½ inches. The plate was the product of the

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* Lord Brassey's Annual for 1892, p. 309.

works of Schneider and Company, of France. Its performance was so promising, especially in the manner in which it took up the striking energy of Holtzer projectiles without cracking, that other tests were instituted by the ever watchful and progressive Bureau of Ordnance of the Navy Department, using American made plates of nickel-steel.

These tests were made at Annapolis and at the new naval proving ground at Indian Head. So emphatically did the tests confirm the behavior of the nickel-steel plate first tried, that the Navy Department at once decided to have all future armor for our war ships made of this alloy. This introduction of nickel-steel armor was a long step forward for the plate, and the credit of it rests first, with Schneider and Company, and secondly with Ex-Secretary of the Navy Tracy and Captain Folger, Ex-Chief of the Bureau of Ordnance of the Navy.

Almost simultaneous with this improvement occurred another of even a more striking nature and far-reaching in its effect on the armor question.

It has been noted that the hard steel face of the compound plate caused the old chilled-iron projectiles to go to pieces on impact. The principle involved in this action of the compound plate is, in theory, that the hard face of the compound plate, by presenting a hard rigid surface to the projectile at the very inception of its attack, prevents the point of the projectile from even entering the surface of the face of the plate, and the point being thus kept out at a critical instant, the ogive of the projectile receives no support from the metal of the plate, and, as a result, great reactionary stresses are developed throughout the projectile, tending to cause rupture; the effect is the same as if the projectile were at rest standing on its base and received on its point a blow from some huge hammer, in which the energy of the blow was equal to the energy of the projectile on striking the plate. In short, the object of the plate is to make the projectile do its work in breaking itself up, instead of doing work of penetration in the plate. For, if the point of the projectile is able to enter the plate far enough to secure a firm support for the ogive, the metal of the plate tends to keep the projectile together and to promote penetration. After the introduction of the Holtzer projectiles the points of armor-piercing projectiles had no difficulty in entering compound and steel plates and after overcoming thus the resistance associated with the first stage of impact, the subsequent course of the projectiles through the body of the plates was comparatively easy, especially with the soft iron body of compound plates.

The latest phase of the armor question has had for its object the destruction of chrome-steel projectiles in the same manner as chilled-iron projectiles were formerly broken up by compound armor. Plate makers have endeavored to increase the hardness of the faces of plates so as to keep out the points of chrome-steel projectiles. This involved, of course, giving to a surface layer of the face of the plate not only great hardness but at the same time preserving a high degree of tensile strength and toughness. All this appears to have been accomplished in a wonderfully successful manner by Mr. H. A. Harvey of the Harvey Steel Works of Newark, N. J., and to a less perfect degree by Captain T. J. Tresidder, late of the Royal Engineers. Each invention consists of subjecting the armor plate made in the usual way to a certain final treatment. The processes will each be explained in detail in connection with the consideration of the different types of armor which is to follow.

The Ordnance Bureau of the Navy deserves great credit again for its action in connection with the development of the Harvey process. The value of the invention was at once appreciated and thorough tests made at Indian Head, applying the process to both all steel and nickel-steel armor, with the result, that, employed with nickel-steel, the Harvey process has given us the highest measure of armor stength ever attained, and, in truth, some of the recently tested Harveyized nickel-steel plates have given almost ideal results.

II.

WROUGHT-IRON ARMOR.

While wrought-iron is no longer considered a suitable metal for ship armor, and has not been used for some years in new constructions, it is still of considerable interest, from a ballistic point of view, by reason, partly, of the fact that there are afloat at present many powerful battle-ships, launched before the advent of steel and compound armor, which are still in good fighting condition and will remain in commission for some years to come, and also, because the resistance offered by wrought-iron to the passage of projectiles through it has been made the subject of much study and extended experiments, and, with some authorities, it is regarded as the standard metal for ballistic comparisons of projectiles and all kinds of armor.

It is unnecessary to give a detailed account of the manufacture of wrought-iron armor. It is sufficient to say that the iron is reduced from the pig-iron by the usual commercial process and is given its proper plate form by forging under hammers or presses or passing between rollers.

Its characteristic features as an armor metal are its great ductility and uniformity of physical properties. Compared with other armor metals it is soft and yielding under impact, flowing readily from before the projectile in its passage through the plate after having exerted its full measure of resistance. The effect of impact, due to this last property, is limited almost strictly to the pathway of the projectile.

Its uniformity has led many to regard it as the proper standard of comparison for projectiles and steel armor. Often the resistance of steel armor to the attack of projectiles is expressed in terms of the thickness of wrought-iron the projectiles used would have perforated. The effect of the projectiles on wrought-iron of the same thickness as the plate under test is calculated by the formulas for perforating wrought-iron and to the results thus obtained a certain percentage is credited to the steel or compound plate. This percentage is an arbitrary factor based in each case on the experience or opinions of the experimenters. Krupp puts it at 10 to 20 per cent. for projectiles that remain unbroken. Others have placed it at 25 to 30 per cent. Recent experiments would require that the factor be as high as 50, 60, and, in one or two cases, as high as 100 per cent. But it may be doubted whether this is a proper way to measure the strength of steel armor. Steel is so radically different in its properties as armor from wrought-iron it may well be questioned whether there is any such direct and simple relation between the measures of their strengths. It would appear to be more scientific and logical to seek a formula for steel based upon experimental data. This will be considered again under the head of steel and compound armor.

Resistance to Penetration.

In view of the long period wrought-iron occupied the field unchallenged and of the many experiments made to determine its powers of resistance to the attack of projectiles, and, also, of the uniformity of its physical properties, it would be naturally taken for granted that the law of its resistance had been definitely determined, and that there would be, as a result, one formula accepted by all artillerymen as giving accurate expression to this law. This is not the case, however. In truth one of the most striking aspects of this portion of the subject is the wide variations in the interpretations of the law of resistance that have from time to time been enunciated by investigators. A review of the subject reveals a different interpretation by each of the first-class powers, and even these are not satisfactory to individual authorities in each country, and so other private formulas are advanced.

It will be a matter of some interest to glance at a few of these formulas and to endeavor to compare them, with view to bringing out wherein they are different in their respective interpretations of the law of resistance.

We may take, as among the most prominent, the following: in which t represents the thickness of plate, d the diameter of the attacking projectile, v the striking velocity, w the weight of the projectile, and E the striking energy:

$$t^{0.65} = \overset{0.001092}{\text{[redacted]}} \frac{w^{0.5} v}{d^{0.75}} \text{ (de Marre's)}$$

$$t = \frac{v}{608.3} \left(\frac{w}{d} \right)^{\frac{1}{2}} - 0.14d \text{ (Maitland's)}$$

$$\frac{E}{\pi \left(\frac{d}{2} \right)^2} = 100 \left(\frac{t}{d} \right)^{\frac{1}{8}} t \text{ (Krupp's)}$$

$\frac{E}{\pi d} = 34.98t^{1.868}$ (Muggiano Commission's, for plates between 30 and 55 cm.)

$\frac{E}{\pi d} = 15.72t^{2.035}$ (English Admiralty for plates between 10 and 20 inches)

$$\frac{wv^2}{d} = 2265464t^{1.4} \quad \text{(Gâvre)}$$

$\frac{wv}{d^2} = 400(t + 1.5)$ (Froloff's, for plates more than 2½ inches thick)

$$\frac{wv^2}{d} = 62334(5t + 2d) \quad \text{(Inglis')}$$

$$\frac{wv^2}{d^3} = 437500\frac{t}{d} + 161810\frac{t^2}{d^2} \quad \text{(de Brette's)}$$

$$\frac{E}{\pi d} = kt^2 \quad \text{(Fairbairn's)}$$

It is generally agreed at the present time that the problem of impact of a projectile against an armor plate involves nothing more than a proper accounting for the various transfers of the energy of the projectile that take place.

Under ordinary conditions the transfers of energy will take one or more of the following forms:

1. Producing change of form in the plate, that is penetration, cracking, bulging, etc.
2. Producing change of form in the projectile.
3. Heating the plate.
4. Heating the projectile.
5. Moving bodily the plate.
6. Moving the projectile in rebound.

With hard faced armor, such as steel and compound, the total energy as a rule is distributed in appreciable proportions among all of these divisions, but with soft wrought-iron armor it is chiefly confined to the first. In considering the resisting capacity of a plate we may for all practical purposes express the total loss of projectile energy in terms of the first.

For the purpose of convenient comparison let us solve the above equations with respect to the total energy of impact, and let us write for the numerical coefficient in each case the letter C. We shall have the following:

$E=Cd^{1.5}t^{1.8}$ (de Marre's)
$E=C(0.14d+t)d$ (Maitland's)
$E=Cd^{\frac{5}{8}}t^{\frac{4}{3}}$ (Krupp's)
$E=Cdt^{1.868}$ (Muggiano Commission)
$E=Cdt^{1.645}$ (English Admiralty)
$E=Cdt^{1.4}$ (Gâvre)
$E=Cvd^{2}(t+1.5)$ (Froloff's)
$E=Cdt(d+2.5t)$ (Inglis')
$E=Cdt(t+2.7038d)$ (de Brette's)
$E=Cdt^{2}$ (Fairbairn)

It is evident that the law of resistance as given by each of these formulas is determined by the relations existing among t, E and d, and we may change the value of C without affecting the law proper.

Let us impose the condition that C shall have such a value in each, as shall give the same value for E when $d=10$ and $t=10$. We shall have the following:

$E=5.8168d^{1.5}t^{1.8}$ (de Marre's)
$E=32.21(0.14d+t)d$ (Maitland's)
$E=3.672d^{\frac{5}{8}}t^{\frac{4}{3}}$ (Krupp's)
$E=4.9852dt^{1.868}$ (Muggiano Commission)
$E=3.3938dt^{2.085}$ (English Admiralty)
$E=14.619dt^{1.4}$ (Gâvre)
$E=3.34d^{2}(t+1.5)$ (Froloff's; v taken constant)
$E=1.04914dt(d+2.5t)$ (Inglis')
$E=0.99144dt(t+2.7038d)$ (de Brette's)
$E=3.672dt^{2}$ (Fairbairn)

Starting with the values $d=10$, and $t=10$, let us first assume t constant and assign to d values from 10 to 18, and deduce, for each formula, the corresponding values of E; then assume d constant, make t to vary and deduce values for E in the same manner. The results may be tabulated as follows:

TABLE I.

Showing law of resistance of wrought-iron armor to perforation by projectiles, as given by various formulas. First: for a constant thickness of plate and variable diameter of projectile. Second: For a constant diameter of projectile and a variable thickness of plate.

KRUPP.				GAVRE.				DE MARRE.				MAITLAND.				ENGLISH ADMIRALTY.				FROLOFF.			
$t = 10$ inches.		$d = 10$ inches.		$t = 10$ inches.		$d = 10$ inches.		$t = 10$ inches.		$d = 10$ inches.		$t = 10$ inches.		$d = 10$ inches.		$t = 10$ inches.		$d = 10$ inches.		$t = 10$ inches.		$d = 10$ inches.	
d	Perforating Energy.	t	Perforating Energy.	d	Perforating Energy.	t	Perforating Energy.	d	Perforating Energy.	t	Perforating Energy.	d	Perforating Energy.	t	Perforating Energy.	d	Perforating Energy.	t	Perforating Energy.	d	Perforating Energy.	t	Perforating Energy.
in.	ft.-tons.	in.	ft.-tons.	in.	ft.-tons.	in.	ft.-tons.	in.	ft.-tons.	in.	ft.-tons.	in.	ft.-tons.	in.	ft.-tons.	in.	ft.-tons.	in.	ft.-tons.	in.	ft.-tons.	in.	ft.-tons.
10	3672	10	3672	10	3672	10	3672	10	3672	10	3672	10	3672	10	3672	10	3672	10	3672	10	3672	10	3672
11	4304	11	4170	11	4039	11	4196	11	4234	11	4154	11	4089	11	3992	11	4039	11	4458	11	4443	11	4006
12	4975	12	4683	12	4406	12	4739	12	4824	12	4653	12	4515	12	4316	12	4406	12	5309	12	5288	12	4340
13	5686	13	5210	13	4774	13	5302	13	5440	13	5162	13	4950	13	4638	13	4774	13	6261	13	6206	13	4673
14	6433	14	5751	14	5141	14	5881	14	6080	14	5684	14	5395	14	4957	14	5141	14	7282	14	7197	14	5007
15	7217	15	6305	15	5508	15	6478	15	6742	15	6217	15	5846	15	5282	15	5508	15	8380	15	8261	15	5349
16	8037	16	6873	16	5875	16	7090	16	7428	16	6761	16	6288	16	5605	16	5875	16	9600	16	9398	16	5675
17	8891	17	7455	17	6242	17	7718	17	8134	17	7316	17	6763	17	5927	17	6242	17	10811	17	10608	17	6009
18	9780	18	8051	18	6610	18	8361	18	8863	18	7880	18	7259	18	6250	18	6610	18	12144	18	11891	18	6343
Formulas.	$E = Cd^{\frac{5}{3}}t^{\frac{4}{3}}$			$E = Cdt^{1.4}$				$E = Cd^{1.5}t^{1.3}$				$E = Cd(0.14d + t)$				$E = Cdt^{2.085}$				$E = Cvd^2(t + 1.5)$			

TABLE I (CONTINUED).

	MUGGIANO COMMISSION.				INGLIS.				DE BRETTE.				FAIRBAIRN.				BY PRINCIPLE OF THE RESISTING DISK.			
	$t = 10$ inches.		$d = 10$ inches.		$t = 10$ inches.		$d = 10$ inches.		$t = 10$ inches.		$d = 10$ inches.		$t = 10$ inches.		$d = 10$ inches.		$t = 10$ inches.		$d = 10$ inches.	
	d	Perforating Energy.	t	Perforating Energy.	d	Perforating Energy.	t	Perforating Energy.	d	Perforating Energy.	t	Perforating Energy.	d	Perforating Energy.	t	Perforating Energy.	d	Perforating Energy.	t	Perforating Energy.
	in.	ft.-tons.	in.	ft.-tons.	in.	ft.-tons.	in.	ft.-tons.	in.	ft.-tons.	in.	ft.-tons.	in.	ft.-tons.	in.	ft.-tons.	in.	ft.-tons.	in.	ft.-tons.
	10	3672	10	3672	10	3672	10	3672	10	3672	10	3672	10	3672	10	3672	10	3672	10	3672
	11	4039	11	4390	11	4155	11	4328	11	4334	11	4148	11	4039	11	4443	11	(1) 4235 (2) 4272	11	(1) 4059 (2) 4163
	12	4406	12	5162	12	4656	12	5036	12	5050	12	4644	12	4406	12	5288	12	(1) 4792 (2) 4887	12	(1) 4449 (2) 4611
	13	4774	13	5994	13	5183	13	5796	13	5819	13	5160	13	4774	13	6206	13	(1) 5345 (2) 5508	13	(1) 4842 (2) 5113
	14	5141	14	6885	14	5728	14	6609	14	6642	14	5696	14	5141	14	7198	14	(1) 5882 (2) 6131	14	(1) 5240 (2) 5626
	15	5508	15	7836	15	6294	15	7474	15	7518	15	6252	15	5508	15	8263	15	(1) 6383 (2) 6749	15	(1) 5641 (2) 6157
	16	5875	16	8847	16	6882	16	8391	16	8488	16	6828	16	5875	16	9402	16	(1) 6883 (2) 7356	16	(1) 6046 (2) 6718
	17	6242	17	9917	17	7491	17	9360	17	9431	17	7424	17	6242	17	10614	17	(1) 7346 (2) 7947	17	(1) 6453 (2) 7278
	18	6610	18	11032	18	8121	18	10381	18	10468	18	8040	18	6610	18	11900	18	(1) 7767 (2) 8519	18	(1) 6865 (2) 7877
Formulas.	$E = Cdt^{1.868}$				$E = Cdt(d + 2.5t)$				$E = Cdt(2.7038d + t)$				$E = Cdt^2$				$E = C(nd)^2t$ $(A)\ n = 1.52 + 0.003(T - 10d)$ $(B)\ n = 1.346 + 0.024(0.6T - d)$ t = depth of penetration. T = thickness of plate attacked.			

These results are further illustrated graphically in plates I and II, which bring out in striking relief the wide range covered by the formulas. For $d = 18$ and $t = 10$, plate I shows a variation in E of from 11891 foot-tons as given by Froloff's formula to 6610 foot-tons as given by the Gâvre and other formulas containing d to the first power. In the same manner plate II shows a variation of E, when $t = 18$ and $d = 10$, of from 12144 foot-tons, as given by the English Admiralty formula to 6250 foot-tons as given by Maitland's.

It will be observed that while de Marre's, Krupp's and de Brette's formulas occupy a mean position in both plates I and II, there is a radical change in the position of others. For example, Froloff's passes from the extreme right in plate I to the extreme left in plate II; on the other hand, the English Admiralty, Muggiano Commission, and Fairbairn formulas pass from the extreme left in plate I to the extreme right in plate II. The Inglis and Gâvre formulas give evidences of the same tendency, while de Brette's shows a slight swing from right to left, like Froloff's. Maitland's, though standing apart from the de Marre and Krupp formulas, like them shows no marked angular change.

The more distinct groupings of the curves in plate II than in plate I is evidence that there is closer agreement in the interpretation of the law for d constant and t variable than for t constant and d variable. The formulas of the group on the right in plate II are apparently based on the assumption that penetration is proportional to the energy per unit of length of circumference of the cross-section of the projectile. The middle group makes it proportional to the total energy. Froloff's assumes it to be proportional to the first power of the velocity—to the momentum instead of energy. The first assumes penetration to be similar to the action of a punch, the second assumes it to be similar to the action of a wedge, the third similar to the impact of elastic bodies. The first is now generally abandoned; the third is not known to be accepted by any authority except General Froloff. Only the second assumption is believed to be entitled to confidence.

Taking the loss of energy by the projectile in passing through a plate as a measure of the work performed by it, this, in turn, may be taken as a measure of the resisting capacity of the plate. The resistance offered is due to the cohesive forces which bind together the molecules of the metal and thereby make up the mass of the plate. These forces resist not only rupture, but also any force tending to cause a relative change in the original positions of the molecules. We may conceive, as a fundamental idea, two or more molecules bound together at a definite distance apart by elastic forces which oppose displacement in all directions within certain limits. The mass of metal is made up of an innumerable number of such groups. The projectile in entering and penetrating the plate encounters opposition from these forces continuously along its path within the plate; along the path it overcomes them causing rupture among the molecular aggregations, and beyond the limits of actual path it strains the molecular systems some within the limits of their elasticity and some beyond the elastic limit. In short the resistance of the plate is due to the reaction of the molecular forces which oppose the separation, displacement, or disturbance of the ultimate particles of the metal. We cannot deal with the fundamental forces existing between two molecules to obtain a unit of measure, nor can we determine specifically a measure of the force associated with the cold flow of the metal from before the projectile in its passage through the plate, but it is possible by experiment to obtain a value for the integrated effect of these small differential quantities of force, in terms of the projectile energy expended in producing a total observed effect.* This expended energy may then be made the first

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* The fundamental consideration to be kept in mind in future experiments should be *the loss of energy* by a projectile which passes completely through a plate. If this be ascertained for a series of projectiles having a uniformly graded difference of diameters, attacking a series of plates of different thicknesses, all data would be had which are necessary for preparing a trustworthy formula of perforation. It would seem to be a comparatively simple matter to determine this loss of energy, experimentally, quite accurately. It is suggested that a system of ballistic screens in circuit with the usual ballistic machine for determining velocities could be arranged *behind* the plate so as to register the velocity of the projectile at a given point in rear after it had perforated the plate. Having the velocity at this point it would be a simple problem in exterior ballistics to determine what velocity the projectile had on leaving the rear face of the plate. From the striking velocity and leaving velocity we could pass to the corresponding energies, and the difference between these two would be the loss of energy due to the resistance of the plate.

member of an equation expressing the strength of the plate; when confirmed by many experiments, and properly equated with functions of t and d, it expresses the law of resistance. In this manner Krupp's and de Marre's formulas, and others based on the assumption that penetration is proportional to the total striking energy, have been written out.

Reasoning along this line it has seemed probable to the writer, that the resistance offered by a plate of wrought-iron to the attack of any projectile should be confined to the comparatively small mass of metal pushed aside or cut out by the projectile in its passage and a further small mass immediately about the shot hole; that is to the mass in which there is any molecular disturbance, in contradistinction to the movement of the plate as a body. If it be assumed that the metal per unit of weight offers an intrinsic resistance to the passage of a projectile, it follows that the measure of strength of the plate will be proportional to the weight of the limited mass of metal above defined. The volume of this mass will be that of a cylindrical disk having the thickness of the plate for its altitude, and for its cross-section a circle which will be a function of the diameter of the projectile. If d represent the diameter of the attacking projectile and t the thickness of the plate, the volume of the resisting disk will be expressed by $\pi(nd)^2t$, in which n is a constant to be determined by experiment, and expresses the ratio of the radius of the resisting disk to the diameter of the projectile, therefore nd is the radius of the resisting disk. Taking the weight of one cubic inch of wrought-iron to be 0.28067 pounds the weight of the resisting disk in tons will be given by:

$$w = 0.000393 64(nd)^2t \quad . \quad . \quad . \quad . \quad . \quad . \quad 1.$$

The resistance of the molecules to separation and disturbance may be expressed in the form of the energy per ton of the resisting disk that the projectile must carry to produce any given change in the position of the molecules, as, for example, that caused by the passage of the projectile through the plate. This will, of course, be constant for the same kind of metal.

It is evident, if we can obtain a value for this constant, that the energy necessary to perforate the plate will be had by multiplying the weight of the resisting disk in tons by the constant of resistance. If E represent the projectile energy required, and C the constant of resistance for wrought-iron, and w the weight of the resisting disk in tons, we shall have the expression:

$$E = Cw \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad 2.$$

We now assume a value for n in equation 1; then, by experiment, determine a value for E, whence, from equation 2, the value for C may be deduced. Let us assume, for example, that when d is equal to ten inches and t is equal to ten inches n is equal to 1.25,* and let us take the same value for E under these hypotheses as prescribed for the several formulas above, viz: 3672 foot-tons. We shall then have for the weight of the resisting disk:

$$w = 0.00039364(1 \cdot 25d)^2 t = 0.61507 \text{ tons.}$$

Hence: $E = 3672 = C0.61507.$

Hence: $C = \frac{3672}{0.61507} = 5970.$

That is, under this assumed value for n, we must credit to wrought-iron a resisting capacity of 5970 foot-tons per ton of metal disturbed by the passage of the attacking projectile, and every ton of wrought-iron has the power, through the operation of its molecular forces, to absorb 5970 foot-tons of projectile energy if all the molecules participate in the work.

Substituting this value of C in equation 2, we shall have:

$$E = 2.3501(nd)^2 t \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad 3.$$

In which E expresses in foot-tons the amount of energy which must be carried by a projectile having a diameter of d inches, to perforate t inches of wrought-iron.

The radius of the resisting disk (nd) will vary with the form of the head of the projectile, and with t and d.† For projectiles with ogives struck with a radius of from two to two and one-half calibers we may write:

$$n = 1.52 + 0.003(T - 10d) \quad . \quad . \quad . \quad . \quad . \quad A.$$

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* This is done by inspection of the plate *immediately* after it has received the blow of the projectile. With soft metals n will approach unity, and with hard elastic steels it will be greater than unity, running up to 3½ and perhaps 4 for $d = 10$, and $t = 10$.

† It will also vary with the striking velocity, but, for wrought-iron, this variation may be neglected without material error within the limits of practical velocities.

and for projectiles with ogives from one and one-half to two calibers we may write:

$$n = 1.346 + 0.0024(0.6T - d) \quad . \quad . \quad . \quad . \quad \text{B.}$$

In which T represents the thickness in inches of the plate attacked. For complete perforation T is equal to t in equation 3; for incomplete perforation t is less than T.

This formula has been incorporated in the table on page 507, in order that it may be compared with the other formulas, and is plotted on plates I and II for both values of n as given by equations A and B. For a constant diameter and variable thickness of plate, plate II shows that for values of n from equation B, the formula gives results similar to those of the middle group, being almost identical with those given by de Marre's formula, while values of n from equation A are practically a mean between Maitland's and de Marre's.

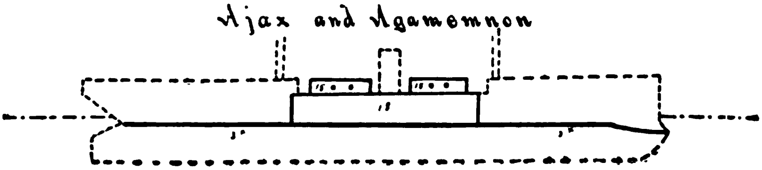
Plate I shows a marked difference however in the interpretation of the law of resistance for a constant thickness of plate and variable diameter between this formula and the others. It will be observed that whereas all the other formulas give either straight lines or lines convex toward the axis of diameters, this formula gives a line slightly concave towards this axis. The interpretation as given by the right line is, that the resistance of a plate of constant thickness increases directly with the increase of diameters; for the convex lines, that it increases more rapidly than the increase of diameters; for the concave, less rapidly. It would seem that this point might readily be determined by experiment and yet we note the wide range of interpretation of this point as evidenced in plate I. The last interpretation is believed to be supported by both *a priori* reasoning and experiment. It is to be noted that, under the assumption of a limited "resisting disk," an increase of diameter increases two dimensions of the attacking projectile but only one of the resisting disk. For example, the increase of two inches, in passing from our 10-inch to our 12-inch army projectiles, increases the weight, and therefore, for a constant velocity, the striking energy seventy-five per cent.; whereas the increase of plate metal disturbed, corresponding to this increase, is only forty-four per cent. It is well known that the striking velocity necessary for perforation decreases with the increase of diameter, much more then should the energy, which varies as the square of the velocity, decrease. Experimenters have observed that large projectiles stand up to their work better than smaller ones, especially in the case of hard armor. This is ascribed to the fact that there is less tendency to deformation, and the ogive is forced more readily into the face of the plate and then receives support from the metal of the plate. Krupp, in this connection, states that "the strain upon the metal of the projectile increases with the value of the ratio of the thickness of the plate to the diameter of the projectile." It is believed, therefore, that the rate of falling off of energy necessary to perforate is greater than has heretofore been allowed, and that the formula herein proposed gives more adequate expression than the others to the observed fact that larger projectiles are relatively more efficient than smaller ones.

Finally, it is believed that this brief review of the subject of the ballistics of penetration of wrought-iron shows it to be in a most unsatisfactory state. If this metal is to be taken as the standard for ballistic comparisons of armor and projectiles it is important that a correct and universally accepted interpretation of the law of resistance be arrived at. As the question now stands there is ample justification for the recent assertion of an English authority that it is "a disgrace to science."

IRON-CLAD BATTLE SHIPS.

The characteristic features of the principal battle ships now afloat clad with wrought-iron are given herewith. The outline drawings of ships are intended to present those points of most importance, regarding the ships as targets. The armored parts are included within full lines. The unarmored parts are bounded by broken lines. The thickness of armor is given on each drawing in inches; the numbers with a cross to the right and above indicate the thickness of the horizontal protective deck armor. The drawings are not made accurately to scale; they do indicate, however, approximately, the sizes of ships and the dimensions of parts. They have been sketched from the plates given in Lord Brassey's Annual, Ordnance Note No. 337, King's War Ships, and the Naval Intelligence Annual for 1889. The descriptive parts have been taken from these same sources in part, and in addition from the "Report of the Board on Fortifications or Other Defenses." It has been the aim to give those characteristics which would be of service to the sea-coast artilleryman in recognizing a war ship, determining the kind and weight of fire necessary, and the parts of the ship to which each kind of fire should be directed. The vessels of each country are arranged in alphabetical order.

ENGLAND.



These are sea-going turreted battle ships, having a central citadel, or redoubt, enclosing two turrets placed obliquely across the ship. The sides of the citadel extend down below the water-line and form a partial belt, leaving the fore and aft parts unprotected against direct fire. A horizontal protective deck three inches thick passes from front to rear on a level with the lower part of the belt armor. The principle of the "raft body" is applied in these ships, the bottom having many water-tight compartments, and the water-line regions have a cork belt. The coal bunkers are arranged so as to give coal protection to the boilers and machinery. They carry two signal masts. They were launched in 1879 and 1880.

The armor would be perforated by our 8-inch, 10-inch, 12-inch, and 16-inch guns at the following ranges:

Turret Armor.

8-inch: would not perforate at muzzle.
10-inch: would perforate up to 3488 yards.
12-inch: would perforate up to 6000 yards.*
16-inch: would perforate up to 6000 yards.

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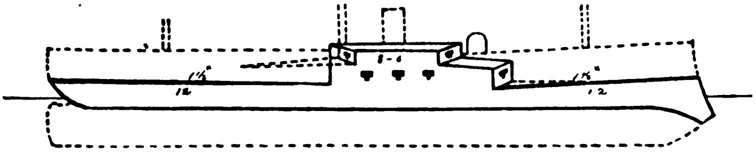
* Ranges beyond 6000 yards not considered.

Redoubt Armor.

8-inch: would not perforate at muzzle.
10-inch: would perforate up to 1314 yards.
12-inch: would perforate up to 4806 yards.
16-inch: would perforate up to 6000 yards.


Alexandra

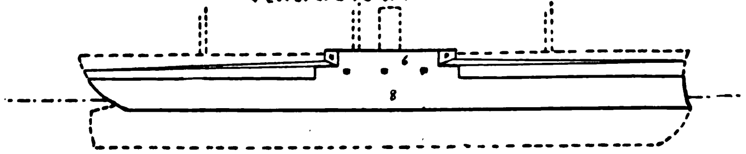
This is a full-rigged casemate battle-ship, having a central casemate with a double tier of guns for fore and aft fire. Protective deck over belt from one inch to one and one-half inch thick. Complete belt of water line armor twelve inches thick. Casemate armor from six to eight inches thick. The ship was launched in 1875. The limits for armor perforation by our guns are as follows:

Water-line Armor.

8-inch: up to 1240 yards.
10-inch: up to 4786 yards.
12-inch: up to 6000 yards.
16-inch: up to 6000 yards.

Casemate Armor.

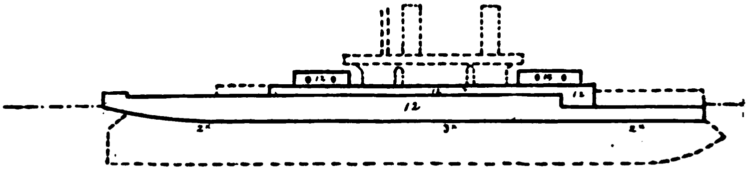
	6-inch.	8-inch.
8-inch:	up to 5802 yards.	3944 yards.
10-inch:	up to 6000 yards.	6000 yares.
12-inch:	up to 6000 yards.	6000 yards.
16-inch:	up to 6000 yards.	6000 yards.


Audacious

This is a central casemate ship with two tiers of guns, upper tier arranged for fore and aft fire. The armor is dist uted similarly to that of the *Alexandra*. The belt armor is e inches thick and the casemate armor is six inches thick. ship is bark rigged. She was launched in 1869. The limits armor perforation are the same as for the casemate armor of *Alexandra*.

Of the same type are the *Invincible*, launched in 1870: the *Duke*, launched in 1870; the *Swiftsure* and *Triumph* also launc in 1870.

Devastation and Thunderer



These are turreted sea-going battle ships. There is a c plete water-line belt twelve inches thick enclosing a mid breast height of 12-inch armor, which, in turn, encloses turrets. The turrets are placed on fore and aft line and h 14-inch armor on forward turret and 12-inch on after. Ther one signal mast. A protective deck of two to three inches th ness covers the below water regions. An unarmored su structure rises between the turrets giving a characteristic app ance to the ships. They were launched in 1871. The limits perforation are:

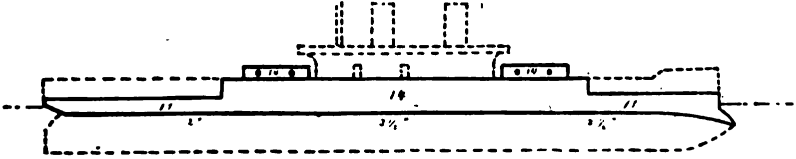
The 12-inch Armor.

8-inch: up to 1240 yards.
10-inch: up to 4786 yards.
12-inch: up to 6000 yards.
16-inch: up to 6000 yards.

The Forward Turret Armor.

8-inch: up to 182 yards.
10-inch: up to 3488 yards.
12-inch: up to 6000 yards.
16-inch: up to 6000 yards.

Dreadnaught



This ship is in general appearance similar to the *Devastation* and may be considered a modification and improvement of that ship. It differs from the *Devastation* principally in that the belt rises amidship to form the sides of the central breast-height. The turret armor and midship belt armor is fourteen inches thick. The protective deck armor is from two and one-half to three and one-half inches thick. The ship was launched in 1875. The limits for armor perforation are:

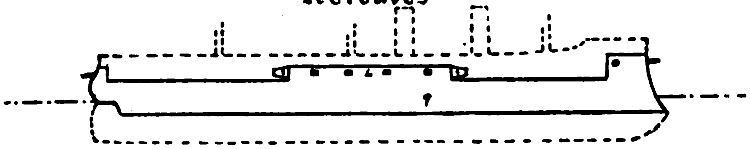
For the 11-inch Armor.

8-inch: up to 1835 yards.
10-inch: up to 5507 yards.
12-inch: up to 6000 yards.
16-inch: up to 6000 yards.

For the 14-inch Armor.

8-inch: up to 182 yards.
10-inch: up to 3488 yards.
12-inch: up to 6000 yards.
16-inch: up to 6000 yards.

Hercules



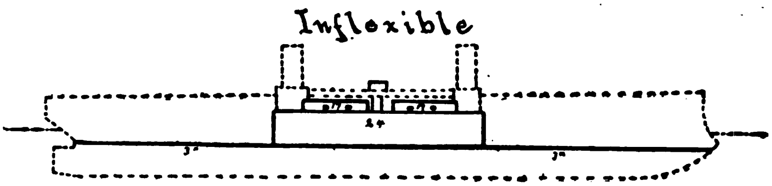
This is a casemate battle ship, having casemates forward, aft and amidship; the midship casemate is also arranged for fore and aft fire. It carries 9-inch belt armor and 6-inch casemate armor. It is full rigged. The limits of armor perforation are as follows:

9-inch Armor.

8-inch: up to 3175 yards.
10-inch: up to 6000 yards.
12-inch: up to 6000 yards.
16-inch: up to 6000 yards.

6-inch Armor.

8-inch: up to 5802 yards.
10-inch: up to 6000 yards.
12-inch: up to 6000 yards.
16-inch: up to 6000 yards.



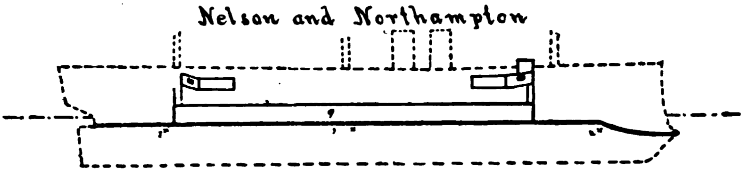
Similar to the *Ajax* and *Agamemnon,* but larger and more powerful. Citadel armor twenty-four inches thick; turret armor seventeen inches thick. 3-inch protective deck. Launched in 1876. Sides of central citadel pass down below water-line forming partial belt. Ends of ship unprotected. Turrets placed obliquely within citadel. Two signal masts. Cork belt, coal protection and "raft body," as in *Ajax*. Armor perforation as follows:

Turret Armor.

8-inch: cannot perforate.
10-inch: up to 1813 yards.
12-inch: up to 5377 yards.
16-inch: up to 6000 yards.

Citadel Armor.

8-inch: cannot perforate.
10-inch: cannot perforate.
12-inch: up to 1679 yards.
16-inch: up to 6000 yards.



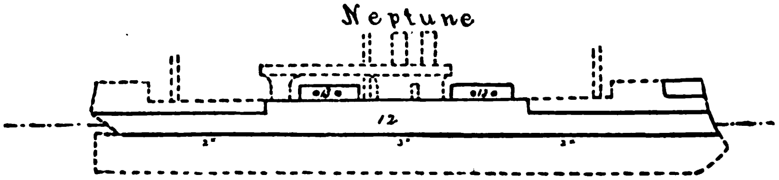
These are belted cruisers; belt 181 ft. 9 inches long; protective deck from three to two inches thick; bulkheads forward and aft with wings protecting chase guns and from raking fire; unprotected broadside; belt armor nine inches thick; bulkhead armor six inches. These ships are bark rigged and were launched in 1876. Limits of armor perforation as follows:

Belt Armor.

8-inch: up to 3175 yards.
10-inch: up to 6000 yards.
12-inch: up to 6000 yards.
16-incn: up to 6000 yards.

Bulkhead Armor.

8-inch: up to 5800 yards.
10-inch: up to 6000 yards.
12-inch: up to 6000 yards.
16-inch: up to 6000 yards.



This is a turreted battle ship with forward casemate. It carries a complete water-line belt twelve inches thick and eight feet wide rising amidship to eleven feet above the water-line, forming a citadel enclosing the two turrets and protecting the vital parts. Turret armor thirteen inches thick; protective deck three to two inches thick. It has a superstructure similar to the *Devastation* type springing over the rear turret. The ship is bark rigged and was launched in 1874. The limits of armor perforation are as follows:

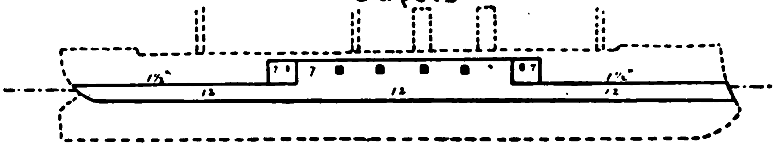
Belt Armor.

8-inch: up to 1240 yards.
10-inch: up to 4786 yards.
12-inch: up to 6000 yards.
16-inch: up to 6000 yards.

Turret Armor.

8-inch: up to 693 yards.
10-inch: up to 4118 yards.
12-inch: up to 6000 yards.
16-inch: up to 6000 yards.

Superb



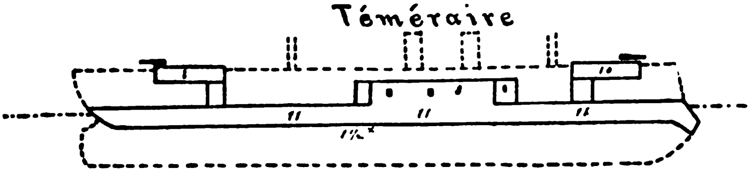
This is a casemated battle ship having a central casemate and carrying a complete water-line belt which rises amidships forming sides of the casemate; the casemate is arranged for fore and aft fire. Belt armor twelve inches thick; casemate armor seven inches thick. Protective deck over belt one and one-half inches thick. The ship is ship rigged and was launched in 1875. Limits of armor perforation as follows:

Belt Armor.

8-inch: up to 1240 yards.
10-inch: up to 4786 yards.
12-inch: up to 6000 yards.
16-inch: up to 6000 yards.

Casemate Armor.

8-inch: up to 4875 yards.
10-inch: up to 6000 yards.
12-inch: up to 6000 yards.
16-inch: up to 6000 yards.



This is a casemate battle ship having a central casemate arranged for broadside and ahead fire; a complete water-line belt, and two pear-shaped barbette towers, one forward and one aft, with armored loading cylinders; the guns in towers are mounted on disappearing carriages. There is a protective deck one and one-half inches thick. Water-line armor eleven inches thick, casemate armor eight inches thick, turret armor eight to ten inches thick. The ship was launched in 1876 and is brig rigged. Limits of armor perforation as follows:

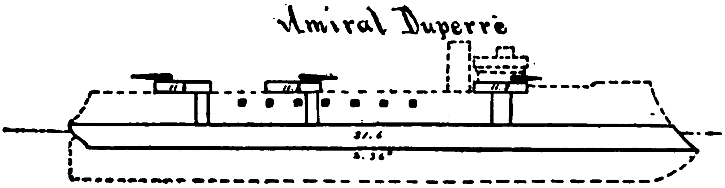
Belt Armor.

8-inch: up to 1835 yards.
10-inch: up to 5507 yards.
12-inch: up to 6000 yards.
16-inch: up to 6000 yards.

Casemate and Turret Armor.

8-inch: up to 2474 (10-in.) and 3944 (8-in.) yards.
10-inch: up to 6000 yards.
12-inch: up to 6000 yards.
16-inch: up to 6000 yards.

FRANCE.



This is a battle ship having four barbette towers; two a little in front of the smoke pipe, one in the waist, and one aft. It has a complete belt along the water-line, and armored loading cylinders pass from the towers to the level of the belt. The be.t armor is 21.6 inches thick, the tower armor 11.8 inches. There is a protective deck 2.36 inches thick. There are three masts with fighting tops. The water-line section is larger than those above it, giving a characteristic fish-back appearance to the ship, a feature shared by a number of French war ships. The broadside is entirely unprotected. The ship was launched in 1879. Limits of armor perforation as follows:

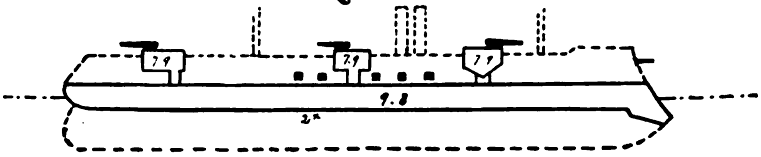
Belt Armor.

8-inch: could not perforate.
10-inch: could not perforate.
12-inch: up to 3000 yards.
16-inch: up to 6000 yards.

Tower Armor.

8-inch: up to 1200 yards.
10-inch: up to 4700 yards.
12-inch: up to 6000 yards.
16-inch: up to 6000 yards.

Duguesclin



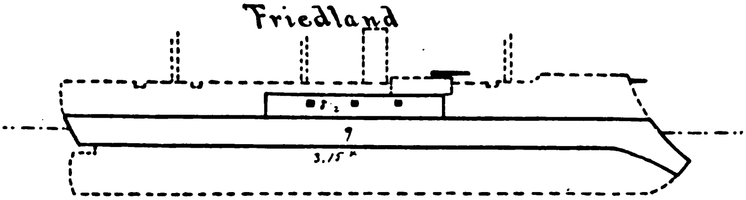
This ship is classed as an armored cruiser but with the exception of the thickness of armor she has many of the features of a battle ship. The distribution of armament and armor is similar to that of the *Amiral Duperré*. There are two smoke pipes, and she is ship rigged. The ship was launched in 1883. The *Vauban* launched in the same year is a sister ship. Both the *Duguesclin* and *Vauban* are patterned after the *Turenne* launched in 1879. The *Bayard*, launched in 1880, is a sister ship of the *Turenne*. The main difference between these is, that the two former are built of iron and the two latter of wood. The belt armor is 9.8 inches, the tower armor 7.9 inches, the protective deck two inches. Limits of perforation as follows:

Belt Armor.

8-inch: up to 2500 yards.
10-inch: up to 6000 yards.
12-inch: up to 6000 yards.
16-inch: up to 6000 yards.

Tower Armor.

8-inch: up to 4000 yards.
10-inch: up to 6000 yards.
12-inch: up to 6000 yards.
16-inch: up to 6000 yards.



This is a casemate battle ship having a central casemate covered with eight and one-half inches of iron and a complete water-line belt nine inches thick. There are two unarmored barbette towers a little forward of the smoke pipe. Protective deck 3.15 inches thick. The vessel is ship rigged and was launched in 1873. The *Trident* and *Colbert* are similar to the *Friedland* except they have no protective deck and the belt armor is eight and one-half inches and casemate armor six and one-third inches; they were launched in 1876 and 1875. The *Richelieu* is also similar to the *Friedland* except there are four armored barbette towers, one over each corner of casemate, the belt and casemate armor same as on the *Trident* and *Colbert* and the protective deck is 4.36 inches thick. They were launched in 1873. The armor is the same thickness as on the *Trident* and *Colbert.* Limits of armor perforation as follows:

Belt Armor of Friedland.

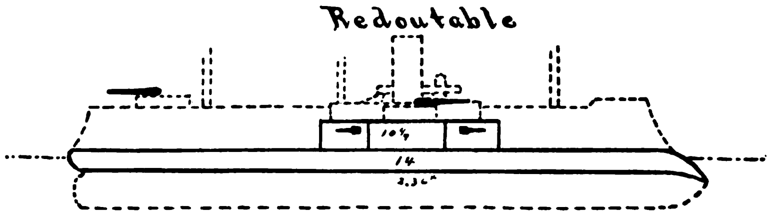
8-inch: up to 3175 yards.
10-inch: up to 6000 yards.
12-inch: up to 6000 yards.
16-inch: up to 6000 yards.

Casemate Armor of Friedland and Belt Armor of Trident, Colbert and Richelieu.

8-inch: up to 3400 yards.
10-inch: up to 6000 yards.
12-inch: up to 6000 yards.
16-inch. up to 6000 yards.

Casemate Armor of Trident, Colbert and Richelieu.

8-inch: up to 5700 yards.
10-inch: up to 6000 yards.
12-inch: up to 6000 yards.
16-inch: up to 6000 yards.



The *Redoutable* is a belted battle ship with central casemate and has two unarmored barbette towers abreast of the smoke pipe and one aft. It has a complete armor belt of iron fourteen inches thick; the casemate armor is ten and one-fourth inches thick. The *Devastation* and *Courbert* are similar to the *Redoutable* except they have no barbette tower aft, the water-line armor does not extend to the stern but stops twenty-eight feet short of stern and the belt armor is fifteen inches thick and casemate armor eight and two-third inches. The *Redoutable* was launched in 1876, the *Devastation* in 1879, the *Courbert* in 1881. All these are ship rigged. The *Friedland* class differs in outward appearance from the *Redoutable* class chiefly in that in the latter the stern at water line projects beyond all parts above it, whereas in the former there is a very slight over hang; also in the latter there are two guns in each broadside while in the former there are three. The limits of armor perforation are as follows:

Belt Armor of Redoutable.

8-inch: up to 182 yards.
10-inch: up to 3488 yards.
12-inch: up to 6000 yards.
16-inch: up to 6000 yards.

Casemate Armor of Redoutable.

8-inch: up to 2000 yards.
10-inch: up to 5800 yards.
12-inch: up to 6000 yards.
16-inch: up to 6000 yards.

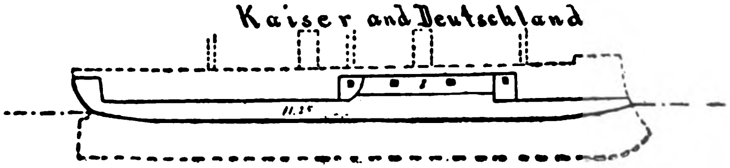
Belt Armor of Devastation.

8-inch: could not perforate.
10-inch: up to 2893 yards.
12-inch: up to 6000 yards.
16-inch: up to 6000 yards.

Casemate Armor of Devastation.

8-inch: up to 5700 yards.
10-inch: up to 6000 yards.
12-inch: up to 6000 yards.
16-inch: up to 6000 yards.

GERMANY.



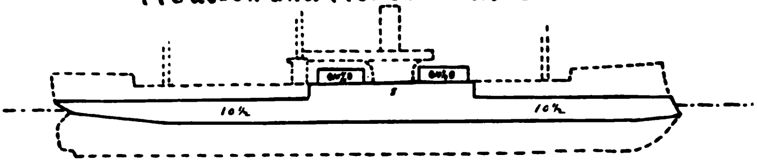
These are casemate battle ships with complete belt and armor rising in rear as protection for stern guns. Casemate is rectangular and situated a little forward of middle, has two guns arranged for fire ahead, two for broadside on each side, and two for stern fire. Belt armor is 11.25 inches thick; casemate, eight inches. Launched in 1874. Ship rigged. Limits of armor perforation as follows:

Belt Armor.

8-inch: up to 1700 yards.
10-inch: up to 5300 yards.
12-inch: up to 6000 yards.
16-inch: up to 6000 yards.

Casemate Armor.

8-inch: up to 3944 yards.
10-inch: up to 6000 yards.
12-inch: up to 6000 yards.
16-inch: up to 6000 yards.



Preussen and Frederich der Grosse

These are turreted battle ships of the British *Monarch* type. except there is no stern casemate. Two turrets placed midship on fore and aft line within a breastwork ninety feet by fifty-three feet. Complete belt. Turret armor ten and one-fourth inches thick. Belt armor ten and one-half inches thick. Launched in 1873 and 1874, respectively. Ship rigged. Limits of perforation as follows:

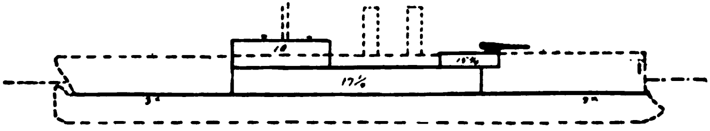
Belt Armor.

8-inch: up to 2154 yards.
10-inch; up to 6000 yards.
12-inch: up to 6000 yards.
16-inch: up to 6000 yards.

Turret Armor.

8-inch: up to 2314 yards.
10-inch: up to 6000 yards.
12-inch: up to 6000 yards.
16-inch: up to 6000 yards.

Sachsen



This is a barbette battle ship. Forward guns in pear-shaped barbette tower, after guns in rectangular overhanging redoubt, 2-inch iron hurricane deck over them. Main protective deck three inches thick. Belt only partial, amidship, in the wake of machinery and magazine. Only one mast, with military top. The armor is put on in "sandwich" form and is seventeen and one-fourth inches thick on belt; fifteen and one-fourth inches thick on forward tower; ten inches thick on redoubt. The ship was launched in 1877. The *Bayern* and the *Wurtemburg* (1878) and the *Baden* (1880) are sister ships to the *Sachsen*. Limits of perforation:

Belt Armor.

8-inch: could not perforate.
10-inch: up to 1700 yards.
12-inch: up to 5200 yards.
16-inch: up to 6000 yards.

Forward Tower.

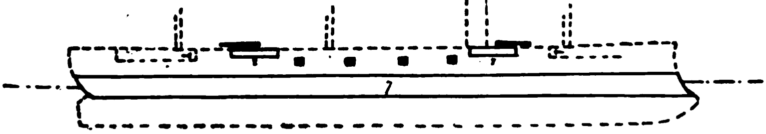
8-inch: could not perforate.
10-inch: up to 2400 yards.
12-inch: up to 6000 yards.
16-inch: up to 6000 yards.

Redoubt Armor.

8-inch: up to 2474 yards.
10-inch: up to 6000 yards.
12-inch: up to 6000 yards.
16-inch: up to 6000 yards.

RUSSIA.

Minin



The *Minin* is an armored cruiser, but of sufficient power to merit special description. She carries a complete belt of 7-inch armor, and four barbette towers covered with 8-inch armor, one each side forward and one each side aft. The broadside battery is unprotected. She was launched in 1878, and is ship rigged. Perforation limits as follows:

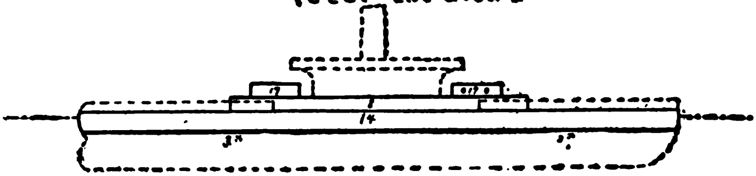
Belt Armor.

8-inch: up to 4875 yards.
10-inch: up to 6000 yards.
12-inch: up to 6000 yards.
16-inch: up to 6000 yards.

Tower Armor.

8-inch: up to 3944 yards.
10-inch: up to 6000 yards.
12-inch: up to 6000 yards.
16-inch: up to 6000 yards.

Peter the Great



This is a turreted battle ship built by the Russians to cope with the English *Devastation*. It is similar in general appearance and distribution of armor to the latter. The armor, which is "sandwich," is fourteen inches thick in the belt, eight inches thick in the breast-height enclosing turrets, and seventeen inches thick on turrets. It was launched in 1872. Perforation limits as follows:

Belt Armor.

8-inch: up to 182 yards.
10-inch: up to 3488 yards.
12-inch: up to 6000 yards.
16-inch: up to 6000 yards.

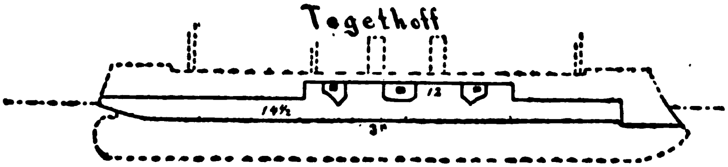
Turret Armor.

8-inch: could not perforate.
10-inch: up to 1813 yards.
12-inch: up to 5377 yards.
16-inch: up to 6000 yards.

Breast-work Armor.

8-inch. up to 3944 yards.
10-inch: up to 6000 yards.
12-inch: up to 6000 yards.
16-inch: up to 6000 yards.

AUSTRIA.



This is a central casemate battle ship; two guns with bow and beam fire, two with beam fire and two with stern and beam fire. Belt fourteen and one-half inches thick stops short of bow thirty-three feet. Protective deck three inches thick. Casemate armor twelve inches thick. Launched in 1878. Ship rigged. Perforation limits as follows:

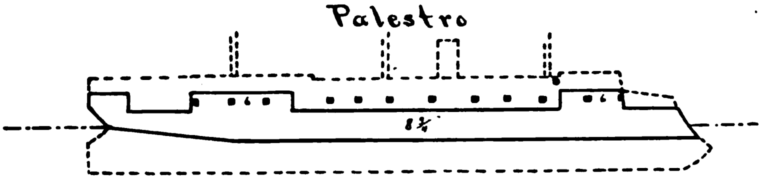
Belt Armor.

8-inch: at muzzle.
10-inch: up to 3200 yards.
12-inch: up to 6000 yards.
16-inch: up to 6000 yards.

Casemate Armor.

8-inch: up to 1240 yards.
10-inch: up to 4786 yards.
12-inch: up to 6000 yards.
12-inch: up to 6000 yards.

ITALY.



This is an old type battle ship with two casemates, one forward and one in the waist. There is a complete belt which rises at the stern to protect a gun. Belt armor is eight and three-fourth inches thick; casemate armor six inches thick. Launched in 1871, and is ship rigged. The *Principe Amadeo* is a similar ship. Perforation limits as follows:

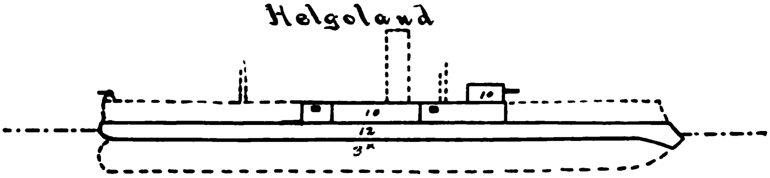
Belt Armor.

8-inch: up to 3300 yards.
10-inch: up to 6000 yards.
12-inch: up to 6000 yards.
16-inch: up to 6000 yards.

Casemate Armor.

8-inch: up to 5800 yards.
10-inch: up to 6000 yards.
12-inch: up to 6000 yards.
16-inch: up to 6000 yards.

DENMARK.



This is a casemated and turreted battle ship. One turret a little forward of midship. Complete belt of 12-inch armor. Casemate and turret armor ten inches thick. Two masts with military tops. Protective deck three inches thick. Launched in 1878. Perforation limits as follows:

Belt Armor.

8-inch: up to 1240 yards.
10-inch: up to 4786 yards.
12-inch: up to 6000 yards.
16-inch: up to 6000 yards.

Casemate and Turret Armor.

8-inch: up to 2474 yards.
10-inch: up to 6000 yards.
12-inch: up to 6000 yards.
16-inch: up to 6000 yards.

TABLE II.

PRINCIPAL IRON-CLAD BATTLE SHIPS.

Name.	Thickness of Armor, inches.			Description of Ships.
	Belt.	Turret.	Casemate or Side.	
ENGLAND.				
Téméraire	11	10 (fore) 8 (aft)	8	Iron; sheathed; launched in 1876; battle and cruising ship; complete belt; redoubt midship; two fixed turrets, one forward, one aft, pear shape; guns mounted on disappearing carriages; protective deck 1″.5; brig rigged.
{ *Devastation* { *Thunderer*	12	14 (fore) 12 aft	12	Iron; 1871; high free board battle ship; two turrets on fore and aft line; armored breast-work including turrets; one mast; protective deck 3″ to 2″ thick.
Dreadnought	11	14	14	Modified and improved type of *Devastation*; protective deck 3″.5, 2″.5, and 2″ thick; central citadel armored rising from water, forming sides of ship up 12′; belt armor 5′ below water.
Neptune	12	13	12	Iron; sheathed; 1874; battle and cruising ship; two turrets; casemate; protective deck 3″ to 2″; water-line belt 8′ wide, at middle armor rises 11′ above water, forming citadel enclosing turrets and protects vital parts.
Inflexible	24	17	24	Iron; 1876; battle ship; central citadel, sides of citadel forming partial belt; citadel encloses two turrets placed obliquely; unprotected ends; cork belt; two masts; protective deck 3″; turrets compound; coal protection.
{ *Ajax* { *Agamemnon*	18 "	15 "	18 "	Iron; 1880-79; similar in type to *Inflexible;* protective deck 2″ and 3″.
Alexandra	12		8	Iron; 1875; battle ship; full rigged; protective deck over belt 1″.5—1″ thick; complete water-line belt; central casemate with two tiers of guns.
Superb	12		7	1875. Battle ship. Ship rigged. 1½″ deck over belt. Belt. Casemate battery armored 111′.

Where thickness of armor is variable only the maximum thickness is given.
The dates are those of launching.

TABLE II (CONTINUED).

PRINCIPAL IRON-CLAD BATTLE SHIPS.

Name.	Thickness of Armor, inches.			Description of Ships.
	Belt.	Turret.	Casemate or Side.	
Audacious	8		6	1869. Battle ship. Complete belt. Bark rigged. Casemate 59′ on gun deck, 32′ 7″ on spar deck.
Invincible	"		"	1869. "
Iron Duke	"		"	1870. "
Swiftsure	"		"	1870. "
Triumph	"		"	1870. "
Sultan	12		6	1870. Battle ship. Ship rigged. Complete belt. Casemate 84′ 4″ on gun deck, 32′ 3″ on spar deck.
Belleisle	12		6	1876. Small type battle ship; brigantine rigged. Belt. Casemate 45′ long.
Orion	"		"	1879. "
Northampton	9			1876. Belted cruiser. Sides unprotected. Protected from raking fire by bulkheads with wings. Bark rigged. Protective deck 3″.2 thick. Belt 181′.
Nelson	"			
Shannon	"			1875. Belted cruiser. Ship rigged. Belt from 60′ abaft stem to stern. Protected by bulkheads from raking fire.
Rupert	12	14	12	1872. Turret coast defense ship; schooner rigged; breast work turret; ram; one turret forward; complete belt.
FRENCH.				
Friedland	9		8½	1873. Battle ship. Complete belt. Casemate. Unarmored barbette towers. Protective deck 3″.15 thick. Barbette towers abreast and forward of smoke pipe. Elliptical half-towers. Ship rigged.
Trident	8⅝		6⅓	1876. Similar to *Friedland*, but no protective deck. Two barbettes abreast of smoke pipe on each side.
Colbert	8⅝		6⅓	1875. "

TABLE II (CONTINUED).

PRINCIPAL IRON-CLAD BATTLE SHIPS.

Name.	Thickness of Armor, inches.			Description of Ships.
	Belt.	Turret.	Casemate or Side.	
Redoutable	14		9½	1876. Similar to *Friedland.* Protective deck 2''.36.
Devastation	15		9½	1879. Similar generally to *Friedland.* Belt stops 28' short of stern. Deck armor 2''.36.
Courbet	"		"	1881. "
Richelieu	8⅖		6.3	1873. Battle ship, belt, casemate, armored barbette towers. Protective deck 4'' 36. 4 barbettes, one on each corner of casemate.
Amiral Duperré	21.6			1879. Battle ship. Complete belt. 4 armored barbette towers. Unprotected broadside. Protective deck 2''.36. 3 masts, armored tops. Barbette towers one aft, one in waist, one on each side forward of smoke pipe.
Tonnerre	13	11.8	9⅞	1875. Mastless turret battle ship. Armored breast work 9⅞'', surmounted by unarmored superstructure. Armored deck 2''. Belt entire length. One turret in forward end of breast work.
Fulminant	"	"	"	1877. "
Duguesclin	9.8	7.9		Armored cruiser with complete belt and four barbette towers similar to *Amiral Duperré.* Sides unprotected. Armored deck 2''. Ship rig.
Vauban	"	"		
Turenne	"	"		
Bayard	"	"		
La Galissonnière	5⅞		4¾	1872. Armored cruiser. Casemate and barbette towers. Ship rigged. Complete belt. Barbettes forward of smoke pipe on each side.
Victorieuse	"	4.7	"	1875. "
Triomphante	"	7.9	"	1877. "
Thétis	"	"	"	1877. " Smaller than above three.

TABLE II (CONTINUED).

PRINCIPAL IRON-CLAD BATTLE SHIPS.

Name.	Thickness of Armor, inches.			Description of Ships.
	Belt.	Turret.	Casemate or Side.	
ITALY.				
Palestro	8¾		6	1871. Old type battle ship. Belt and two redoubts. Ship rig. Belt complete. Two casemates: one forward, one aft.
RUSSIA.				
Peter the Great	14	17	8	Battle ship. Belt complete Breastwork 160′ long. Two turrets: one forward, one aft. Unarmored superstructure between turrets. Mastless. Protective deck 3″. Armor, sandwich.
General-Admiral	7		6	1873. Armored cruiser. Complete belt. Low rectangular redoubt over which the guns are mounted in barbette. Ship rig.
Gerzog-Edinburgski	"		"	1875. "
Minin	7	8		1878. Armored cruiser. Complete belt. Four armored barbette half-towers: one each side forward, one each side aft. Ship rig. Unprotected broadside.
GERMANY.				
Preussen	10½	10¼	8	1873. Battle ship of British *Monarch* type. Complete belt. Two turrets, one fore and aft. Breastwork 90′ 6″×53′ 6″. Ship rig.
Friederich der Grosse	"	"	"	1874. Sister ship to *Preussen*.
Kaiser	11¼		8	1874. Battle ship. Broadside casemate; rectangular. Complete belt. Ship rig.
Deutschland	"		"	1874. Sister ship.

TABLE II (CONTINUED).

PRINCIPAL IRON-CLAD BATTLE SHIPS.

Name.	Thickness of Armor, inches.			Description of Ships.
	Belt.	Turret.	Casemate or Side.	
Sachsen	17¼	10	10	1877. Battle ship; guns in barbette, barbette tower and redoubt; forward gun in pear-shaped tower. After guns in rectangular overhanging redoubt, 2-inch iron deck over them. Main protective deck 3-inch iron. One mast, military top. Derricks for handling boats. Belt 135 ft. 4 in. long in wake of machinery and magazine only. Sandwich armor.
Bayern (1878)	"	"	"	
Würtemberg (1878)	"	"	"	
Baden (1880)	"	"	"	
Hansa	6		6	1872. Armored cruiser. Complete belt. Double decked casemate. Ship rig.
SPAIN.				
Sagunto	5·9		5·9	1869. Old type broadside battle ship. Complete belt. Side armor in wake of battery. Armored short central casemate on upper deck. Ship rig.
Numancia	5			Old type broadside armored ships. Low speed. Condition of all poor.
Vitoria	"			
Zaragoza	"			
Mendez Nunez	"			
AUSTRIA.				
Kaiser	6¼	5½	5½	1871. Old type casemate battle ship. Ship rig. Complete belt. One three-port turret each side upper deck.
Custoza	9		7	1872. Old type battle ship; double deck casemate. Sides cut away fore and aft to allow for bow and stern fire. Ship rig. Complete belt.
Erzherzog Albrecht	"		"	1872. Similar to last. Sides cut away for four guns bow fire and two guns stern fire.

TABLE II (CONTINUED).

PRINCIPAL IRON-CLAD BATTLE SHIPS.

Name.	Thickness of Armor, inches.			Description of Ships.
	Belt.	Turret.	Casemate or Side.	
Tegetthoff	14½		14	1878. New type casemate battle ship. Ship rig. Protective deck 3 inches. Belt to 32 ft. 10 in. of bow. Armored bulkhead. Two guns in forward compartment of casemate have bow and beam fire; four guns in after compartment have stern and beam fire.
Don Juan de Austria	8		6	1875. Armored cruiser. Ship rig. Casemate armored. Complete belt.
Kaiser Max (1875)	"		"	"
Prinz Eugen (1877)	"		"	"
HOLLAND.				
Konig der Nederlanders	8	12		1874. Turreted cruiser and battle ship. Ship rig. Complete belt, Two turrets.
DENMARK.				
Helgoland	12	10	10	1878. Battle ship. Casemate and turret. Two masts, military tops. Deck 3 in. Complete belt.
TURKEY.				
Messudieh	12		10	1874. Broadside casemate battle ship. Complete belt. Casemate 135 ft. long. Ship rig. Protective deck 1 inch. Sister ship to the English ship *Superb*.
Hamidieh	10		6	1885. Broadside casemate battle ship. Complete belt. Ship rig.
Idjilalieh (Majestic)	6	4½	4½	1870. Armored cruiser. Armored casemate surmounted by barbette towers. Complete belt. Brig rig.
Feth-i-Bulend	9	6	6	1870. Armored cruiser; old type; complete belt: casemate: ship rig. Sides cut away for fore and aft fire.
Mukadim-i-Hair	"	"	"	Sister ship to *Feth-i-Bulend*.

TABLE II (CONTINUED).

PRINCIPAL IRON-CLAD BATTLE SHIPS.

Name.	Thickness of Armor, inches.			Description of Ships.
	Belt.	Turret.	Casemate or Side.	
PORTUGAL.				
Vasco da Gama	10		10	1876. Armored cruiser. Overhanging central casemate. Barkentine rig.
BRAZIL.				
Javary	12	13		1875. Sea going monitor. Two turrets on fore and aft line. Two signal poles.
Sete de Setembro	4½		4½	1874. Cruising iron-clad old type. Belt. Redoubt. Schooner rig.
CHILI.				
{ *Almirante Cochrane*	9		8	1874. Armored cruiser. Complete belt. Overhanging casemate. Cut away for fore and aft fire. Bark rig.
{ *Blanco Encalada*	"		"	Sister ship.
Huascar	4½	5½		1864. Low free board. Single turret. Complete belt. Brigantine rig. Cut away for fore and aft fire.
JAPAN.				
Fu-Sō	7		9	1877. Armored cruiser. Complete belt. Armored casemate. Ship rig.
{ *Kin-go*	4½			1877. Armored cruiser. Belt runs nearly to bow and stern. Armored bulkhead. Bark rig. Are not armored ships in usual sense of the term. No armor against end-on fire and no armored deck.
{ *Hi-yei*	"			

RANGE TABLE FOR THE 8-INCH B. L. RIFLE. (STEEL).

By Captain JAMES M. INGALLS, First Artillery, U. S. A.

Weight of projectile = 300 lbs. Log $C = 0.71670$. $\frac{\delta_1}{\delta} = 1$.

Coefficient of reduction = 0.9 *M. V.* = 1950 f. s. Wind, none.

Range in yards	Angle of departure (φ)	d	Δ'φ	Δ''φ	Time of flight in seconds	Drift in yards	Angle of fall	Striking velocity in f. s.	Thickness of steel shot would penetrate in inches
	° ′	′	′	′			° ′		
500	0 23.0	4.5	0.1	1.1	0.78	0.1	0 23	1872	15.0
600	0 27.5	4.6	0.1	1.3	0.94	0.1	0 28	1857	
700	0 32.1	4.7	0.1	1.4	1.10	0.1	0 32	1842	
800	0 36.8	4.7	0.1	1.6	1.27	0.2	0 37	1827	
900	0 41.5	4.8	0.2	1.8	1.43	0.2	0 43	1812	
1000	0 46.3	4.9	0.2	2.0	1.60	0.3	0 48	1797	14.2
1100	0 51.2	4.9	0.3	2.2	1.77	0.3	0 54	1782	
1200	0 56.1	5.0	0.3	2.4	1.93	0.4	0 59	1768	
1300	1 01.1	5.1	6.4	2.6	2.10	0.5	1 05	1753	
1400	1 06.2	5.1	0.5	2.9	2.28	0.6	1 11	1739	
1500	1 11.3	5.1	0.6	3.1	2 45	0.7	1 17	1725	13.4
1600	1 16.4	5.2	0.7	3.3	2.62	0.8	1 23	1711	
1700	1 21.6	5.3	0.8	3.6	2.80	0.9	1 29	1697	
1800	1 26.9	5.4	1.0	3.9	2.98	1.0	1 36	1683	
1900	1 32.3	5.4	1.1	4.2	3.16	1.1	1 42	1670	
2000	1 37.7	5.5	1.2	4.5	3.34	1.2	1 49	1656	12.6
2100	1 43.2	5.5	1.3	4.7	3.52	1.3	1 57	1643	
2200	1 48.7	5.6	1.4	5.0	3.71	1.5	2 02	1629	
2300	1 54.3	5.7	1.6	5.3	3.89	1.6	2 09	1616	
2400	2 00.0	5.8	1.7	5.5	4.08	1.8	2 17	1603	
2500	2 05.8	5.8	1.9	5.8	4.27	1.9	2 24	1590	11.9
2600	2 11.6	5.8	2.1	6.1	4.46	2.1	2 31	1577	
2700	2 17.4	5.9	2.2	6.3	4.65	2.3	2 39	1564	
2800	2 23.3	6.0	2.4	6.6	4.84	2.5	2 47	1551	
2900	2 29.3	6.1	2.6	6.9	5.03	2.7	2 55	1539	
3000	2 35.4	6.2	2.8	7.2	5.23	2.9	3 03	1526	11.2
3100	2 41.6	6.2	3.0	7.5	5.43	3.1	3 11	1513	

Range in yards	Angle of departure (φ)	d	$\Delta'\phi$	$\Delta''\phi$	Time of flight in seconds	Drift in yards	Angle of fall	Striking velocity in f. s.	Thickness of steel shot would penetrate in inches
	° ′	′	′	′			° ′		
3200	2 47.8	6.3	3.2	7.8	5.63	3.4	3 20	1501	
3300	2 54.1	6.3	3.5	8.1	5.83	3.6	3 28	1489	
3400	3 00.4	6.4	3.7	8.4	6.03	3.9	3 37	1477	
3500	3 06.8	6.5	4.0	8.8	6.24	4.1	3 46	1465	10.6
3600	3 13.3	6.6	4.2	9.2	6.45	4.4	3 55	1454	
3700	3 19.9	6.6	4.5	9.6	6.65	4.7	4 04	1443	
3800	3 26.5	6.7	4.8	10.0	6.86	5.0	4 14	1432	
3900	3 33.2	6.8	5.1	10.4	7.08	5.3	4 23	1421	
4000	3 40.0	6.9	5.4	10.9	7.29	5.6	4 33	1410	10.0
4100	3 46.9	7.0	5.7	11.4	7.51	6.0	4 43	1399	
4200	3 53.9	7.0	6.1	11.9	7.73	6.3	4 54	1388	
4300	4 00.9	7.1	6.4	12.4	7.95	6.7	5 04	1377	
4400	4 08.0	7.3	6.8	12.9	8.17	7.1	5 15	1366	
4500	4 15.3	7.3	7.2	13.4	8.39	7.5	5 26	1355	9.5
4600	4 22.6	7.4	7.5	13.9	8.61	7.9	5 37	1344	
4700	4 30.0	7.5	7.9	14.3	8.84	8.3	5 48	1334	
4800	4 37.5	7.6	8.3	14.7	9.06	8.8	6 00	1323	
4900	4 45.1	7.7	8.7	15.2	9.29	9.2	6 11	1313	
5000	4 52.8	7.7	9.1	15.6	9.52	9.7	6 23	1303	9.0
5100	5 00.5	7.8	9.5	16.0	9.75	10.2	6 35	1293	
5200	5 08.3	7.9	10.0	16.4	9.99	10.7	6 47	1283	
5300	5 16.2	8.0	10.5	16.8	10.23	11.2	7 00	1274	
5400	5 24.2	8.1	11.0	17.1	10.47	11.8	7 12	1264	
5500	5 32.3	8.2	11.5	17.5	10.71	12.3	7 25	1255	8.5
5600	5 40.5	8.4	12.0	17.7	10.95	12.9	7 38	1246	
5700	5 48.9	8.4	12.6	18.0	11.20	13.5	7 51	1237	
5800	5 57.3	8.5	13.1	18.3	11.44	14.1	8 05	1229	
5900	6 05.8	8.6	13.7	18.6	11.69	14.8	8 19	1220	
6000	6 14.4	8.6	14.3	19.0	11.94	15.4	8 33	1212	8.1
6100	6 23.0	8.7	14.9	19.5	12.19	16.1	8 48	1204	
6200	6 31.7	8.8	15.6	20.0	12.45	16.8	9 02	1195	
6300	6 40.5	9.0	16.2	20.4	12.71	17.5	9 17	1187	
6400	6 49.5	9.1	16.9	20.9	12.97	18.3	9 33	1180	
6500	6 58.6	9.1	17.6	21.3	13.23	19.0	9 48	1172	7.7
6600	7 07.7	9.3	18.3	21.6	13.49	19.8	10 03	1165	
6700	7 17.0	9.4	19.0	22.0	13.76	20.6	10 19	1157	

Range in yards	Angle of departure (φ)	d	Δ'φ	Δ''φ	Time of flight in seconds	Drift in yards	Angle of fall	Striking velocity in f. s.	Thickness of steel shot would penetrate in inches
	° ′	′	′	′			° ′		
6800	7 26.4	9.5	19.7	22.3	14.02	21.5	10 34	1150	
6900	7 35.9	9.6	20.5	22.7	14.29	22.3	10 51	1144	
7000	7 45.5	9.7	21.2	23.2	14.56	23.2	11 07	1137	7.4
7100	7 55.2	9.8	22.0	23.7	14.83	24.1	11 24	1130	
7200	8 05.0	9.9	22.7	24.3	15.11	25.1	11 41	1124	
7300	8 14.9	10.0	23.5	24.8	15.38	26.0	11 58	1118	
7400	8 24.9	10.2	24.3	25.4	15.66	27.0	12 15	1112	
7500	8 35.1	10.3	25.1	26.0	15.94	28.0	12 33	1106	7.1
7600	8 45.4	10.3	26.0	26.5	16.22	29.0	12 50	1101	
7700	8 55.7	10.5	26.8	27.1	16.51	30.1	13 08	1095	
7800	9 06.2	10.5	27.7	27.6	16.79	31.2	13 26	1090	
7900	9 16.7	10.7	28.6	28.2	17.08	32.3	13 44	1086	
8000	9 27.4	10.7	29.5	28.8	17.37	33.5	14 02	1081	6.9
8100	9 38.1	10.9	30.4	29.4	17.66	34.7	14 20	1076	
8200	9 49.0	10.9	31.3	30.0	17.95	35.9	14 39	1072	
8300	9 59.9	11.1	32.3	30.6	18.24	37.1	14 57	1068	
8400	10 11.0	11.1	33.2	31.2	18.53	38.4	15 16	1064	
8500	10 22.1	11.3	34.2	31.8	18.83	39.7	15 35	1060	6.7
8600	10 33.4	11.4	35.2	32.4	19.13	41.0	15 54	1056	
8700	10 44.8	11.5	36.2	33.1	19.42	42.4	16 14	1053	
8800	10 56.3	11.6	37.2	33.7	19.73	43.8	16 33	1049	
8900	11 07.9	11.7	38.2	34.4	20.03	45.2	16 53	1046	
9000	11 19.6	11.8	39.3	35.1	20.34	46.7	17 13	1043	6.5

This range-table was computed for the normal conditions given at the head of the table. The second column gives the angles of departure corresponding to the ranges in the first column. In the third column are given the difference of each two consecutive angles of departure for a common difference of 100 yards in the range. The fourth column contains the variations of the angles of departure due to a variation of one-tenth of the value of the ballistic coefficient (C). The fifth column gives the variations of the angles of departure produced by a variation of fifty feet in the muzzle velocity. All these variations of the angle of departure are positive or negative, according as the variations which produced them, diminish or increase the range, and can easily be determined in each case. The other columns of the range-table are sufficiently described by their captions.

The use of the table can best be indicated by a few examples.

EXAMPLE 1.—What is the angle of elevation for a range of 3964 yards; conditions normal, jump 6′? We have

$$\text{angle of elevation} = 3^\circ\ 33'.2 + .64 \times 6'.86' = 3^\circ\ 37'.6.$$

EXAMPLE 2.—What is the angle of elevation for a range of 6827 yards; temperature of the air 90°, barometer 30.16 inches, and muzzle velocity 1924 f. s.?

From Table III of Handbook we find $\frac{\delta_1}{\delta} = 1.054$, and, therefore, the variation of ϕ for the given atmospheric conditions is .54 times the tabular value of $\Delta'\phi$. To get the variation of ϕ due to the variation of the muzzle velocity we take $\frac{26}{50} = .52$ of the tabular value of $\Delta''\phi$. We therefore have

$$\varphi = 7^\circ\ 26'.4 + .27 \times 9.'5 - .54 \times 19'.7 + .52 \times 22'.3 = 7^\circ\ 30',$$

and

$$\text{angle of elevation} = 7^\circ\ 30' - 6' = 6^\circ\ 24'.$$

EXAMPLE 3.—Suppose that in Example 2, the actual range with an angle of elevation of 7° 24′ was only 6754 yards. What should be the angle of elevation for the next shot?

The angle of departure was 7° 30′, and for this angle we have $d = 9'.5$, which is the variation of the angle of departure for a variation of 100 yards in the range. Therefore for $6827 - 6754 = 73$ yards, the variation in the angle of departure will be $.73 \times 9'.5 = 7'$. The gun should therefore be laid with an angle of elevation equal to

$$7^\circ\ 30' + 7' - 6' = 7^\circ\ 31'.$$

ARTILLERY DIFFICULTIES IN THE NEXT WAR.

By First Lieutenant JOHN W. RUCKMAN, First Artillery, U. S. A.

[CONCLUDED.]

III. MATERIAL CONSIDERATIONS.

When the organic and educational condition of an artillery reaches its highest state of perfection, difficulties may still remain. These new difficulties will chiefly be of a material nature, many of which may already be in view and steps taken towards their removal, more just appearing and others still below the horizon. Poor or inadequate material only may be found at a fort, rendering a thorough administration and drill impossible. When however this condition exists in connection with bad organization and instruction, a combination results in which inefficiency is at its worst and the consequences may be most awful. In a given well-organized and instructed garrison the defense will mainly depend upon the character of the guns, and sufficiency and adaptability of auxiliary appliances.

GUNS.

As the guns we expect to have for our future defense promise to compare favorably with any guns which are likely to be brought against them it will not be necessary to discuss their relative values. It must be added however, that as they, when mounted, will doubtless be required to protect the country for many years, this equality will probably not always exist.

CARRIAGES.

In future the gun-carriage will play a part equal in importance to that of the gun. The fact that the carriage must be something more than a necessary evil tolerated simply to support the gun seems not to have been appreciated in our army. Notwithstanding this it must become a part of the gun and be able to develop its full power and accuracy. Made in future not merely to hold the gun and check its recoil, but also with a view of giving the gun life and mobility undreamt of in the past. The carriage must be strong, carefully made, and capable of fulfilling all work that may be required of it. The upper carriage should return after each discharge to the same place on its chassis. This condition is essential to indirect fire.

The value of the preceding remarks is apparent; tor it will be of little moment to reduce the gun's error to zero and allow that of the carriage to be hundreds of yards. Artillery work from this time forward will require that gun and carriage shall be constructed with equal care and accuracy and that the whole system shall be consistently well made. It will not be the future policy of artillerists to use costly guns upon inexpensive poorly designed carriages. In all cases it will be better to cut down the number of guns one-half and put the remainder into carriages suited to the work, than to be limited to such designs as have prevailed until now.

The next artillery war will impose the condition that our guns *shall be aimed with quickness, precision and continuity.** This condition we believe will tower above all others and that failure to attain it will mean defeat. Sighting devices whatever their nature, must be constructed with respect to these considerations. Ammunition is now too costly, and in future battles time will be too valuable to risk useless waste. Endeavors must be made to send every shot to its mark. Books and papers are now full of descriptions of quick-firing guns; quick-aiming guns would be much more to the point. Unaimed fire for coast-defense, except in very special cases, will be worse than useless.

While all apparatus connected with a modern gun must be efficacious it must be as elementary as possible consistent with this result, and while the necessary machines may be more or less complicated *their operation must be simple.*

Disappearing carriages have been advocated for the following reasons:

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* Since this was written the following article illustrating present tendencies has appeared: "Appariel auxiliaire permettant le pointage et le chargement simultanés et augmentant ainsi considérablement la rapidité du tir des pièces."—*Revue Maritime et Coloniale*, Mai 1893.

1. Their guns can be silenced only by a direct hit.

2. The greater part of the personnel is permanently under cover.

3. No satisfactory reconnaissance of the position can be made by the enemy.

First.—It may be said in reference to these arguments that those familiar with target practice from a solid platform know the difficulty of obtaining a "direct hit" even at short ranges. It would seem that the chances of disabling a gun, for the time at least, would be greatly enhanced by putting the gun in a deep emplacement behind a high parapet such as are required for this class of carriages. The enemy's projectiles striking a high parapet, it would seem, will throw down large fragments upon the guns and detachments. Barbette guns and a low parapet, we believe, will reduce this danger to a minimum. This is especially important in view of the probable use of long howitzer shells carrying heavy bursting charges of high explosives which are certain to be used in future bombardments.

Second.—In consequence of recent adoption of vertical fire these carriages no longer afford the detachment the shelter claimed for them and their advocates are supplying them with shields to protect from this kind of fire. These shields can as well be applied to barbette guns.

Third.—The question of reconnaissance scarcely needs consideration when we remember that it is not the policy of our government to maintain secrecy in regard to our defenses and that all enterprising nations will always know as much, if not more, than we do about the position and interior arrangement of our defenses. In such cases reconnaissance of our positions would be clearly superfluous. Moreover, if there be any virtue in this claim, barbette guns could be artificially disguised in a few minutes. The above claims doubtless have some merit in them, but we believe they ignore the most important element in the question. In a well equipped fort ships, we believe, can be made to fight at a distance, notwithstanding the present tendency of naval tactics to close with shore batteries. If this be true, the probability of disabling a gun by a direct hit from an unstable platform need scarcely be taken into account.

As with field artillery, we believe the defense should overwhelm the assailant from the first. Whenever the enemy attempts to close to obtain an effective range he should receive a well directed, deliberate, but rapid fire, whose effect should reveal to him the nature of his antagonist. If the first shots are true and terrible in their results it may be doubted if he will make good practice that day. Some of our guns may and probably will be dismounted, but it will also be a question of *dismounting the enemy's guns.* For him to anchor within effective range should mean his destruction. The barbette gun pointing above the parapet and covered with a suitable shield, would always be in position to pour forth its missiles upon him. We, as artillerymen, cannot very graciously object to having our emplacements made safe and comfortable, but when these attentions tend to make it safe and comfortable for the enemy, it is time to stop. There is something, we believe, in always being in place and ready to defy the assailant. Give us fewer complicated devices for hiding from him and the difference in better means of controlling our fire and the enemy will not be so anxious to see us. It will in the first place be a question of guns and in the second place the amount of metal accurately delivered in a given time. The former will influence the enemy's determination to attack, the latter his determination to persist. *The battle must ultimately turn on the damage we can do him, not on the amount we keep him from doing.*

The future carriage must be constructed with regard to the above-mentioned conditions of loading and aiming. From the nature of the case it is evident that they will not permit the use of a large number of men wasting their time with handspikes. In the first place this will be ineconomical, in the second impossible. All heavy work and much light work must be done by machinery. It is objected by a certain class of writers that these ideas will introduce complicated machinery into our work, but we need not be alarmed; for the history of war material is full of such solicitude, since the days of the club, the sling, and the spear. During all the past ages the same fears have been urged with the same *anxiety*, *fervor* and *reason.* We shall need for our own carriages, already accurate, equally accurate mechanism to control them. The mechanism will possess the necessary strength, be sensitive to the touch and prompt in obeying the will of the operator, so that the carriage, as if endowed with life and sense, may move from one side to the other, forward or backward, at the wish of the gunner. This will be essential in future gun tactics and fire control. In the din and confusion of future battle, when commands cannot be heard, the movement of the attendant heavy masses must emanate from a single mind conversant with his work. In all cases in history where ships have run past shore batteries within effective range old methods of handling the guns prevailed. In future new methods will obtain. The effect of these changes remains to be developed. War has been truly denominated a rough business, but it will be none the less rough *on the enemy* if our aiming mechanism be efficacious, our gun and carriage precise, and our sights true. All parts will be strong but refined in their nature. There will be no delicate pieces of mechanism in the whole system, so we need not distress ourselves with regard to our cannoneers smashing them with handspikes, since this relic of bygone ages will be excluded from the gun's equipment.

ELECTRIC MOTORS.

For many reasons we believe that the electric motor is, *par excellence*, the machine best adapted to the transformation of energy into artillery work. To obtain full effect the gun must be arranged to load, aim and fire while in motion. These objects can be obtained by use of the electric motor with the greatest facility, with the additional advantage of being capable of control from any point in the circuit. This latter consideration is important in connection with present tendencies, which are towards entire control from central stations. Again the angular motion of a moving ship with respect to the gun can be produced and maintained in the battle and the gun kept pointed always on the enemy. The same may be said of the elevation and other movements. These tactical advantages, added to those of economy and simplicity, at least render this motor worthy of exhaustive trial.

AIMING.

The aiming will require the most careful attention. No problem in gunnery to-day affords so much room for improvement as this one in our service. A range dial connected with the elevating mechanism should be simple and practicable. There is no good reason for introducing degrees of elevation into any of our practical work. They are only useful to the computer and the sight-maker. For direct fire a suitable well mounted telescope will answer for aligning. Indirect fire will be done with the vernier and azimuth circle.

TRANSMISSION OF ORDERS AND INTERIOR TRANSPORTATION.

A method of transmitting orders in a fort seems to have been ignored in our works. A more necessary portion of a well-equipped place could scarcely be omitted. While a system of transmitting orders may not, in the past, have been necessary, all may depend on an efficient system in future. Whatever we may adopt, we believe the following conditions must be fulfilled:

Quick delivery of a written or printed message at the required point. Pneumatic tubes or electrical typewriters may afford a means of solution.

Interior transportation is in its worst possible condition. A suitable scheme can only be worked out by ourselves after long experience.

POSITION FINDING.

To save time and ammunition position finding will be used to locate the exact position of the enemy. In cases where this cannot be done with reasonable correctness, firing will probably be withheld.

Among the first efforts at position finding may be named the "method of squares." It forms in the historical development a connecting link between the old, where accurate ranges were thought to be useless refinements, and the new, where the range is considered essential. The harbor was divided into a large number of squares whose centers were located by their distances and azimuths from the gun. The object had to be located by triangulation and the number of the square whose center was nearest, was sent to the gun. The distance and azimuth of the center were found from prepared tables and the gun laid accordingly. The first efforts were exceedingly crude and unsatisfactory. This method was adopted for our coast artillery in General Orders No. 108, Headquarters of the Army, Adjutant General's Office, 1888. The side of a square was prescribed as 100 yards. The distances and azimuths of all squares within a radius of three miles were to be computed and tabulated. The tables when made out were enormous and impracticable. The polar coördinates thus tabulated gave data for points varying from 100 to 140 yards apart depending on the direction in which the object was moving. It is also evident that any given observation would on arriving at the gun always be several squares behind the ship's true place. By decreasing the size of the squares the tables become more cumbersome but the tabulated results when applied should be more accurate. Finally at the limit a ship's path would be made up of points whose distances and direction would be known. This is the result which will be obtained by the coming position finder which, without any cumbersome tables, or any other of the numerous objections to the squares, will trace upon a map the path of a hostile vessel. The system of squares had so many insurmountable obstacles wrapped up in it that it has long been discarded. Although the system was obsolete when adopted by us, and barren of practical results, its adoption was a great step forward. It was a move to obtain some kind of a system where none had existed. It produced in the country study and discussion which we believe not only demonstrated its utter impracticability, but put the question in its true light and developed a sentiment which is gradually evolving the correct solution.

Although there are at present many kinds of position finders in the field they all have the same object in view. They are divided into two principal classes as they depend upon a horizontal or vertical base. Those using the horizontal base require two observers and stations, may use any length of base, adapt themselves to any site, and are open to the objection that the observers may be observing different objects.

Those using the vertical base are called depression instruments and are applicable only where considerable elevation exists. They require fine mechanism, are liable to be less accurate, and require but one observer. The nature of our coast will make the use of both classes advantageous. They should, we believe, be used in combination wherever practicable. On account of the confusion which may arise from two observers watching different ships, some precaution must be taken to prevent it. This may require an auxiliary finder. A depression instrument when present would answer this purpose. The more accurate these instruments become, the better. In striving to reduce errors efforts must be made all along the line. The probable error in the range finder is as important as that in the gun; both must be reduced as much as possible. The future range and position finder will trace the path of a vessel continuously upon the map of the harbor. Unless placed at the gun-battery, the plotting apparatus must operate in connection with another device for sending range and direction to this point. The elements transmitted must be independent of measurements made on paper. An inexpansive range-scale passing over the map will obviate this difficulty. In regard to the value of the path of the vessel, there seems to be a difference of opinion, but we believe it will be essential to the best results. It will reveal an enemy's rate and direction at all times, betray circle sailing and other tricks to which he may resort, many of which would otherwise escape detection; allow the batteries to take him in disadvantageous positions, and will aid materially in ascertaining his tactics and intentions.

For direct fire ranges may be received from a central station. A small pointer moved by the plotting mechanism may be super-imposed upon the range dial already mentioned. The two pointers being supported as the hands of a clock. That one urged along by the position finder will always show the range; coincidence of the two will show that the gun is elevated. For indirect fire an identical device will show azimuths of the gun and object. In both cases it will probably be found as easy to transmit motions to the gun as to the pointers, in which case the gun would be both elevated and oriented from the central station.

In conclusion we may say that by the time our emplacements are constructed and the guns mounted, that position finders will be at hand suited in all respects to the work before them. We are now behind in fortifications, guns, range finders, and all war material, but we are also far, *far behind in the spirit of artillery science*. We are behind in the sentiment, methods and realization of that unceasing toil which to some is drudgery, that must be performed in order to make these future instruments possible. We have yet to be trained in these processes and specially educated up to their successful operation.

GRAPHIC REPRESENTATION OF DEVIATING AGENTS.

In the central station of the battery or fort will be a diagram over which a pointer will move and point out at all times the direction and intensity of the wind with its two components. This will be large enough to show all values from a distance. In a similar manner variations in barometer and thermometer will be computed and allowed for. These results will also be on diagrams so that no computations will ever be necessary within the station. The anemometer will stand at an elevated distant point and represent as nearly as possible the area covered by the guns.

SMOKE.

We read that the recent changes in powder will revolutionize warfare. It will be remembered that changes and improvements in powder and other war material have been revolutionizing warfare for the last thousand years and this revolution is still progressing. We doubt if war will ever be completely changed in a day, a year, or a whole period of years. It evolves its principles from conditions and adapts itself to its environment just as all other social movements. We must therefore question the correctness of the prediction that the advent of smokeless powder is going to overturn all military principles and enforce new ones of its own. We still cling to the idea that a great change in these things will work itself out slowly and steadily during a long period of years. It may yet be a long time before smokeless powder comes into general use and by that time we shall probably take it as a matter of course, and may be surprised to see how similar the old and the new methods will seem. So long as common powder is used smoke will be incident to the battle and will favor sometimes one side and sometimes the other, depending entirely on circumstances. It may be reasonably assumed that when smokeless powder replaces the present powder smoke will still be produced by either side whenever its presence will serve a definite purpose.*

A fleet may envelop itself in smoke and enter a harbor, but such action imposes the condition of slow and uncertain movement and exposes the vessels to the danger of successful attack by torpedoes and torpedo boats. The value of such an attempt would certainly depend upon the surrounding circumstances. A well posted line of offensive sentinel boats would easily discover an enemy thus attempting to enter a harbor. In cases where the fleet could be seen from observing stations it can be located and met with indirect fire, in which case the smoke becomes an advantage to the defense. Again, until the era of smokeless powders, both sides may have to suspend firing on account of smoke, or both sides may use it to cover their operations. As matters now stand it is impossible to predict what effect its presence or absence will have on future artillery operations. The question of any great change in artillery methods due to its presence or absence may well be doubted. Since it has been reported that fleets enshrouded in smoke have entered ports, it is reasonable to suppose that this will be tried again, and the prevention of such enterprises remains for the consideration of the defenders. This stratagem, with use of darkness and fogs, renders a perfect system of patrol and sentinel duty with swift offensive boats more important than ever. On account of the accuracy of future artillery fire in daylight, night will be a favorable time for the enemy to make his dispositions and destroy passive obstacles. In view of this fact it is quite probable that

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* *La fumée artificielle.*—Conformément à la demande de M. l'ingénieur mécanicien Oriolle, de Nantes, des expériences ont été faites à Toulon pour l'utilisation de la fumée opaque comme moyen de soustraire un bâtiment à la vue d'un ennemi supposé ou véritable ou de protéger une attaque. Le torpilleur *128* était désigné pour ces expériences; d'autres torpilleurs, postés à la distance de 400 mètres et formant le cercle, veillant sur lui. Le *128* a fourni son nuage artificiel et a franchi le cercle à la faveur de ce rideau. Un rapport officiel mentionnant les résultats exacts sera addressé au Ministre de la marine.—*La Marine Française*, 15 Mars, 1893.

desperate night encounters will take place in the vicinity of mine fields and other obstacles. These attacks will give rise to developments of counter defensive weapons such as the search light, submarine boat, torpedo boat and dirigible torpedo. In future, so much will depend on surprise and initiative, that the assailant will make every effort to conceal himself until the moment of attack. Modern naval tactics incline to short ranges, and if hostile ships reach a suitable position unobserved or unmolested their chances of silencing shore batteries will be greatly enhanced. *Therefore every defensive weapon and apparatus which will conspire to prevent this must be brought into play and used with vigilance and skill.* It is imperative that the weapons be extremely offensive in their character and always ready to strike home on the slightest opportunity.

The obstacles will be protected by the guns as at present. They, like all passive obstacles, simply detain the enemy under fire and, like all passive defenses, must ultimately give way if resolutely and persistently attacked.

Submarine mines operated from the shore will be especially vulnerable to submarine boats acting around the flanks and in rear. For such boats to cut the main cables will be but a simple matter. Mines can also be destroyed with certainty by dynamite guns projecting large charges of high explosive. With these weapons in possession of an enemy, we have little to hope from our submarine mines; they will delay but they cannot prevent the final moment.

THE CONTROL AND CONCENTRATION OF FIRE.

Much will depend, we believe, upon the manner in which the fire is concentrated and delivered. Batteries using direct fire will be laid upon a given point of the hostile ship. In indirect fire simplification will result if all guns of a battery can be given the same azimuth. To do this and avoid the errors caused by aiming along parallel lines a special device is necessary. Such a device may be obtained from a consideration of the following equation: $\theta = \frac{d \sin(\alpha + y)}{\rho}$ in which θ is the angular correction to be made in the vernier; d the distance between the gun of reference and any gun considered; a a constant angle; y the variable azimuth of the reference gun, and ρ the range. The second member is a function of y and ρ and therefore represents a surface. This surface may with a simple mechanical device be used as a cam which will shift the vernier a distance θ, and so adjust all verniers. Thus with a constant azimuth from the position finder the guns of a battery may be made to converge upon the point whose coördinates are y and ρ.

Vertical fire with mortars will probably begin at long ranges. When vessels are concealed by smoke or other causes it may be necessary for advanced sentinel boats to plot their position and transmit it to the mortar batteries. The present scheme of sixteen mortars arranged in sub-groups of four in the corners of a square contemplates volley firing. The mortars will be aimed and fired along parallel lines. It has been shown by mathematical investigation that this scattering effect is, under present conditions, the most advantageous for mortar fire. This investigation is based upon data now on hand. A general solution of the problem would show that other conditions of observation and fire would demand divergent or convergent lines of fire for maximum results. In other words, the question will reduce to our ability to group our shots closely around a given point and to place that point near the target. For a certain mean absolute deviation from the center of impact and a given distance of this point from the target the converging and parallel methods should give the same results. For shorter distances of the center of impact from the target the converging method should give best results; while for greater values of this distance a diverging fire would excel. The upper currents of the air, it has been argued, will be so strong and variable that it will be useless to attempt to concentrate on a given point; but this reason may be urged against concentrated fire of any kind. The following facts bear upon this difficulty, if it really be a difficulty:

1. The effect of wind on a projectile is most important in the first portions of the trajectory.

2. The wind currents of high altitudes are usually stronger but also more uniform in velocity and direction.

3. In the higher portions of the trajectory the retardation and consequently wind effect will tend towards a minimum.

4. Investigations of the relation between the wind of the lower and higher altitudes can be made.

In fact every element which affects the problem must be carefully investigated, and every effort made to bring the target and center of impact into coincidence. The true artillerist, while drawing all possible advantages from the past and the present and availing himself of their teachings, must remain ever awake to their shortcomings and keep his mind ever turned to progress and the future. Therefore, the application of probabilities to future data must be constantly made and rules for future operations constantly developed. It must be observed that whatever rules apply to the past, the next war will exact methods of the future. The pointing of *guns* in parallel should in no case be permitted, for such practice can scarcely be anything but deliberate waste of ammunition and assumes that it is useless to try to improve our aiming. No effective fire can result from a *scattering principle* and the *chance* of obtaining a hit. All such schemes are confessions of weakness dangerous to accept and which no true artillerist should be willing to make. Finally, in this connection, it may be stated that all scattering methods are erroneous in principle.

GENERAL PRINCIPLES OF THE DEFENSE.

Having considered the preceding problems we may now pass to the means of putting the different parts into operation and using them to the best advantage. As said before, the plan of defense should always be on hand and ready to be put into execution. Each officer must thoroughly understand its general scope and the particular part he is to play in its development.

A battery, we believe, should always concentrate its fire on a particular object. Groups of batteries in like manner should concentrate upon a prescribed vessel or vessels. Finally, such communication must exist between the central station and all batteries that the commanding officer can quickly and simultaneously direct all or any portion of his guns upon a given point or object. He would thus, so far as the application of tactics is possible, be able to use any kind of tactics suited to the defense, and concentrate all his guns upon any vessel he wished to overwhelm and destroy. In fact with suitable devices and facilities he could, we believe, so control and concentrate his fire as to draw a veritable "dead line" upon the water.

In the general case an enemy would have in view not the destruction of the forts so much as the menace or destruction of more vital interests behind them. In such cases he would while trying to clear the passage, be compelled to engage the forts. During this preparation of the way, the hostile vessels should not be permitted to anchor or sail slowly for an instant. If thus prevented, he will but waste his ammunition. The necessary experience and accuracy to accomplish this can only be obtained by a painstaking and persistent course of target practice. During the first stages of the attack our fire should be rapid, but above all it should be efficacious and overwhelming. No pains should be spared either during peace or in battle to make shots tell in the beginning. It will be to the enemy's advantage on account of his smaller calibers and unstable platforms to close with the batteries. The batteries should be able to keep him at a distance and leave him the alternative of great disadvantage or destruction. The action of the batteries as a rule should be concerted and convergent. This operation, if judiciously carried out, would greatly delay and possibly prevent his removal of the obstructions.

The attack, however, if persistent, will probably make this only a question of time; when this result is obtained the critical moment will be at hand. It will be to his advantage to make the passage as soon after the opening as possible. Estimating the run under an effective fire at three miles and the speed at ten miles, he would be exposed to fire for eighteen minutes. When it becomes evident that a ship is going to run the batteries, the latter, while engaging the remainder of the ships up to the last moment, should stand ready to concentrate their fire upon and destroy it. This will be a period for stratagems on the part of both sides, and each may endeavor to envelop the other in smoke. The side which accomplishes this earliest or most effectually will obtain an advantage. Passing these diversions, we will notice the actual effort of the ship to pass the fire of the defenders.

Eighteen minutes may seem a very short time indeed, but when judged by the amount of iron that could, with suitable arrangements, be rained upon a vessel, the interval might be reckoned in years. During this time we believe that every available gun should *appear* and *remain* above the parapet and put in the maximum number of shots at short range. If ever this stage is reached in a future attack there will be no time for losing sight of the enemy by receding behind the parapets to reload. It will not be a time for skulking or crawling into holes. As in the future infantry battle the assailant must come out and show himself in his onward rush, and as at the same moment the defender must come out from his cover and face the opponent at any cost, so will the time come in an artillery duel when the assailant will attempt his rush and the defense must bring their guns to the front and keep them there. Some of the guns may be destroyed, but they must take that risk. Some would better be destroyed than that all should spend half their useful time behind the parapet, out of sight of the enemy. *It must be remembered that protection is a means, not an end, and, as in other conflicts, must be abandoned under the demands of necessity.* In most of our harbors running the batteries would have to take place within short range of the guns. Harbors in future will be protected by heavy, quick-firing, and dynamite guns. These, when furnished with a suitable training apparatus and acting together to concentrate their fire upon a given ship would compel it to move through a hail-storm of projectiles of all sizes capable of killing its crew, dismounting its guns, perforating its armor, and blowing it out of the water. Based upon past experience, the principle is now accepted that ships unobstructed by passive obstacles can force a passage in spite of shore batteries. Future conditions especially with respect to volume, accuracy, rapidity and power of fire, cannot be compared to those of past examples, and we must be cautious in deducing cast-iron rules from such experience. The above principle has been demonstrated beyond question under the old conditions, but the value of this fact for the future remains to be seen. No ship or ships of the past have ever been, even for a short period, subjected to a concentrated fire of guns of the above-mentioned character, all trained with modern machines and capable of being continuously aligned while delivering their fire. The next war promises conditions so different from those of the past that we may withhold judgment as to the success of operations based upon any precedents. Had former fleets been subjected to such guns and concentration of fire as will obtain, henceforth, history might have told other stories, and the fate of Lissa, Hilton Head, and even Alexandria, been different. It will be remembered that by thorough organization, study, and preparation beforehand, and persistent offensive action in 1870, the German field artillery reversed all accepted rules for its employment and created for itself an offensive and defensive rôle undreamt of before. In like manner it may not be too much to hope that the future heavy artillery which is skillfully, boldly and fearlessly handled will establish its superiority over all opponents and demonstrate to the world that if it will not it cannot be beaten. Such a result however can be reached, we believe, only by the complete removal of the difficulties already pointed out and by a realization of that mobility and offensiveness outlined in the preceding discussion. In addition to the difficulties already mentioned, others, on account of changing conditions, will arise from time to time and some will appear on the day of battle. Thorough study and inquiry during peace and the habit of treating important questions at short notice must form our main reliance in such cases.

We must be prepared to dispose of them as an experienced engineer meets an unexpected difficulty. To push investigations far into future artillery problems, to foresee, suggest, and correct when possible, and to be watchful and ready for all questions, will be the true course of the future artillery soldier.

Organization and instruction in keeping with future developments are the prime essentials to artillery success. Following these come the ability to ascertain and understand new considerations with promptitude and energy and the genius to satisfy them from available resources.

An artillery combining these requirements will, we believe, experience few difficulties in future wars, and under reasonable circumstances cannot be defeated.

NOTES ON CONFEDERATE ARTILLERY INSTRUCTION AND SERVICE

By Professor M. W. HUMPHREYS, University of Virginia.

Had all parties been willing, the good results of our civil war might have been more satisfactorily accomplished by peaceful means with less expenditure of money and without any suffering. If, then, the war is not to remain an unmitigated evil, it becomes us, before it is too late, to try to reap from it some useful fruits. Now if the improvement of our relative status as a military power is not one of the results of the war, we may well despair of finding any good in it. That war gave birth to the epoch-making iron-clad vessel; but this result can be, and has been, utilized by other nations as readily and effectually as by us; and the same may be said of all improvements that have followed in the *matériel.* Any *advantage* to be derived by us must be some lesson which we stand in special need of learning, or which, when learned, will specially benefit us. Such special need, if it exists, must be due to some condition peculiar to us. What, then, are our peculiarities? It is sufficient for the present purpose to mention just one: The proportion of our population adequately acquainted with the art of war, will, under our system, always be much smaller than in the case of any other great power. At the close of the civil struggle we had great experience in practical warfare; but that generation is passing away, and it may be assumed that even the survivors have not all learned every lesson the war taught. One observes one defect, another observes another; one has discovered what he considers an improvement upon existing means and methods, while another has done the same in another direction, or has discovered another improvement in the same line. A comparison of experiences, therefore, is of the first importance; and this would be equally useful to those who did not take part in the war, but will be entrusted with the organization and training, if we ever take the field with a large army.

These considerations have induced me, though a civilian pursuing a vocation far removed from war, to yield to the request of the editor of this *Journal*, and state some of the experiences of the artillery service in the Confederate army. In doing this I am greatly embarrassed by several facts. The chief of these is that some things which it will be necessary to say will seem to be reflections upon the officers under whom I served; but such is not the intent. It is simply impossible to write intelligently on the subject without mentioning errors of omission or commission on the part of officers, and an article excluding mention of these errors would be useless. Another is the necessity I am under, not only of speaking in the first person, but also of stating facts the very mention of which savors of egotism. Then one feels a natural aversion to telling what he found to be the best way to kill people. Finally I feel that it is presumptuous in one who only held the rank of sergeant in the Confederate army and is disqualified to hold a higher rank in the United States army, to offer any remarks on a military subject. Still I have overcome all these scruples through the hope that some good may possibly result.

It is to be hoped that if our country ever becomes engaged in war, the operations will be confined to the sea or at least the seacoast. For such warfare this article could certainly not be of any service. But there is a possibility of our becoming involved in a struggle that would require the employment of an immense army of volunteers on land. We should not have enough trained and educated military men to officer such a force; and even if we had them, it would be unwise to fill all the offices by appointment of men who are strangers to those under them. Volunteer commands are gotten up in great measure by the exertions of influential patriotic men; and the prospect of some recognition of their special efforts must in many cases be an incentive that should not be withdrawn. Moreover, our self-governing citizens would feel it to be their right, as citizen-soldiers, to have some voice in the selection of their immediate commanders. In short, we should find the general conditions very much as they were in 1861, when whole batteries and (in the South, at least,) whole battalions of artillery went into active service without a single man, whether officer, non-commissioned officer, or private, who knew anything about artillery. In view of these facts it may be useful to record some of the difficulties such organizations experienced, the errors they committed, the progress they made, etc., even when it is certain that our trained artillerists would not learn from this source anything new in their profession. It is important that experts should know the shortcomings of others, that the needful steps may be taken to prevent their repetition. It is, therefore, chiefly the wants and defects of a volunteer force that this article is intended to illustrate, and it will have accomplished its purpose if it contributes anything to the elimination of these faults in the future; but at the same time the possibility, however remote, that some of our experiences might prove useful to artillerists as such will be kept in view.

The infantry of the Confederacy was provided with instruction and training in the manual and use of arms and in elementary evolutions. For this purpose cadets of military schools were detailed as drill-masters. But I have never heard of any such provision being made for artillery, except in isolated cases where the men composing a company secured the services of experts before they organized and entered the army. Possibly the Federal artillery was more fortunate. Certainly there ought to have been, and ought to be again under like conditions, systematic instruction of as practical a nature as possible, and this instruction should be given to officers especially. There might be organized a special camp of instruction for them, where they would have practice in actual firing. But it is not my purpose to point out how the needs of raw artillery may be met: if they are known, a way to meet them can be devised.

Both on account of the revolutionizing improvements that have been made in cannon since the war, and because the Confederate artillery and ordnance supplies were inferior even to the Federal of that time, it might seem utterly useless to take any account of the Confederate experiences. But it has been shown repeatedly in this *Journal* and elsewhere, that experiences acquired with the poorest guns, especially if those experiences reveal erroneous methods, can be utilized in serving the best guns, and that the better the gun the better it must be served to secure the same ratio of the maximum possible efficiency.

This article deals only with light field artillery ("mounted," *i. e.*, with the cannoneers *not* mounted on horses,). There is reason to believe that the sea-coast guns were, as a rule, in more experienced hands than the field guns, or at least that, for some reason, they were more systematically served. With the horse artillery I had no experience.

The whole ground is immense. Among the special subjects, on which our experience had a bearing, are the following:

The necessity, in making up an artillery command, to have an eye to securing willing and competent drivers.

The selection and training of horses and their management and treatment in winter quarters, in camp, and on the march.

The preservation and actual (not formal) inspection of the *matériel.*

The training of men to handle and maneuver guns (manual of the piece, maneuvers of the battery, march, etc.).

The general disposition and maneuver of guns in the face of the enemy.

The special details of coming into action, and the disposition of limbers and caissons.

The selection of the exact location with reference to the general topography of the field and the immediate contour of the ground.

When, what, at what, how, and how often to fire.

How to hit.

The last named of these subjects should be the beginning, middle, and end of all artillery training, and the present article will be confined to it and its collaterals. To hit an object at the first round, one must know the distance and the elevation his gun requires for that distance; but neither of these is usually known with any degree of exactness, and often the distance can be only roughly approximated, and may be very erroneously estimated. Consequently, while how to estimate distance is an important part of the subject, a still more important one is how, after firing, to correct the error. Then again the mere process of directing the line of sight upon a distant object offers physical difficulties familiar to everyone who has aimed guns without telescopic sights. Such, then, are some of the collaterals of the question how to hit.

The battery whose experiences are to be discussed was formed when the Confederate army was reorganized before the opening of the second campaign, and was in active service until after the surrender at Appomattox. It originally had six guns, but was reduced to a four-gun battery at the opening of the Valley campaign of 1864. Up to that date the pieces had included 6-pdr. smooth-bores, 12-pdr. howitzers, 3-inch rifles, 10-pdr. Parrott guns, and 20-pdr. Parrott guns. The battery had all these pieces at the same time except that the last 6-pdr. was given up when the first 20-pdr. Parrott was received. When the battery was reduced to four pieces, these were all 3-in. rifles, but they were of different kinds with different ranges and degrees of accuracy, so that each gun always had to find its own, even approximate, range. During the campaigns of 1862 and 1863 the battery served usually with detached brigades in a mountainous region; but in 1864 it was incorporated into a battalion and served in a large army. Its two best guns were at the same time its worst, a steel 3-in. rifle, weighing only about 500 lbs., which often broke its carriage when fired, and a 20-pdr. Parrott, weighing nearly 2000 lbs., which the horses were often unable to pull up a hill or on soft ground. The present article, however, will not deal with the relative merits of old-fashioned guns.

The organization of the company was as follows: A captain, four lieutenants, an orderly sergeant, six sergeants, twelve corporals, a quartermaster (sergeant), a commissary, a wagon-master, three artificers, and about 110 men—drivers and cannoneers. Three of the lieutenants were each a "chief of section" (two pieces), and the fourth lieutenant was "chief of caissons." Each of the six sergeants was a "chief of piece," or "detachment," six of the corporals were "gunners," and each of the remaining six was a "chief of caisson." By "gunner" was meant the man whose duty it was to aim or lay the piece (we usually called it "pointing"). It was always the privilege, however, of an officer or a sergeant to perform this duty and the sergeants as well as the corporals were regarded as gunners. In fact the line was very vaguely drawn between sergeants and officers on the one side, and between sergeants and corporals on the other. The organization was scarcely ever intact. It frequently happened that a corporal acted as chief of piece, and a sergeant as chief of section, or chief of caissons; and in 1864-5 a sergeant often commanded the battery itself (sometimes even in battle), took his turn as "officer of the day" for the battalion, commanded the caissons of the whole battalion in time of battle, and performed all the duties of a commissioned officer.

The company was chiefly made up of men reared in small towns or in the country. Very few of them were wholly illiterate, and still fewer possessed more than a good common school education. None had received any military instruction or training before the war began, though several had served in infantry from the beginning of the war to the organization of the battery. The writer had been attending a college which suspended all other studies and took up infantry tactics, field-fortifications, and gunnery, in the spring of 1861. The gunnery taught, however, was purely theoretical and altogether unavailable for any practical purpose. With this exception no member of the company had any knowledge of artillery worth mentioning. There were only four men in the company, so far as I can recall, who knew any mathematics beyond elementary algebra and geometry, and none of these were commissioned officers; and there were but two that had even the slightest knowledge of the calculus. The writer was familiar with the lower branches of mathematics, and had a special fondness for descriptive and analytical geometry; but had studied very little calculus.

The men were carefully and regularly drilled from the start. They were first taught the manual of the piece with the necessary detachment drill; then were added the evolutions of the battery, sometimes with the pieces drawn by horses, sometimes with the men alone. In the latter case the evolutions were not unlike those of an infantry battalion of six companies. In short, we were taught everything except the one thing that all else was a preparation for—the art of hitting. Our drill included much more, even, than is required in actual service. It cannot be asserted, however, that the excess was useless. The training prepared the men to meet unexpected emergencies, and sometimes we found occasion to perform some particular evolution that one would not have expected ever to be required. Once, for instance, it became necessary under a heavy fire in a contracted space to "change front to fire to the right, left wing to the rear," and immediately afterwards to return to the original position. On another occasion a gun weighing about 1000 lbs., at a very important crisis, when engaged with infantry about 400 yds. distant, leaped from its carriage, the keys of the trunnion-caps having come out. The gun was remounted, the keys secured with the sergeant's shoe-string (the pins ordinarily used being found missing), and the gun was fired again not more than one minute (as estimated at the time) after the discharge that had dismounted it. Hence there is nothing to be said against the thoroughness of the drill; but the failure to instruct in gunnery (or the art of pointing) becomes all the more striking by contrast.

The battery had been organized about six weeks when the first intimation of anything like gunnery was made by an officer; and as this was the *only* intimation I ever heard, it may be worth while to record it. We were drilling at the pieces, at that time 6-pdr. smooth-bore guns, the shells of which had circular metallic fuses up to five seconds. The officer drilling us suddenly suspended the drill and asked each gunner in succession: "At how many seconds would you cut your fuse for 800 yds." One made one guess, another made another. According to my diary I guessed "two seconds," estimating that at 800 yds. the projectile ought to be about with the sound. The officer then said with a sneer, "It would require the *full five seconds!*" Our guns at this time were not supplied with tables of ranges.

Nor was this fault confined to our officers. To the end of the war the text-books accessible to us, though they had a few remarks on gunnery (chiefly nomenclature), treated the subject as one of entirely secondary importance, and offered scarcely any information of practical value. In one of these books is found, indeed, the suggestion that "artillerymen should be frequently practised in estimating distances by the eye alone, and rectifying the estimate afterward, either by pacing the distance, or by actual measurement with a tape-line or chain," which is well enough but for the fact that it is slow and tedious to step off or measure with a chain now a thousand yards or a mile in this direction, then a mile and a half in that direction. About a year before the end of the war the non-commissioned officers were required to study and pass an examination on artillery tactics, and the sergeants were required as a part of their examination, to give the commands on the field necessary to change the battery from positions it occupied to other designated positions; all of which was proper enough, but our manual taught us nothing about how to attain the ultimate object of all those evolutions. No instruction in gunnery was ordered until June, 1864; and as it devolved upon me to give this instruction, I must, with renewed apologies for seeming egotism, speak of my own attitude in the course of our experiences.

I had selected the artillery service because I imagined I should be fond of gunnery, and though only seventeen years old had stipulated with the recruiting officer and prospective captain, that I should be made a gunner. Having been appointed "first gunner," I procured from time to time such helps as I could in the way of books, and devoted much time and labor to a vain attempt to solve the problem of a projectile moving in a resisting medium, and to reduce the results to practical form. The only work I had in which this problem is treated was Boucharlat's Mechanics. But I found that among the men, and to some extent even among the officers, there was a positive prejudice against "theoretical" gunnery. It was by the slowest degrees that this prejudice disappeared. It was only through the aid of almost incredible good luck in practice that I induced men to believe that there was any good in gunnery. And it must be confessed that, as they conceived it, they were not far wrong. It seemed to be the prevalent notion that a "scientific gunner" professed to arrive at all his results by pure mathematics. This misconception was never wholly removed, but the prejudice well-nigh disappeared before 1865. The men who at first had the greatest contempt for "theory" were the gunners themselves. About these and others who acted in that capacity, a few remarks may not be amiss.

All commissioned officers were elected by the members of the company. During the first year most of the sergeants also were elected, but a few were appointed. Later the sergeants, and from the beginning the corporals, were all appointed by the commanding officer of the battery. To what extent fitness for the place was considered by the men when voting, it would be unsafe to say; but that such fitness was not the prime consideration in some instances was perfectly obvious. Even the appointments did not always appear to be made with a view to efficiency; and when they were so made, the qualities sought in the early period were not always the most important. Among our original gunners were some almost illiterate men, selected because they had great reputations as marksmen with the mountain rifle,—men who could "hit a squirrel's head fifty yards," or who had been known to "kill a deer two hundred yards." Now a good eye is, indeed, a necessity, and the ability to align sights at a near object is certainly of some use to a gunner; but these qualifications alone amount to very little. One man was urged by many for appointment because he could "drive the center every time" and "*had but one* eye" so that when aiming he did not have to shut the other one. And yet, when once we were estimating the distance to two trees, respectively about 600 and 800 yards distant, that one-eyed man insisted that the nearer tree (which was the smaller) was further away than the other. He, it is just to say, was not appointed. In the course of time we learned that general intelligence and the ability to estimate distances with some accuracy (which latter implies a good eye) were much more important than skill with a squirrel gun. According to my own experience the aiming of a cannon was more nearly related to directing a surveyor's compass,—a thing in which I had had some practice, which certainly was beneficial. But all of us had to learn (though some, I fear, never did) how to direct the sights of a cannon at a distant small object. The difficulty of doing this needs no emphasis: all artillerists must be familiar with it. To what extent this practical difficulty has been, or, in case of war, would be eliminated by the use of telescopic sights, I am not prepared to judge; but it was with us a greater obstacle to successful firing than some people would ever suspect. There are men of intelligence who lack the ability to comprehend some of the simplest optical phenomena, and seem unable to perform the most elementary experiments with their own eyes, such as looking at one thing while they *observe* another. When I had occasion to train men in the use of the eye, I found that some could not look at a near object with both eyes and *observe* at the same time that more remote small objects were seen double, and *vice versa.* The first thing I did in this case was to train them to do this, and then to use one eye in the same way and observe that the objects were *not* doubled. I could then feel some assurance that they were capable of looking at the sights and observing the object, and *vice versa.*

As has been already intimated, it began gradually to devolve on me in a manner to instruct others in gunnery. At first a few of those concerned conferred with me of their own motion and, so far as I ever knew, without any suggestion from the officers; and I merely explained to them how I estimated distance and how I proceeded in getting the range of an object, and practiced them in the actual estimation of distances. The commanding officer, however, in the course of time began to require me to correct tables of ranges, or, when these were lacking, to prepare tables, for new guns after a few experimental shots. Finally, when in June, 1864, our battery was reduced to four 3-in. rifles and my 20-pdr. Parrott was given up, I was required to retain the rank of sergeant, and it was made my duty, as "chief gunner" (a specially created function), to superintend the firing of all the guns to the extent of seeing that they obtained and kept the range, and to instruct others in practical gunnery. The ensuing campaign proved so active that neither of these duties was systematically performed. Though nominally a supernumerary sergeant, there was but one engagement (and that a small one) in which I did not have a temporary vacancy to fill either as gunner, chief of piece, chief of section, chief of caissons, or even as commander of the battery; and much of the time I acted as orderly sergeant, and was detailed as "officer of the day" just as if I had been a lieutenant. Moreover, so far as I knew, no order was ever given the gunners to be instructed; so that the matter was entirely voluntary, and not all of them ever attended the few formal lessons I tried to give, though at least one (a sergeant) from another battery attended.

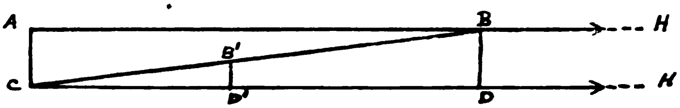
I now proceed to give my experience in the work above named along with an account of the development of gunnery in the battery. No systematic presentation will be attempted.

Every artillerist knows that he must feel his way when the range has not been measured or previously obtained by firing; but the nearer he can guess it before his first experimental shot, the better. Hence the first thing was to learn to estimate distances. Here two cases arise: first, when one is familiar with a locality, or can distinctly take in the topography with the eye, as when looking over a plain from an eminence; and secondly, when neither of these conditions is fulfilled. The means that have to be adopted in the second case are equally applicable to the first; but is desirable to be able without them to form some idea of distance by simple, direct contemplation; that is, one should know what a mile, for instance, is, when he sees it. For the first case we simply guessed at distances and then measured them. We on one occasion carefully measured several stretches with a tape-line, and also stepped them. In this way we learned how to step yards, or to convert our natural paces into yards. After that we satisfied ourselves with pacing. The tediousness of this method proved a serious obstacle to adequate practice; but where our battery served, it was usually impossible to find enough smooth level ground to lay off a base for triangulation. Near our winter-quarters during the winter of 1862-3 was a small level area from which a good deal of the surrounding country was visible. On this space we laid off a square with as great precision as possible, by geometrical means, marking the sides with a cord and the corners with wire pins. Having estimated the distance to a selected object, each participant writing down his own guess without conference, we would sight at the object from the ends of one side of the square and mark the points where the vertical planes of sight cut the opposite side, prolonged if necessary. Having now measured the distance between these two points and between one of them and the pin from which it had been located (sometimes this line was a side of the square already measured), we had the means of determining the distance by simple proportion. This method, without instruments, seems very crude; but the results (which I found it necessary to verify occasionally by actual measurement with a tape-line, to keep up confidence) proved surprisingly accurate. When a little boy I had often amused myself by measuring distances in a somewhat similar way and had sometimes calculated the elevation of hill tops, the height of trees, etc.; so that I had some experience in devising substitutes for instruments. These it is needless to describe. It will be observed that by the practice just described we were learning, not to measure distances (I did the measuring myself), but to estimate distances, the measurement being merely a test of the accuracy of the guesses.

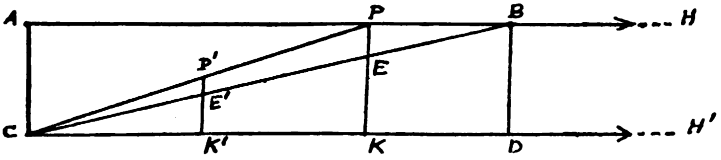
Usually, however, when a battle came off, we were unfamiliar with the ground, and there were undulations or groves or other obstacles to a direct contemplation of the intervening space. The difficulties confronting the gunner in this case constitute one of the most important subjects connected with the field artillery service. Of course those who operate the great stationary guns of our forts know the distances to all fixed objects in their view, and have at hand the means of promptly locating any new object that may appear and the point where a shot strikes; but our field artillery lacked all these advantages, and I have not only known men to greatly underestimate or overestimate the distance to a hostile battery and waste much time in getting the range, but I have seen them actually fire for hours under the impression that they had the range, when in fact the projectiles were striking the top of a hill a quarter of a mile short of the enemy's position, or the side of a hill a quarter of a mile beyond. Those who have received a military education may consider such a blunder too absurd for serious consideration; but it is a blunder that was by no means rare in our civil war, and would no doubt be committed again by uninstructed volunteers. The battery which I saw do the undershooting mentioned was a Confederate battery, and the Federals that day won a victory almost entirely by the superiority of their artillery. The converse case occurred between the same forces two weeks later; and this time it was the Federal artillery that proved inefficient, and the Confederates were victorious almost without the use of infantry. On this occasion a battery of four guns secured a position which enabled it to enfilade the Federal artillery. This position was on a low, treeless ridge, and behind it was a higher ridge with scattering trees on its top. At first four, then a larger number of Federal guns, were turned upon this battery, and though the distance was not more than half a mile, they shot over the heads of the Confederates from early in the forenoon till late in the afternoon, and failed to inflict the slightest damage on man, beast, or gun, while they themselves suffered severely and were eventually silenced. It is evident that the Confederate battery was supposed to be on the hill that was behind it, and the existence of the depression between the hills was probably not suspected. The remote hill was constantly struck. The error was the more natural because we did have on the farther hill a line of infantry, which withdrew behind the hill when the artillery duel commenced. Is it possible, it will be asked, that officers in the fourth year of the war could allow such blunders? One might answer by enumerating many still more unaccountable errors.

Two means were employed in estimating distances under the circumstances named; and though in the future range finders will no doubt be provided, it may be worth while to describe our methods. These means were, first, the distinctness of vision and the apparent size (visual angle) of known objects near the target, and, secondly, the parallax of the target caused by moving laterally near the gun. The former means it was difficult to apply. The visual angle subtended by a man's body, for instance, could not be measured; and the distinctness of vision depends much upon the condition of the atmosphere, the time of day, the direction with reference to the sun, the relative color of objects and of the back-ground, etc, Moreover, everyone must learn rules for himself. I found that my eye was quite exceptional, and that consequently my experience was useless to others. On one occasion a line of battle running through the woods on the side of a mountain (before the leaves were fully out: May 9, 1864) was pronounced a brush-fence by everyone near me, and yet I could distinctly see the men's legs as they stepped. But, although this method of estimating distance is very uncertain, it is not entirely useless; for close attention to the appearance of men, horses, gun carriages, and the like, will in the course of time enable one to avoid enormously erroneous estimates of distance; but the rules sometimes laid down are of little value except as general hints how to utilize the appearance of things. As stated before, each one must practice his eye and form special rules for himself.

The second method, unless instruments are used, is not much more accurate; but it will always prevent blunders such as those described above, and enable one to find the range more promptly with the gun. It has always seemed to me that in many cases which arose instruments might have been used to advantage, though I have never seen them used in the field. I cannot say we did not have them. Our battery once hauled around for several months (sometimes with the cooking utensils) a fine theodolite in its original case. It was captured by our men at Gauley Bridge, W. Va., in 1862, and if I remember correctly was labeled "Theodolite No. 10, United States Topographical Bureau." But we never made any use of it. One of its levels was at last removed and fastened to the axle-body of the little steel rifle by means of nails driven in and bent over it. Whether the axis of the level was parallel to that of the trunnions, nobody knew or cared; nor did it make any difference, since we could not get the bubble to stand in the middle by leveling the ground under the wheels, and the first time the gun was fired the glass was shivered and the alcohol scattered in the air. After this occurrence the theodolite disappeared, and I never learned what became of it. I tried to extemporize crude devices for prompt measurement of parallax; and in this, as in most analogous attempts, the immediate result was of little practical value except as preventing enormous errors, but the theory and repeated attempt to apply it tended to cultivate a useful habit of observation and to develop the faculty of drawing intelligent conclusions from phenomena. I did not attempt to measure angles directly, but adopted the following plan. Let A be a point near the gun,



and B the object whose distance is desired. From A carefully note the point (H, H′) in which AB prolonged (or the vertical plane containing AB) cuts the horizon. (Usually the point A may be selected *near* the gun, so that some distinguishable object will mark H.) Now step off AC perpendicular to AB, and from C observe the relative positions of B and H. The latter will appear in the direction CDH′, and if AC is small (say 100 yds.) and the horizon is at all distant the point (H, H′) on the horizon may be regarded as the true vanishing point, or, in other words, AB and CD are virtually parallel. If the horizon is not remote in comparison with AB and AC, the line CDH′ should be directed towards a point situated a distance AC to the right of H. This distance AC on the horizon must, indeed, be estimated by means of surrounding objects or derived directly from AH, if this is approximately known; but an error in this estimation only affects a fraction of the general result. Draw BD parallel to AC in the figure; connect C and B, and draw B′D′ parallel to BD. Now stand at C and hold a graded rule in the position B′D′ and read off the length B′D′. Sometimes, when practicing, I used a measured rule (Gunter's) for CD′, and adopted various devices for observing and measuring B′D′ across the end of the rule; but in the face of the enemy, if I took any measurement at all, I held a little pocket rule at arm's length, having learned by practice to hold it twenty-eight inches from my eye. I carried in my head the various lengths of B′D′ when AC was 100 yds. and AB varied from 500 to 2500 yds.; but the computation in any case required only a few seconds of mental operation. The difficulty of making the observation is very much the same as that of aligning the sights of a gun at a distant object, only the eye serves as the rear sight, simplifying the case, which is at the same time complicated by the necessity of observing simultaneously two objects. But the chief difficulty is to keep the object marking the vanishing point fixed in the memory. In fact it is best to watch it as you move, and to do this it may be more convenient to step off AC first, and from C project B upon the horizon; then, watching this point on the horizon, go back to the gun (walking by faith). In the face of the enemy, however, it frequently was impracticable to attempt any definite measurements; but almost always, not only before aiming the first time, but especially after the gun was laid, and when the first shot was about to be made, I stepped far enough to one side to be able to draw some inference from parallax, the significance of which I had learned by experience. Often the firing of other guns rendered the identification of my shot difficult, and sometimes I was interfered with by officers and ordered to my "post." The method just described relates solely to the distance of the object to be hit, and was applied before laying the gun. When the effect of one round has been observed the method is the same in principle, and will be made clear by a glance at the annexed figure. The lettering is, in the main, as before. Suppose a *line* shot has hit at P. The rule held before the eye is in the position P′E′K′; and it is obvious that P′K′:P′E′::PK:PE: AB:PB, so that K′E′P′ is a miniature of APB, viewed from the side. In battle I never attempted more than a rough estimate in this way; but a rough estimate is vastly better than unconsciousness of the very existence of an error, which unconsciousness is liable to occur if no observation of the sort named is made. The method of correcting the error of the first shot will be stated in its proper place in the account of our experiences, which will be given presently.



Some of our pieces were provided each with a tangent scale held firm in its socket with a thumb-screw, while others had each a movable pendulum hausse. These rear sights were at the centre of the breech on top, the front sights being on top of the muzzle. The notches in the breech sights, and especially the edges or points of the muzzle sights, were usually very coarse. The object of this I never could conjecture. The first thing I always did on being assigned to a new piece was to sharpen the sights. Some of our pieces (chiefly captured Parrott guns, I think) had the front sights on the trunnions and the tangent scales on the side of the breech. Even the captured guns, by the way, had those same coarse sights that rendered accuracy of aim impossible. During our war I never saw telescopic sights or sights that could be adjusted laterally.

Our ammunition was inferior to that of the Federal artillery. This fact became conspicuously obvious sometimes when (as at Bell Grove, October 19, 1864) Federal ammunition fell into our hands. The worst of it was that there was great lack of uniformity in the strength of the powder, and seemingly in the time of the fuses. No reflection on the Confederate ordnance department is implied by these remarks. With the means at their disposal their achievements were amazing; but the indisputable fact remains that our ammunition was in every way inferior to that of the Federal army. The supplies received at different times often differed very much in power, and sometimes we inadvertently mixed different supplies in our boxes, or had to change from one to the other in the heat of battle. At one engagement which I recall the Federal accounts represented us as having used pig-iron as projectiles. This, of course, was a mistake; but it was a natural one. There was some pig-iron scattered over that battle-field (how it got there, I do not know); and our ammunition was particularly bad and lacking in uniformity. At one time during the battle I had an opportunity of using case-shot from a 12-pdr. howitzer on a mass of men not more than 800 yds. away, and it became obvious that the shot did not kill. The (paper) fuses were in the form of a frustum of a cone, and the fuse-plugs were of wood. The tapping of the fuse with the mallet drove the plugs partly into the shells, and frequently, when the piece was discharged the plug jumped entirely into the shell or else let the fire pass it: at any rate the shell often exploded in the bore, or at the muzzle of the piece. It was also on this occasion that some guns never found out which ridge the hostile artillery was on. Hence, while the statement that we used pig-iron was not correct, the mistake was natural enough. But what was, perhaps, worst of all about our ammunition was that we usually had only a limited supply of it. Consequently we were rarely allowed to practice except in testing new guns; and in battle we sometimes were forbidden to fire at anything but masses of infantry. Hence our opportunities for practice in firing at a small object, such as a target or a hostile gun, were limited.

The pieces themselves were often very inaccurate. We had to use guns after they were really worn out, and sometimes our new pieces were defective. For two years we had a beautiful bronze 3-in. rifle, which was very untrustworthy in comparison with the Federal iron 3-in. rifles, some of which we afterwards used. Its caliber seemed to be a little too large, and often (possibly, however, from stripping) the projectiles failed to take the grooves. For a short time we had also a 20-pdr. Parrott, beautifully finished inside and outside, which we used in one engagement; but the shells did not once fail to strip. I tried hammering the rim to fit the grooves, and wrapping the whole projectile with twine; but all to no purpose. I made careful measurements, and could detect no difference between its caliber and that of another 20-pdr. Parrott (Federal), which, though not so smoothly finished inside, was an excellent gun but for occasional stripping. I threw light into its bore and carefully inspected it, but never detected the fault. I now *suspect* that the grooves had uniform twist, or at least began with too much twist. One of our guns, as already stated, was a steel 3-in. rifle, weighing only about 500 lbs., which was said to be a French experimental gun that had run the blockade. It was remarkably accurate and long-ranged. The barrel was longer than that of our other guns of the same caliber. It was a muzzle-loader: in fact, though there were a few in the Confederate army, I never saw a breech-loader during the whole war. The gun in question, however, gave us infinite trouble by kicking its carriage to pieces, breaking out of its bronze cap-squares, or in some way disabling itself. If nothing else happened, it would get choked. From all this it will be seen that not much can be expected from a discussion of our experience in trying to hit; but as this article deals rather with *corrigenda* than with positive results, such a discussion may prove not wholly useless.

Under the circumstances one would naturally suppose that when we did fire our guns, we took care to learn as much as possible from every round; but this was far from being the case. We sometimes fired seemingly idle salutes with blank charges. On one occasion, when our battery, being by accident far away from all other forces, arrived at a village after dark, we fired several rounds and actually threw a shell with uncut fuse toward the side of an uninhabited mountain. Moreover, in the early part of the war, when we practiced, it was done without any system whatever, and seemed to have no definite purpose. Much of the firing was simply at the trunks of trees, that is, at vertical lines, and the distance was either ignored entirely or guessed. Not only was no attention paid to the thermometer or barometer, but no one seemed to be aware that ranges obtained where we were, 2000 feet above the sea, would not hold good for every elevation above the sea. As time went on there was considerable improvement. Late in the fall of 1862, when the active campaign was evidently over and we were constructing winter-quarters, an officer discovering that my works on artillery and other books containing formulæ and tables of logarithms were in my limber-chest, threw them out on the ground in a heavy rain, because the "regulations" forbade carrying in the chests anything but "ammunition and artillery implements." I knew nothing of his act till next morning when I found my books utterly ruined. And yet, one year after this the non-commissioned officers of our battery were all required to procure and study a work on artillery tactics. From the latter time on our battery officers classed works on artillery as "implements" or "equipments;" but a field officer, in July, 1864, when we were in Maryland, inspected our battery and threw my book out on the ground. There was no other means at hand of carrying it, and our battery was on the rear-guard, pretty closely followed by a regiment of Federal cavalry; so, labeling the book as "abandoned for want of transportation," I fastened it to a thorn-bush by the road-side. But again, in the winter of 1864-5, when our battalion had fired its last round, we were required by field officers to study artillery tactics, and I was highly complimented for a "perfect recitation" on the duties of No. 1 in loading the piece! In all this there is evidence of individual progress, though some of it was a trifle late.

Let us return to 1862. Our original guns had been "turned over," some of them to the Confederate ordnance department, the rest to George Crook; and we were supplied with six new pieces. Some of these had tables of ranges pasted in the limber-boxes. These tables were not only printed and uniform for all guns of the same caliber without reference to the pattern, but some of them seemed to be, not theoretical, but what might be called conventional: the elevation, range, and time of flight were all three given in round numbers. This was probably the best our ordnance department could do; but it was our place as artillerymen to modify these tables to suit ascertained facts, and to construct tables for the pieces that had none. But at our first trial of the guns, as has been stated, we shot at a *vertical line, distance unmeasured.* The officers did nearly all the pointing, and no notes whatever were taken. At the close of the practice each gunner (corporal) was allowed to make a shot with a 6-pdr. bronze smooth-bore. The tree, distant less than 800 yards, had been struck once by the little steel rifle; but at what point and with what elevation it had been aimed seemed to concern no one. All the other shots had missed the tree and nobody cared where they struck. But at last, when the gunners' turn came, I ventured to ask at what point we should try to hit the tree. A point was designated, and some shots were made, missing the tree. When the gunner who immediately preceded me had aimed, I looked through the sights and received from him the pendulum hausse just as it was. The projectile struck very close to the right of the root of the tree. When I was about to aim, a device occurred to me which is so simple and self-evident that I hesitate to state it, and yet I never met with any one that used it, and I subsequently found difficulty in getting some to grasp it. I placed the unchanged hausse in its seat and aimed the gun exactly as it had just been aimed, that is, *at the same point* and *with the same elevation:* if fired in that position it ought to strike about the same place it did before. Next, leaving the gun unmoved, I ran the slide of the hausse up until the line of sight was brought down to where the shot struck (the line passed a little to the left of that point). Finally, assuming practical rigidity of the trajectory I raised the muzzle of the gun with the elevating screw until the new line of sight was brought to bear upon the point to be hit. The slight lateral correction was estimated: in fact, the sights were so coarse that it was merely a question which part of them the line presented by the tree should pass through. There was considerable murmuring at my slowness, and even some of the citizens, many of whom, male and female, were present, joined in and offered some witticisms. But fortune came to my rescue: a 6-pdr. smooth-bore did for once make two consecutive somewhat similar shots, and mine was the second of these shots. The projectile struck almost exactly as was intended, and knocked a large block of wood out of the tree. The only credit I claim for that shot is that I made the accident possible by placing the target within the limits of dispersion. The tree was not hit any more, and nothing had been learned, except in the vaguest way, about the range of our guns.

Not long after this we practiced again; but most of the shooting was still at the trunks of trees, though some of it was at stumps. One case-shot was fired at a large hawk sitting on the top of a dead tree. No distances were measured and no notes taken by those conducting the practice. The objects fired at, however, were on inclined ground, rising to a considerable height beyond the targets, so that it was easy to observe where the projectiles struck, or the apparent point of explosion as viewed from the piece. I undertook to utilize as many of these shots as possible by applying the principle on which I had pointed the gun a short time before. When a shot had been fired, I got permission to point the gun in exactly the same way again, and then change the sights so as to bring the line of sight upon the point struck, or the point at which a shell seemed to explode (the actual point projected upon the background) Subsequently I measured the distance to as many of the points struck as I could identify. The observation of exploding shells gave the time of flight corresponding to the elevation in each case. From these data the range was calculated approximately, on the assumption that the time of flight was equal to the time required for the projectile to fall through the air a distance equal to the range multiplied by the tangent of the elevation (this was a few weeks before my books were destroyed). The strong prejudice existing at this time against "theorizing" deterred me from making any suggestions, and the only part I took in the practice was, just before each discharge, to predict what the projectile would do when a serious error seemed to me to have been committed in pointing. One of the lieutenants remarked to me on the comparative uselessness of firing at a vertical line without taking any note of the drift or deflection; but he made no protest so far as I know. We had no more field practice that fall and winter, except when we tried the steel rifle with the level from the theodolite attached to its axle. On this occasion only two or three rounds were fired, one from the rifle, the rest from a howitzer. The distance was not measured nor any notes taken.

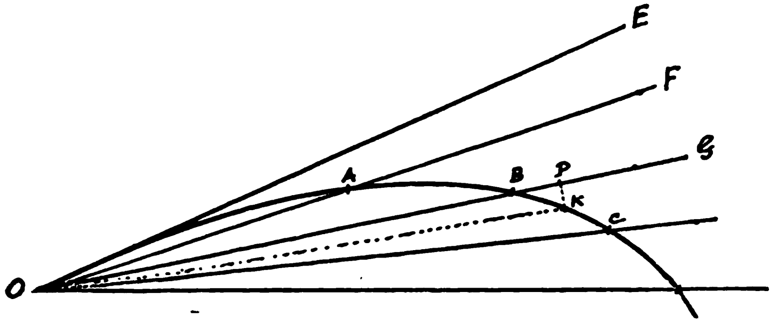
During the winter of 1862–3 four batteries, including ours, were formed into a battalion under a field-officer. At the opening of spring some of the guns were fired at a selected object,—a stump, I think. No measurements were made and no notes were taken. Moreover, the object selected was on the opposite side of a river. Nothing could be gained by laying off a base and calculating the distance, as there was no record of the elevations used nor any means of identifying different shots. Of course a sergeant (I had been promoted to that rank) did not presume to open his mouth in the presence of a major and several captains.

During the campaign of 1863 the batteries of our battalion were again distributed among detached brigades, operating in the same department but independently of each other, and for the most part widely separated. Our battery was in remarkably few sharp engagements; but on several occasions we used our guns in skirmishes and in one artillery duel of twenty-four hours' duration. We practiced a little twice, once with a detached section and once when the battery was all together. In the case of the detached section some beautiful firing was done with the steel rifle, at a stump more than a mile away on the side of a steep hill. I utilized all the shots fired. The other piece was a bronze 12-pound howitzer, recently supplied with fresh ammunition which proved almost worthless. The rounds we fired indicated that the very maximum range attainable could hardly have exceeded a mile, while the range of the five second fuse was hardly ordinary musket range. Whether any report of this fact was made I never knew; but we had to use up the ammunition. When the whole battery practiced, the captain caused men to remain in the vicinity of the targets and mark where every shot struck. I was permitted to take an active part in supervising the practice, and after the firing was over measured the distances. It was found that the ammunition of two pieces (iron 12-pounder howitzers) was composed of two kinds, the range of one kind, to put it roughly, being nearly twice that of the other.

During the winter of 1863–4 we procured a 20-pounder Parrott gun and some other new pieces. These were tried in my absence (I was detached with the horses). For the first time various distances were measured before the practice began. The results were reported to me with instructions to prepare tables of ranges from them. The target in each case had been fired at until it was considered as virtually hit, and note was taken only of that round. Of course all the other rounds might have been utilized as well. After this we never again practiced at targets. Beginning with May 9th and closing with November 22nd, our battery was engaged twenty times. On some occasions we fired only a few rounds, while in one battle we fired from ten different positions an aggregate of 804 rounds with three guns, my piece firing 363 times.

It was usually supposed by members of our company that tables of ranges were calculated by some mysterious mathematical process, known as "scientific methods." I did not have even empirical formulæ, though I sometimes interpolated by an empirical process of calculation. Usually, however, I determined the ranges and elevations by graphic methods, and calculated the time of flight, first theoretically, $t = \left(\frac{2\,r \tan a}{g}\right)^{\frac{1}{2}}$; then I modified the results after the analogy of previously determined tables, and our own actually observed shots. The uncertainty of our fuses and the absence even of stop-watches, rendered the time column in the tables inaccurate; but the approximation was sufficient to prevent gross errors at the beginning of an engagement. The ranges and elevations were obtained by drawing two lines perpendicular to each other, and marking points corresponding to ranges treated as abscissas and the elevations treated as ordinates (measured from the origin downward), and drawing a line (I can hardly call it a curve) through these points and tangent to the axis of abscissas at the origin. This line in some instances made it obvious that the data were not consistent with each other; so I sometimes tried to strike an average in the graphic process, but I did not dare to alter any observed figures in the tables prepared. This led to still more glaring inconsistencies in my tables, so that I had to *temper*, as it were, my own results before furnishing them to the respective gunners. Of course when we had used two kinds of ammunition, differing in power, I guarded against combining their results in the same table. Had I not taken this precaution, my "graphic curve" would have had some loops in it. As already intimated, I assumed that every shot utilized in forming a table of ranges had struck the centre of impact; and I departed from the data only when their incongruity was conspicuous.

The method, previously mentioned, of correcting the error of an experimental shot so as to hit the required object at the second round, is directly applicable only when the point struck is at the same distance as the point to be hit. In battle this hardly ever happens except in the case of lateral deflections, such as are due to wind, to rotation of the projectile (drift), the rotation of the earth or less obvious causes. Still it happened on several occasions that our battery was confronted by guns placed on bluffs so steep that the residual error was very slight after one correction, and sometimes our own guns were on the brow of a cliff or very steep hill; so that the direct application is sometimes practicable. But if the slope is gentle or the ground level, the method must be supplemented by other devices. When, therefore, under these circumstances a shot had been fired and the point struck had been noted, the question arose, how much the elevation of the gun must be changed. To form even a vague estimate it was necessary to know the form of the trajectory. This knowledge is also needed in the use of case-shot. As this was my favorite ammunition except when trying to dismount a gun, I gave the subject much thought and of course saw that the projectile should explode, not directly between the gun and the enemy, but on a trajectory passing through the enemy's position. It was my practice, however, to use the case-shot as shell or even solid shot until I got the range. In fact the safest plan seemed to be first to use it as solid shot, then as shell, then shorten the fuse a little (the same amount no matter what the distance). The inexperienced are sure to think that case-shot correctly used is going too high if the range is considerable. To determine, then, the form of the trajectory, I assumed its "rigidity," and



projected the curve by drawing from a point *O* a series of lines *O E*, *O F*, *O G*, etc., so that the angles between *O E* and each of the other lines were equal respectively to the angles of elevation in the table of ranges, and then marking points $A_{\prime}$, $B_{\prime}$ etc., on these lines so that *O A*, *O B*, etc., should represent the ranges corresponding to the elevations, and finally drawing a curve, tangent to *O E* at *O*, and passing through $A_{\prime}$, $B_{\prime}$ etc. In the figure the angles are made too large, so that the other dimensions may be reduced without confusing the figure. If a shot fired at

P strikes *B*, the additional elevation (of the piece) needed is, of of course, *P O K*, *P K* being an arc with its centre at *O*.

In determining graphically the table of ranges and in plotting the trajectory, I took no account of the change of the law of resistance within the "ballistic bad limits." I knew only that when the velocity of a projectile exceeds that of air rushing into vacuum or that of sound, the resistance is greatly increased. One serious difficulty presented itself; most of our tables assigned a considerable range to 0° elevation. This I found by careful measurement to be partly due in some instances to the fact that the muzzle-sight did not quite compensate for the dispart; but towards the end of the war it became clear to me that the projectile did not start on the line fixed by the axis of the gun before firing. I do not think any of my books could have said anything about "jump," for I shared the opinion which seemed to be universal, that a gun could not change its position, or at least the direction of its axis while the projectile was still in the bore. But on the 20th of May, 1863, a howitzer which I was firing in an artillery duel got to making perfectly wild shots, the errors being chiefly deflections to the right or left. Afterwards in field practice it did the same thing and was condemned. When we were removing it from the army I observed that the whole framework that supported the trunnions was loose in its joints. Afterwards another howitzer commenced making similar shots and was found to be in the same condition. I tightened the loose parts by screwing up the taps and at once the piece resumed its usual degree of accuracy. It was this that led me to the belief that the reaction from the vent, or some other influence, caused the gun when fired, to suddenly press so hard upon the trail as to bend it before the projectile left the bore. Whether the theory was correct or not the fact was obvious; but I never attempted to determine with any precision the angular value of the jump.

From all that has been said it will be seen that our practical gunnery may be formulated as follows:

1. Estimate the distances, both directly and by concisely considering the distinctness and apparent size of things, and, if necessary by observing the parallax resulting from a lateral movement.

2. Point the piece with great care directly at the object, using (as a rule) an elevation slightly less than that required by the estimated distance.

3. Fire the piece, the corporal observing the effect from the piece and carefully noting the deflection if there is any, the sergeant stepping to one side and observing.

4. Aim the gun exactly as before, and then change the breech sight so that the artificial line of sight shall pass through the point actually struck. (In field practice, record this new elevation, and the measured distance to the point struck.)

5. If this point is at about the same distance as the object to be hit, merely bring the new line of sight to bear upon the object by elevating or otherwise moving the gun ; but if the object is at a different distance, consider the form of the trajectory and the observations (3) and estimate the correction needed for the elevation. It may be advisable in this case to dispense with rule four. Also circumstances may render it wise to try to hit, or even to slightly overshoot, at the first round.

Many other little devices adopted, especially in connection with the time of flight, and the relation between the distance and certain phenomena of sound (such as the time between the firing of the gun and the return sound of the impact or explosion, or the time between the flash of a shell or a hostile gun and the report) were of little practical value for want of stop-watches. The effect of the rotation of the earth also occurred to me, and I calculated its value for different ranges, times of flight and latitudes ; but at first, committed the error of supposing it was influenced by the direction with respect to the points of the compass.

It is not easy to determine how successful we were in applying the crude methods described. In my own case it is certain that improvement resulted from the repeated attempts to apply the methods, and in some instances their direct application was in some degree successful. Others who were instructed in the methods, it may be safely stated, had their faculty of observing and interpreting phenomena more fully developed. Still it is true that some men seemed naturally to comprehend any situation, and made good gunners without any instruction that came to my knowledge. This was true of at least one in our battery who became a gunner in 1864; while on the other hand, a sergeant belonging to another battery, who acquired considerable distinction as a gunner in 1864, ascribes his greater success in that campaign entirely to instruction he heard given in our battery, although he admits he was strongly prejudiced against "theoretical gunnery," and attended the first time in a purely critical spirit. Others again seemed to be little benefited by any theoretical knowledge. They would explain methods, and go through the motions of obtaining the range and correcting errors in assumed cases; but when it came to actual firing in the face of the enemy, they would cast all that to the winds, and begin to fire with nervous haste, taking careless aim and guessing haphazard at the necessary correction, so that they were liable after one error to err the next time as much or more in the opposite direction. These men were not cut out for gunners, and it is possible that no instruction or experience could ever have made gunners of them.

Enough has been said to show that our condition was sad. In presenting our experiences, I have carefully guarded against confounding what I have learned since the war with what I knew during the war. This it has not been easy to do, as my diary kept during the war is silent as to details of this kind, confining itself rather to *what* was done than telling *how* it was done. I think, however, that nothing of any significance, except part of the nomenclature, has been infused into the treatment from subsequently acquired knowledge. The recent graphic works on ballistics I have not seen. Captain Ingalls' work would have been literally a joy to me had it existed and come into my hands during the war; but there is no need to give assurance that it has not influenced me in what I have said in this article.

To what extent our battery was typical I am not prepared to say. Some batteries were certainly in no better condition than ours. Very few were commanded by artillerists. General Johnston, while speaking of the surprising efficiency of the Confederate artillery at First Manassas, says "we had but one educated artillerist." This artillerist was educated at West Point, went out as a captain, and became brigadier general and chief of artillery in Lee's army. His original company furnished forty commissioned officers during the war. This may however, have been due to the fact that the company was made up at an important seat of learning, and was largely composed of highly educated and influential men. Though well acquainted with our chief of artillery for years after the close of the war, I have never learned anything from him about any attempts to instruct men himself or have them instructed by others; but I never asked him the direct question. I was also in almost daily intercourse with General Lee until his death, but I never heard him mention the subject. The only allusion to this subject I remember to have encountered in our war literature is interesting, and will be suitable as a close to this tedious article.

In a biography of the above named artillerist is published a letter written by him while commanding a battery. In this letter, speaking of what seems to have been the first action participated in by his battery (on this occasion only a single six pounder smooth bore being present), after mentioning the opening of the Federal fire, he says: "We however, quietly took our position and awaited the best moment for opening fire with our single gun. That moment arrived when I saw a body of horse, which seemed to be a squadron of cavalry about to charge, on the turnpike about a half-mile in front of our position. At that body I instantly had the gun directed with careful instructions how it should be aimed. In another instant the messenger of death was speeding on its way. The effect was obvious and decided. Not a man or a horse remained standing in the road nor did we see them again."

On this passage the biographer, who had exceptionally good opportunities of learning the facts, makes the following comment:

"The 'instructions' for aiming the gun on this occasion were: 'Steady, now; aim at the horses' knees.' Nor was this first lesson on the importance of firing low lost upon the men who afterwards proved themselves such efficient artillerists."

On other occasions reference is made to his directions how to aim, but what the directions were is unhappily not stated.

HADFIELD'S MANGANESE STEEL AND CHROMIUM STEEL PROJECTILES.

By Captain EDMUND L. ZALINSKI, Fifth Artillery, U. S. A.

The advances made in the manufacture of steel armor have given it a momentary supremacy over the gun. The best made so-called armor-piercing projectiles are frequently shattered as if made of glass when striking the Harveyized plates. The very high velocities now attainable are of no avail in the absence of suitable projectiles.

Unless an overwhelming energy with reference to the resisting ability of the plate is developed, perforation is out of the question. Failing to perforate, we must resort to smashing it by tremendous blows delivered from guns of very large caliber.

For either work a projectile must be provided which, whilst very hard, must have an enduring toughness.

Such have not yet been evolved. The most successful ones have been made of alloys of manganese and chromium with carbon steel.

We are indebted to the investigations of Robert Hadfield for manganese steel, and to his son R. A. Hadfield for its development, and a more definite knowledge of its properties as well as those of silicon, aluminum and chromium steels. Of these alloys, it appears that only chromium and manganese steels are of direct interest to the artillerist for the manufacture of projectiles. The most successful of the projectiles of the present are either of chromium steel or a combination of chromium and manganese. Both manganese and chromium steel contain carbon, and their characteristics are largely influenced by the percentage and character of the latter present. Manganese steel has from about seven to twenty per cent. of manganese. It has a variable effect on the characteristics of the alloy. With 1.5 per cent. manganese steel is brittle, with further increase from 4 to 6.5 per cent. it is so brittle that it may be pulverized under the hand hammer; but when the manganese rises above 7 per cent. the ductility of the water-cooled metal increases in the most striking way, till the manganese reaches 13 per cent. to 14 per cent. When the manganese exceeds this the ductility falls off abruptly, the strength remaining constant till it passes 18 per cent., when this also diminishes suddenly. It is generally free from blow-holes, has good tensile strength and astonishing ductility in combination with great hardness. The hardness is such, however, as to make it difficult to machine by ordinary methods. It yields quite readily however to the emery wheel. It is very hard to ordinary abrasion. Water cooling increases the hardness but slightly, if at all, whilst it increases ductility greatly. Annealing does not materially reduce its hardness. Whilst manganese steel cannot be made as hard as the hardest carbon steel nor as tough as the best soft carbon steel, it can be made to combine a greater hardness with a greater toughness than is obtainable with carbon steel.

A singular feature of its ductility is that, in being stretched, as in tests for elongation, it stretches nearly uniformly throughout its length (outside of the jaws of the testing machine), leaving the reduced part of nearly uniform cross-section, instead of reducing nearly tapering to the plane of fracture, as is the case with ordinary steel. It is practically unmagnetizable when it contains 13 per cent. manganese.

It has not yet been made into armor-piercing projectiles, except in combination with chromium. It possesses qualities which may make it useful in compound or built-up projectiles which will be referred to later. Its qualities should make it suitable for armor. With a higher percentage of carbon and Harveyized, or correspondingly treated, it should offer great resistance to penetration or crushing. Should it not be possible to bring its face to a sufficient degree of hardness a compound all-steel armor might be devised, the main part being of manganese steel and the face being of carbon steel of the thickness and carbon suitable for the greatest resisting hardness. The treatment which would harden the carbon steel face would only serve to toughen the manganese steel backing. The greatest objection to its use for armor is the difficulty of machining. But this may be overcome, if it is found by experiment that it possesses superior resisting qualities. An ingot of manganese steel has been sent to the United States to be rolled into an armor plate and tested for penetration. If properly treated there are reasons for expecting notable results.

The differences and similarities of the conduct of manganese and carbon steel, when suddenly cooled, are shown in the following table: *

Properties.	Effects of sudden cooling.	
	Carbon steel.	Manganese steel.
Hardness:	Enormous increase.	Slight increase.
Percentage of carbon in hardening state:	Very great increase.	Moderate increase.
Density:	Decrease.	Usually no change, but continue slight increase.
Size of grain:	Nil, or decrease.	Increase.
Separation of components:	Decrease.	Increase.
Ductility:	Enormous decrease.	Enormous increase.
Tensile strength:	Increase.	Increase.

The most remarkable feature of manganese steel is the great increase in ductility when cooled suddenly; this effect being directly opposite to that produced on carbon steel similarly treated.

CHROMIUM STEEL.

The simple addition of chromium to carbon steel serves to harden the metal whilst adding to its tensile strength. The alloy is susceptible of being tempered so as to obtain greater hardness than is possible with carbon steel, whilst retaining great tensile strength and some ductility. The alloy does not weld readily. The magnetic properties remain about the same as of carbon steel.

Tables II and V from Mr. Hadfield's paper on chromium steel present interesting comparisons between aluminum, silicon and chromium steel.

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* I am indebted to the various papers of Mr. Henry M. Howe, of Boston, Mass., for tables and information as to manganese steel. E. L. Z.

TABLE II. *Comparison Table of Tensile and Bending Tests of Forged Chromium, Silicon, and Aluminium Steels, all the Materials having been annealed.*

	Per Cent.				Limit of Elasticity in Tons per sq. inch.	Breaking Load in Tons per sq. inch.	Extension per Cent. on 2 inches.	Reduction of Area per Cent.	Bending Test of Annealed Forged Bars.	Remarks.
	C.	Si.	Al.	Cr.						
Si. steel **A** .	.14	.24	. . .	. . .	15.17	25.00	37.55	60.74	Bent double cold	
Al. steel **A** .	.15	. . .	.38	. . .	20.00	26.00	40.35	60.74	Bent double cold	
Cr. steel **B** .	.16	. . .	. . .	.29	17.00	25.00	45.55	65.90	Bent double cold	
Si. steel **B** .	.18	.73	. . .	. . .	19.00	29.50	34.02	52.66	Bent double cold	
Al. steel **C** .	.18	. . .	.66	. . .	18.00	27.00	33.00	52.14	Bent double cold	
Cr. steel **E** .	.12	. . .	. . .	.84	19.00	28.00	42.50	61.20	Bent double cold	
Si. steel **C** .	.19	1.60	. . .	. . .	25.00	33.00	35.10	54.52	Bent double cold	
Al. steel **F** .	.21	. . .	1.60	. . .	13.00	26.00	36.35	67.00	Bent double cold	
Cr. steel **G** .	.21	. . .	. . .	1.51	19.00	33.50	38.07	55.88	Bent double cold	
Si. steel **D** .	.20	2.18	. . .	. . .	25.50	34.00	36.50	59.96	Bent double cold	
Al. steel **H** .	.24	. . .	2.24	. . .	18.50	28.50	33.00	48.62	Bent double cold	
Cr. steel **H** .	.39	. . .	. . .	2.54	24.50	44.00	24.50	33.84	Bent double cold	
Si. steel **H** .	.26	5.53	. . .	. . .	25.00	25.00	0.37	2.00	Would not bend	
Al. steel **I** .	.22	. . .	5.60	. . .	27.00	36.00	6.45	6.16	16° broken	
Cr. steel **J** .	.77	. . .	. . .	5.19	20.00	55.00	8.20	6.88	Bent double cold	Carbon in chrome sample too high to make direct comparison.

TABLE V.—*Comparative Hardness of Chromium, Silicon, and Aluminium Steels (all unannealed). These tests were made by* Professor T. TURNER, *Mason College, Birmingham, with the Sclerometer.*

SILICON STEEL.					ALUMINIUM STEEL.						CHROMIUM STEEL.						Remarks.
No.	Analysis per Cent.			Relative Hardness in Turner's Scale.	No.	Analysis per Cent.				Relative Hardness in Turner's Scale.	No.	Analysis per Cent.				Relative Hardness in Turner's Scale.	
	C.	Si.	Mn			C.	Si.	Mn	Al.			C.	Si.	Mn	Cr.		
898 A	.14	.24	.14	20	**1167 A**	.15	.18	.18	.38	20	**1176 B**	.16	.07	.18	.29	22	Relative hardness of other substances:— Lead . . . . . 1 Copper . . . . 8 Softest iron . . 15 Very hard white iron. 72
898 B	.18	.79	.21	20	**1167 B**	.20	.12	.11	.61	21	**1176 E**	.12	.08	.18	.84	21	
898 C	.19	1.60	.28	24	**1167 D**	.17	.10	.18	.72	20	**1176 F**	.27	.12	.21	1.18	24	
898 D	.20	2.18	.25	24	**1167 F**	.21	.18	.18	1.60	21	**1176 H**	.39	.14	.25	2.54	24	
898 E	.20	2.67	.25	26	**1167 G**	.21	.18	.18	2.20	21	**1176 J***	.77	.50	.61	5.19	55	*This has been partially hardened by heat treatment. In Nos. 1176 J, K, and L, the carbon necessarily present explains the hardness. Judging from the behaviour of B, E, F, and H, there is no reason to doubt the possibility of obtaining a soft 5.6 or even 9 per cent. chromium steel, provided the carbon is under .50 per cent.
898 F	.21	3.46	.29	30	**1167 H**	.24	.18	.32	2.24	20	**1176 K**	.86	.31	.29	6.89	38	
898 G	.25	4.49	.36	33	**1167 I**	.22	.20	.22	5.60	22	**1176 L**	.71	.36	.25	9.18	43	
898 H	.26	5.53	.29	36													

The results obtained in some English tests of Hadfield chromium steel projectiles are given in the following extracts from the same paper:*

"In 1882, the writer's firm supplied chromium shells to the English Government, one of which, a 6-inch, successfully penetrated an 8-inch wrought iron plate, and was so little injured that it could have been fired again; also about the same time a 9.2-inch projectile, which penetrated a 16½-inch wrought iron plate and 8½ inches into a second plate placed behind. The same firm has since been successful in passing considerable numbers into the English service. A short resumé of their latest tests may be of interest. By kind permission of the War Office, the results are illustrated by photographs of the plates and projectiles used.

"Although principally makers of smaller calibers, as regards 'armor-piercers,' one of those experimental shells, 13.5 inches, weighing 1120 lbs., fired from the 63-ton breech-loading gun at a velocity of 1950 feet per second, penetrated an 18-inch compound plate, a 6-inch wrought iron plate, 20 feet of oak backing, a further 10½-inch wrought iron plate, and was then found broken beyond a 2-inch wrought iron plate—that is, a total penetration of 36½ inches of armour plating. This projectile was believed by the Ordnance Committee to pass *whole* through the 18-inch compound and 6-inch wrought iron plates. Fig. 3 shows the penetration effected.

"One of their reception lots, viz., 300 6-inch projectiles, from which two were selected by the Government Inspector, gave the following results (Figs. 4 to 8 show the results of the tests).

"Each shell was fired against a separate 9-inch compound armour plate, with a striking velocity of 1825 feet per second, and a striking energy of 2250 tons. The faces of these plates contained 1.25 per cent. of carbon, so that the tests were severe.

"No. 1 projectile (round 2553, Figs. 4, 5, and 8) penetrated the plate to the eighth layer of oak backing. It was whole, showed no cracks, and very slightly altered in shape.

Diameter of body before firing, 5.963 inches; after firing, 5.974 inches = + .011 inches.
Length before firing. 16.68 inches; after firing, 16.47 inches . . = —.210 inches.

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* "Alloys of iron and chromium." by R. A. Hadfield: *Journal of the Iron and Steel Institute*, No, II for 1892.

"No. 2 projectile (round 2554, Figs. 6, 7, and 8) gave the same penetration, was also whole, showed no cracks, and altered in diameter of body .013 inches, and shortened .210 inches.

"Thus the above shells were only altered one-hundredth of an inch in diameter, and a little over two-tenths in length. (Figs. 4 to 8).

"The following results are, however, probably still more remarkable. A Hadfield 6-inch projectile was fired through a 9-inch compound plate. Being uninjured, it was ground up, fired a second time, and again penetrated another 9-inch compound plate. It was ground up and fired a third time at a 9-inch plate, when it broke up. It is, however, only fair to the projectile to state that the third plate was an experimental one, in which the face had been hardened by special tempering methods. Probably the projectile would still have been whole if fired at an ordinary compound plate. This projectile, after being fired twice, is shown in Fig. 9.

"Another remarkable result is that of a 6-inch bursting shell made by the same makers. This shell was the usual service weight, 100 lbs., but had a core of about double the capacity of an ordinary armor-piercing projectile (the latter are usually termed "shot"), and consequently its walls were of much thinner section and of less strength. This was fired at a 6-inch compound plate, which it penetrated, and was found uninjured 2000 yards (or nearly a mile and a quarter) on the other side. Beyond a slight chip off the point, the shell was unaltered in form, free from cracks, and could have been fired again. This shell is indicated by Fig. 10. The broken shell (Fig. 10^a) subjected to the same test was by another maker. The result with the latter shows that a steel shell, if not properly prepared, is little better than a cast iron projectile.

"An exceptionally severe set of trials is that shown in Figs. 11 to 13. The projectiles were selected at random from ordinary service supplies. The ordinary reception trial is to fire a 6-inch projectile against a 9-inch compound plate, but in this trial the compound plate was 10½ inches thick. As will be seen, notwithstanding the severe test, the four projectiles were practically uninjured, having neither set up nor broken. If the armour had been attached to the side of an ironclad, a few feet highe velocity would have resulted in a complete penetration into th interior of the ship. In other words, at short ranges, with th comparatively light 6-inch breech-loading gun, giving a velocit of say 2000 feet per second, all, excepting the largest moder ironclads, are easily vulnerable at point-blank range. (Figs. 11 to 13).

"In recent American trials it is reported that French-made projectiles, of 6 inches diameter, fired against 10½-inch nickel steel plates penetrated from 9.70 inches to 26 inches, the average penetration being 15 inches. In the case of the Hadfield projectile, fired against a 10½-inch compound plate, the penetrations averaged 26½ inches. It must be remembered that in the American trials, while the nickel steel plates offered greater resistance, the velocity and striking energy, 2075 feet and 2989 foot-tons, respectively, were much higher than those used in the English tests, viz., 1830 feet and 2200 foot-tons. Therefore, whilst the results cannot very well be compared, it will be seen that the English projectiles, with a lower velocity and striking energy gave excellent results. Probably with the same striking energy as at the Annapolis tests they would have penetrated uninjured a 12-inch compound plate."

Mr. Hadfield states that the chromium steel shell contains from 1¼ to 2 per cent. of chromium. The proportion of carbon is not mentioned, nor is it stated whether other elements such as manganese may not be used.

The Hadfield processes have been adopted by the Taylor Iron and Steel Company of Highbridge, New Jersey. They are now manufacturing shell according to Hadfield methods for the United States Navy. The results obtained by the Hadfield projectiles are therefore of direct interest to us. Whether they will succeed in producing armor-piercing shell able to cope with Harveyized plates remains to be seen. But so much has been accomplished by skillful combinations and treatment that there are fair promises of favorable results.

An analysis of the Holtzer projectile gave the following results:

	Point of projectile.	Body of projectile.
Silicon	0.822 per cent.	0.419 per cent.
Phosphorus	0.011 per cent.	0.044 per cent.
Manganese	0.306 per cent.	
Chromium	1.69 per cent.	2.28 per cent.
Copper	0.121 per cent.	trace.
Carbon	1.32 per cent.	1.26 per cent.

The analysis of the material of a projectile, however, conveys but little as to the mode of casting or the after treatment. The best combination of materials, etc., can only be arrived at by long continued patient investigation and usually many disappointments. A portion of the ingredients put into the melting pot become oxidized or otherwise transformed and disappear in the slag and do not appear in the resulting alloy. Such disappearance seems to be unavoidable and experience alone can indicate the proportions required to produce any desired alloy. The investigator cannot always trust to reasoning by analogy in shaping the direction of his experiments. He meets with apparently anomalous results at every step. Success may be found within very narrow limits, on either side of which appear utter failures. A very slight change of composition or of treatment produce markedly different results.

It now appears as if the metallurgist has done his utmost in the production of a simple bolt to perforate armor and, for the moment, has been foiled. It is obvious that the maximum hardness is requisite, but with it there must be sufficient toughness to hold the mass of the projectile together until it has expended its energy on the plate. As it is now, the sharp point used brings a concentration of the shock on a small portion of the projectile; it is broken off and a beginning is made of rupture of the shell, inviting further disintegration. The energy of the projectile is largely expended in its own destruction. Experiments are required to determine that form of head best suited to overcome the hardened resistance of the Harveyized plate, it being assumed that the projectile is of as hard and *tough* material as is attainable and it is propelled with the maximum velocity. Increase in sectional density may aid in the punching effect desired, if a sufficiently stiff metal may be found to resist the tendency to upset. The point may be made considerably blunter without increasing materially the resistance of the air. But should it be found necessary to give the front of the projectile a shape which largely adds to the resistance of the air, it may be desirable to add a point of soft metal or of a thin shell, easily crushed and not affecting the power of impact of the bolt.

Should we fail in producing a sufficiently hard and tough simple bolt of one piece of metal, it would then be advisable to try a built-up projectile of a striking core of very hard material with a jacket shrunk on having great tensile strength. The artillerist cannot afford to accept his defeat as final.

SHRAPNEL FOR FIELD ARTILLERY.

PAR LE COLONEL LANGLOIS, *Professeur à l'Ecole Supérieure de Guerre.*

TRANSLATED AND COMPILED BY LIEUTENANT WILLIAM W. GIBSON, ORDNANCE DEPARTMENT, U. S. A., FROM *L'Artillerie de Campagne en liason avec les autres Armes* (Paris, 1892).

In the Franco-Prussian war of 1870, the shrapnel could not be considered a practicable projectile. The initial velocities of the French and German rifled guns of that period were very feeble, were lost rapidly and the effective ranges were short—1300 meters at most in the French artillery.

Time fuzes were still irregular in their action, not suitably graduated* and the troops were not properly instructed in using them. In 1870 the shrapnel question was not yet mature. After this war improvements in field artillery resulted in securing high velocities, and the question of time fuzes was also satisfactorily settled. It was then recognized that shrapnel was the future projectile for field artillery.

A single difficulty arose, that of obtaining sufficient resistance to support the shock of discharge in the modern field gun, in which the initial velocities are considerable. In regard to this two elements are to be considered, the balls, and the case. At the shock of discharge the balls are violently crowded back toward the rear of the projectile, and tend to crush each other. They ought then to possess great hardness. Pure lead which resisted feeble velocities will no longer answer as the material for the balls. Lead hardened by adding a little antimony has been substituted, but this results in a serious disadvantage, loss of density (10.65 in place of 11.35), which, however, is unavoidable.

As regards the shrapnel case, two distinct efforts are to be

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* The fuzes for French shrapnel, in 1870, were capable of but two settings, one for 1450 meters and the other for 2850 meters.

resisted. 1st, the push of the powder gases at the moment of firing, an effort directed from rear to front longitudinally, and 2nd, the outward thrust of the balls.

This last effort is developed on the one hand because of the crowding of the mass of bullets toward the rear end of the case, and on the other on account of the centrifugal force due to the motion of rotation. The outward push is especially great a short distance in front of the band, and tends to swell the projectile at this point, or to break it. The resistance to expansion seems more difficult to obtain than the longitudinal resistance.[*]

It is thus seen that the efforts to be supported by the shrapnel increase with the initial velocity, and with the velocity of rotation. These conditions tended to increase the thickness of the walls of the shrapnel, and consequently to decrease the interior capacity, and the number of balls in the case. But the fragments furnished by the rupture of the case in firing have very little effect compared to that of the balls. The weight of the case then can be considered as a dead weight, serving merely as a vehicle to transport the *useful weight*, which is that of the "mitraille" (balls simply, or balls and separator plates provided with lines of rupture to give useful fragments).

One of the problems to be solved was the reduction in weight and thickness of wall of case, to increase as far as possible the *interior capacity*. This result was secured by the adoption of steel cases, one of the most important improvements in the organization of shrapnel. The enlarged capacity and consequent increase in the number of balls at the expense of the case has the effect of increasing the density of the projectile, an important advantage.

The necessary solidity is obtained by giving sufficient thickness to the steel case.[†] In the United States electrically welded

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[*] The United States specifications for shrapnel provide for rejection of all shrapnel after proof firing which bear such traces of the rifling as to indicate a deformation or upsetting of the shrapnel due to the above causes.—[TRANSLATOR.]

[†] The solidity of shrapnel is not fully assured by this method, and special arrangements are made in different types of shrapnel to stiffen the case, as in the electrically welded shrapnel for the United States 3.2-inch rifle and also in the Hotchkiss shrapnel. In the former, the cast iron powder tube connecting head with base powder chamber and resting against the diaphragm covering powder chamber, serves as a back-bone, by making the diaphragm, which is of wrought steel, carry weight of head and fuze. The diaphragm is supported by a cast iron tripod in powder chamber. In the Hotchkiss and also F. A. shrapnel the separators contribute to the resistance of the shrapnel.—[TRANSLATOR.]

shrapnel for the 3.2-inch B. L. steel rifle, a thickness of wall of .2125 inch has been found ample, except at the base, where it is .352 inch in thickness in the vicinity of the powder chamber and rotating band.

In France, studies have been directed toward assuring the shrapnel great resistance against breaking up before bursting, on striking hard rocky ground. For this purpose it is sought to make the "mitraille" itself contribute to the resistance of the projectile. It is formed of cast iron separator plates and balls. These plates are superposed and are intended to assure the projectile a resistance almost equal to that of a solid projectile.* Lines of weakness in the plates assist in their fragmentation, in unequal pieces it is true, but varying the least possible from the spherical form.

Recesses in the plates afford seats for the hardened lead balls. The plates, which are in contact, fit the balls quite accurately, and protect them from deformation so that they exercise no lateral push on the walls of the case.

We thus have two types of shrapnel, one type in which the "mitraille" is composed exclusively of hardened lead balls, and the French type in which the "mitraille" is composed of cast iron separator plates and hardened lead balls.

NATURE, FORM AND WEIGHT OF SHRAPNEL BALLS.†

Destructive Zones.

Shrapnel balls should be made of the densest metal possible. The maximum effect then results for the following reasons:

First.—The greatest possible density of the projectile best preserves its velocity to point of burst.

Second.—The densest balls best preserve their velocity after bursting.

Third.—The denser a ball, the more its weight can be reduced while preserving its destructive qualities, consequently a greater number of balls can be accommodated in a shrapnel of determined weight.

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* Considerable resistance against breaking up on striking can be obtained without using separator plates and reducing consequently the number of balls, as in 3.2-inch electrically welded shrapnel.—[TRANSLATOR.]

† See Table I.

For these reasons the first shrapnel balls were made of pure lead, but the velocities of the present guns require the use of a harder material to resist the shock of discharge. Lead hardened by the addition of antimony is employed at the present time. The spherical form is preferable to any other on account of the less resistance it offers to the air. The nature and form of the balls being determined, it remains to fix the weight of each ball.

This consideration ought to guide, in fixing the weight: the ball must be destructive in its action over all its trajectory from the point of bursting to its point of striking the ground, that is to say, its weight should be such that the extent of the destructive zone would be equal to the depth of the cone of dispersion up to the effective battle ranges (3000 meters at least).

It is important then to know the extent of the destructive zone for each projectile according to the velocity with which it is actuated at the moment of bursting. This would be simple if we knew what velocity is essential for balls of a given weight in order that they shall produce sufficiently destructive effects. Here the question arises as to what can be called a sufficiently destructive effect. What would be sufficient against men probably would not be so against horses.

Upon this point there is a great difference of ideas, and this lack of precision accounts for the different solutions of the problem of the weight of ball. Thus in France the weight of ball is 15 grammes, in Germany 13, in Russia 10.7, though the remaining velocities of the projectiles at the same ranges differ little in these artillery systems.

From experiments made by firing spherical balls from hunting guns at animals of different weights, it has been demonstrated that the living force necessary for the balls to pierce the skin and penetrate the flesh some little distance, what we would consider a wound sufficient to disable a man or horse, is proportional to the weight of the animal and to the section of the projectile.

Starting from this basis it is easy to determine what velocity a ball of given weight and density should possess, to give it the necessary living force, and consequently a sufficiently destructive power. The extent of the destructive zone of the ball for a determined remaining velocity of projectile is easily deduced. It is the space traveled by the ball in passing from the remaining velocity at the point of bursting, to the minimum velocity sufficient to produce destructive effect.

The following table shows extent of the destructive zones for balls of different weights:

TABLE I.

	Remaining Velocity of the Balls.	Extent of the Destructive Zones for Balls of Hardened Lead weighing,—		
	Meters.	11 gr.	13 gr.	15 gr.
		Meters.	Meters.	Meters.
(a) Wound sufficient to disable a man.	500	591	643	680
	400	559	605	642
	300	499	548	579
	250	456	500	531
	200	384	422	451
	150	271	302	326
Remaining velocity necessary . .		81	79	77
(b) Wound sufficient to disable a horse.	500	257	299	308
	400	222	252	270
	300	165	191	207
	250	123	146	160
	200	51	69	80
Remaining velocity necessary . .		175	169	166

It would not do, we think, to rely upon the figures of the first part of the table in the determination of the weight of balls necessary in firing against men. A just estimate of the destructive zone ought to be comprised between (a) and (b), approaching the figures given in the latter. At the present time at the range of 3000 metres the remaining velocity of the field projectile is about 250 meters.

With time fuzes some balls are thrown a distance of 200 meters at least from the point of bursting. It seems proper then that the weight of balls should be such as to insure a destructive zone of at least 200 meters for the remaining velocity of 250 meters, consequently a weight of ball equal to 15 grammes does not appear excessive, a ball of this weight not always having great effect against horses.

The German and Russian balls, 13 grammes and 10.7 grammes, appear insufficient in weight, though it is compensated for to a certain extent by the increase in velocity due to the rear position of bursting charge.

For the same remaining velocity of projectile the difference between the velocity of the French shrapnel balls and foreign can be evaluated at the maximum as 25 meters for German shrapnel, and 40 meters for the Russian shrapnel.

Table I (b) will show us if this compensation is sufficient.

Take the point where the destructive zone of the French balls is about 200 meters. (Remaining velocity of balls 300, zone 207 meters.) To have the same destructive zone the German ball should have a velocity of 325 meters (difference +25) and the Russian ball a velocity of 365 meters (difference +65). For the same remaining velocity of projectile, the Russian ball has an inferior zone to the French, the German an equal zone; but as for the same range the remaining velocity of the French projectile is superior, the French have an advantage which is not negligible particularly in the artillery struggle where the disabling of horses is of great importance.

An examination of the table shows how rapidly the destructive zone diminishes with the remaining velocity. The artillery ought to be impressed with this idea in order not to attempt firing at too great ranges whatever be the results of firing on the practice ground against targets.

POSITION OF THE BURSTING CHARGE.*

The bursting charge may be at the center of the projectile, at the front, or at the rear. Nearly all artillery systems except the French have adopted the rear position for the charge.

Central Bursting Charge.

This has the advantage of economizing space, but it increases the dispersion of the balls and diminishes the useful effect of the shrapnel.

Rear Charge.

This position possesses a great advantage. At the moment of bursting, the gaseous products act somewhat as in a cannon, to

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* See Table II.

which the case would correspond, and of which the "mitraille" would be the projectile. The velocity and murderous force of the balls is thus increased. Now if the charge is large, the density of the projectile is reduced and the dead weight* increases. The loss of density prevents the velocity of the projectile from being so well maintained, so that at a certain range the advantage of the rear charge may disappear entirely.

The increase of dead weight is accompanied by a reduction in the number of balls, and by a decrease of interior efficiency and effect.

This fact is rendered apparent by a comparison of the "interior efficiency" of the German and Russian shrapnel, Table II, which differ essentially only in the weight of the interior charge. Due to the rear position of the charge, the increase of the velocity of the balls in the Russian type would be about 25 meters; it must be quite feeble in the German shrapnel.

The rear charge renders the organization of the projectile more difficult in necessitating a long communicating tube between the fuze in front and powder chamber in rear, which takes up considerable space and increases the dead weight with a corresponding reduction in the weight of the "mitraille."

Front Charge.

This position facilitates the organization of the projectile and economizes space. It diminishes the chances of failure to burst, as it brings fuze and bursting charge closely together, and tends to insure greater regularity in points of bursting.

It has the disadvantage of diminishing the velocity of the bullets at the moment of bursting by a value which is not negligible, and may amount to as much as 15 meters.

WEIGHT AND NATURE OF BURSTING CHARGE.

This has been greatly varied by different authorities,† from the inferior limit necessary to insure the explosion of the shrapnel up to the superior limit compatible with its organization,

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* Weight of case, etc., in contra-distinction to useful weight "mitraille."

† See Table II.

that is, the maximum amount of powder, compressed or otherwise, that it will receive.

A feeble bursting charge is particularly necessary in shrapnel with front charge to avoid reduction in velocity of the balls at the moment of bursting. But if the charge is too much reduced the regulation of percussion fire becomes impossible, because the point of fall becomes invisible. Time fuze fire also becomes difficult to observe. We need to employ then a powder producing considerable smoke. Sometimes a very dense body furnishing a great deal of smoke by its combustion is added to the bursting charge.

INTERIOR EFFICIENCY OF SHRAPNEL (OR *RENDEMENT*).

The principal factors in the effect of a shrapnel against animate objects are, the number of fragments, their size, density, and velocity.

Considered from the stand-point of the organization of the shrapnel exclusively, we will compare the *rendement* or interior efficiency of different types of shrapnel.

The values of the "interior efficiency" do not give exact terms of comparison when the "mitraille" is composed of elements of different nature. The fragments of the separator plates, due to their irregular shapes, rapidly lose their velocity and are much less effective than the balls.

[The numbers of fragments of the 3.2-inch Hotchkiss and Frankford Arsenal shrapnel given in table are such as have been obtained in actual firing and are subject to variations. They are greater than was anticipated in the designs of these shrapnel. The numbers given for the French shrapnel are probably those for which the shrapnel were designed, and would be much less generally than obtained in actual firing.—TRANSLATOR.]

TABLE II.

Projectiles.	**Weight of shrapnel.**	**Weight of bursting charge.**	**Position of bursting charge.**	**Number of balls and fragments.**	**Weight of each ball and fragment.**	**Total weight of "mitraille."**	**Interior efficiency.**
	P	p		n	w	$W = nw$	$\frac{W}{P}$
	grm.	grm.			grm.	grm.	
French, 80 mm.	6300	90	Front.	balls 120 frags. 42	15 26	2890	0.459
French, 90 mm.	8700	100	Front.	balls 160 frags. 77	15 28	4550	0.523
German, 78 mm.	5530	19	Rear.	160	13	2080	0.376
German, 88 mm.	8150	22	Rear.	260	13	3380	0.415
Russian, light, 87 mm.	6860	60	Rear.	165	11	1760	0.259
Russian, H'vy, 100 mm.	12500	110	Rear.	340	11	3630	0.291
Italian, 70 mm.	4470	50	Rear.	109	13	1417	0.317
Italian, 90 mm.	6960	80	Rear.	176	13	2288	0.328
U. S. 3.2-in.: Elec. weld*	6122	67	Rear.	170	13.3	2261	0.370
Hotchkiss*	6122	85	Front.	balls 162 frags. 82±	11.4 variable	2990	0.488
F. Arsenal*	6122	78	Front.	balls 162 frags. 104±	11.1 variable	2699	0.440

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* By translator.

THE ARTILLERY-FIRE GAME.

BY H. ROHNE, COLONEL, COMMANDING THE SCHLESWIG FIELD ARTILLERY
REGIMENT NO. 9.

TRANSLATED BY FIRST LIEUTENANT JOHN P. WISSER, FIRST ARTILLERY,
U. S. A., 1892.

[CONCLUDED.]

IV. APPLICATION OF THE GAME IN TESTING PARTICULAR FIRING REGULATIONS.

The fire-game can, however, also be used for testing firing regulations. Although it is an accepted fact that firing regulations cannot be based on theoretical considerations alone, irrespective of the results of practical experience, yet, on the other hand, mere experience alone is not in itself sufficient, since it cannot point out possible causes of failure in the firing regulations themselves. We shall illustrate the application of the game in such a case.

I. OPENING SHRAPNEL-FIRE AT THE SHORT-FORK RANGE.

Our firing regulations have become in the course of time more and more simple; mainly in that the smaller corrections—in case of percussion shell of 25 m., in case of shrapnel of 50 m.—have become less and less important and necessary, and the opening of shrapnel fire at the short-fork range has become the rule. It may, however, be questioned whether in the endeavor to open the shrapnel fire early we have not gone a little too far. The object is not to fire the first shrapnel early, but simply and solely to have an *effective* shrapnel fire established as quickly as possible. A single fork shot, falsely observed or directed, may have as its consequence that all the shrapnel burst behind the target or else far in front of it, and may thereby endanger the existence of the battery in the highest degree, unless such an error can be quickly detected and rendered without effect.

It is a matter of some interest to determine how often such a false establishment of the fork is liable to occur. We will consider here only firings in which the cause of the error is false observation.

Errors due to inaccurate pointing may be regarded as practically excluded, on account of the present careful training of our gunners. The cases in which they cause a firing to fail can be shown to be exceedingly rare. False elevations—and these alone can come under consideration, since simple inaccurate pointing is never of very great effect—are only possible when the chiefs of piece and of section, as well as the gunner are in error. A battery, in which such grave violations of firing discipline and instruction are possible, is beyond hope anyway and has deserved its fate. But with false observations it is quite different. By continual practice they may be reduced in number; but no one has as yet succeeded in avoiding them entirely. In my work "The firing of Field Artillery,"* I have stated (page 27) that in a course of firing at the firing school, out of one hundred observations, *referring only to shots used in establishing the fork*, sixty-two were correct, thirty-one doubtful and seven false. I do not know whether such investigations have been carried on elsewhere or not, but, judging from my experience, no *very* different result will probably be obtained in the near future. For, even if on the one hand the art of observation should make further progress, the use of the ground on the other hand will receive greater and greater attention, and thus make observation more and more difficult.

If we assume, therefore (a slightly more favorable case), that for every sixty-three correct observations there are seven false ones, it is the same as saying that in every ten observed fork shots one will be observed falsely. For the establishment of a short fork at least four observed shots are required, for that of a long fork two. From which it follows that as an average, two-fifths of all short forks and one-fifth of all long forks are incorrectly determined.†

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* "Das Schiessen der Feld-Artillerie."

† The latter assertion is not entirely free from criticism. Indeed it is probable that the number of incorrectly established *long* forks is smaller. If the above mentioned investigations had been limited to shots used in establishing long forks, the result would probably have been much more favorable.

In case the short fork only is incorrectly established, the error is not very great; but in case one of the two shots limiting the long fork is falsely observed, there is no knowing at all how great the error may be. When it happens that the long fork has been incorrectly established, we will always have,—supposing that a second shot was observed falsely, which according to the probabilities, will happen twice in a hundred times,—after the fork has been narrowed down to 50 m., at least one shot in front of the target and three behind, or the reverse. For this reason, it is well in all such cases to proceed with care and caution, not to say doubt and distrust as to the reliability of the data; and it would be advisable, as previously recommended, to obtain in any way possible satisfactory evidence that the fork has been correctly established, before proceeding to shrapnel fire. This may be done in a great variety of ways. Which method should be adopted in any given case may perhaps be determined by means of the fire game; at any rate, the latter can furnish a perfectly clear picture of the progress of events under each method.

The following four methods proposed will probably comprise all that are liable to be used:

1. To endeavor, after establishing the short fork, to obtain more accurate information in regard to the real target distance by continuing the firing with percussion shell.

2. To check (or verify) that shot of the long fork, the correctness of the observation of which is rendered doubtful by the fact that it was observed as deviating largely from the other three that were used in establishing the short fork.

3. To check (or verify) both the shots forming the short fork in the manner explained in the pamphlet "*Was bringen die neuen Schiessregeln der Feld-Artillerie?*" (Berlin, E. S. Mittler & Sohn, 1889.)

4. To *always* check the long fork before proceeding to narrow it down.

If in cases 2, 3 and 4 it appears that the fork was incorrectly established, it must be re-determined.

The method of checking (or verification) consists in every case in firing another shot at that particular range. If this is observed to be like the first one it is considered correct. But if it turns out different two more shots are fired. According to the character of the observation of these last two shots, either the first or the second is regarded as the correct one. Should the observation of the last two shots give them positions on opposite sides of the target, so that on the whole two shots have been observed in front of the target and two beyond, the range may be taken as the true target distance.

Let us compare, by means of the fire game, these four proposed methods with the method prescribed by the firing regulations.

For this purpose the following assumptions are made:

Target distance, *first*, 1870, *second*, 2330 m.

In the first case the short fork shot, in the second the long fork is assumed to be falsely observed. All other observations are assumed to have been made correctly, because otherwise too great an influence would be allowed to mere chance, moreover, with continual false observation *no* rule or method can lead to any practical result.

In order to have in shrapnel fire as many shots capable of observation as possible, it will be assumed that the fuses burn too long by 20 m. The mean point of bursting will then be lowered about 2 m., and there will not be too many ground hits. In this way about the same result is obtained, as if it had been assumed that points of bursting up to 5 m. in height could be observed with the same degree of certainty as percussion shell bursting on striking, an assumption, it must be acknowledged, certainly more than favorable for shrapnel, so that the method of the firing regulations will appear in the most advantageous light.

For determining the positions of the ground hits and the points of bursting, one and the same record of drawing of lottery numbers is used for all cases; and in order not to have the effect of the element of chance too great, small deviations (column A, Appendix 1) are assumed.

A.—*Record of drawing for percussion shell.*

Current number. 1.	Lottery number. 2.	Deviation m. 3.	Target distance (1870 m.) minus deviation. m. 4.	Target distance (2330 m.) minus deviation. m. 5.	Current number. 1.	Lottery number. 2.	Deviation. m. 3.	Target distance (1870 m.) minus deviation. m. 4.	Target distance (2330 m.) minus deviation. m. 5.
1	78	+15	1855	2315	10	68	+10	1860	2320
2	42	− 5	1875	2335	11	14	−25	1895	2355
3	6	−35	1905	2365	12	86	+25	1845	2305
4	36	−10	1880	2340	13	7	−35	1905	2365
5	67	+10	1860	2320	14	20	−20	1890	2350
6	44	− 5	1875	2335	15	79	+20	1850	2310
7	17	−20	1890	2350	16	25	−15	1885	2345
8	76	+15	1855	2315	17	3	−45	1915	2375
9	24	−15	1885	2345	18	57	+ 5	1865	2325

B.—*Record of drawing for shrapnel.*

Current number. 1.	Lottery number. 2.	Deviation. m. 3.	Current number. 1.	Lottery number. 2.	Deviation. m. 3.	Current number. 1.	Lottery number. 2.	Deviation. m. 3.
1	79	$\frac{+20}{-2}$	7	37	$\frac{-10}{\pm 0}$	13	98	$\frac{+50}{-6}$
2	53	$\frac{\pm 0}{-1}$	8	67	$\frac{+10}{-2}$	14	16	$\frac{-25}{+4}$
3	58	$\frac{+5}{\pm 0}$	9	63	$\frac{+10}{+1}$	15	22	$\frac{-20}{+2}$
4	3	$\frac{-50}{+6}$	10	25	$\frac{-15}{+4}$	16	53	$\frac{\pm 0}{-1}$
5	14	$\frac{-30}{+1}$	11	85	$\frac{+25}{-4}$	17	59	$\frac{+5}{-1}$
6	35	$\frac{-10}{+1}$	12	42	$\frac{-5}{+1}$	18	14	$\frac{-30}{+1}$

Position of the mean point of bursting for the target distance

1870 m. 2330 m.

with elevation and fuse setting 2000, at $\frac{+100}{+3}$; 2300, at $\frac{-60}{+4}$.

1900, at $\frac{\pm 0}{+3}$; 2250, at $\frac{-110}{+4}$.

1850, at $\frac{-50}{+3}$; 2150, at $\frac{-210}{+4}$.

Of the following five extracts of firing records the first four relate to the previously mentioned four proposed methods of procedure, while the fifth is in conformity to the firing regulations. The shot, just before which the order is given to pass to shrapnel fire, increasing gradually by steps (50 or 100 m. at a time) is marked with an asterisk (*); at this instant it is assumed that there are four guns still loaded with percussion shell.

In case of the firing records 1 to 4, the battery commander may be blamed for not finding more accurately the distances of the points of bursting in front of the target, in as much as all the percussion shell fired at 2300 m. were observed to strike in front of the target. On the other hand, it is to be remarked that in actual firing—and that alone is here considered—the action of the shrapnel, whether effective or ineffective, would very soon be apparent. Moreover, in case of a larger deviation, one or more percussion shell would very likely have fallen beyond the target.

If we compare these five firing records for both target distances, we shall see that the method prescribed by the firing regulations, *i. e.*, the passage to shrapnel fire immediately after the establishment of the short fork, does, indeed, allow the opening of shrapnel fire the earliest, but, on the other hand, the first *effective* shot is in this case delayed the longest. The first shrapnel shot by this method precedes that by the other methods by 9, 6, 7 and 5 shots respectively, in case the short fork shot was falsely observed; and by 8, 6, 7, 4 shots respectively, in case this happened with the long fork shot. On the other hand, the first *effective* shrapnel is behind hand by 3, 6, 5, 7 shots respectively, in case the short fork shot has been falsely observed; and as much as 11, 13, 12, 15 shots respectively, in case the long fork shot has been observed falsely.

The best method according to this, seems to be number four, *i. e.*, checking (or verifying) the limits of the long fork before proceeding to narrow it down; next stands method number two —checking (or verifying) that particular long fork shot, the observation of which gave rise to doubt as to its actual position, followed by the checking of the short fork; while method one— continuation of the firing with percussion shell according to the

A.—*Target Distance 1870 m.*

Current number.	1.			2.			3.			4.			5.		
	Range ordered. m.	Observation. batt'y	Observation. target.	Range ordered. m.	Observation. batt'y	Observation. target.	Range ordered. m.	Observation. batt'y	Observation. target.	Range ordered. m.	Observation. batt'y	Observation. target.	Range ordered. m.	Observation. batt'y	Observation. target.
1	2000	−	+ 145	2000	−	+ 145	2000	−	+ 145	2000	−	+ 145	2000	−	+ 145
2	2200	+	+ 325	2200	+	+ 325	2200	+	+ 325	2200	+	+ 325	2200	+	+ 325
3	2100	+	+ 195	2100	+	+ 195	2100	+	+ 195	2200	+	+ 295	2100	+	+ 195
4	2050	+	+ 170	2050	+	+ 170	2050	+	+ 170	2000	+	+ 120	2050	+	+ 170
5	2000	+	+ 140	2000	+	+ 140	2050	+	+ 190	2000	+	+ 140	2000*)	+	+ 140
6	2000	+	+ 125	2000	+	+ 125	2000	+	+ 125	2000	+	+ 125	"	+	+ 125
7	2000	+	+ 110	2000	+	+ 110	2000	+	+ 110	1800	−	−90	"	+	+ 110
8	1950	+	+95	1800	−	−55	2000	+	+ 145	1900	+	+45	"	+	+ 145
9	1950	+	+65	1900	+	+15	1800	−	−85	1850	−	−35	"	+ 1	+120 1
10	1950	+	+90	1850	−	−10	1900	+	+40	"*)	−	−10	"	+ 2	+100 2
11	1800	−	−95	"*)	−	−45	1850	−	−45	"	−	−45	"	+ 3	+105 3
12	1900	+	+55	"	+	+ 5	"*)	+	+ 5	"	+	+ 5	"	? 9	+50 9
13	1850	−	−55	"	−	−55	"	−	−55	"	−	−55	"	? 4	+70 4
14	1850*)	−	−40	"	−	−40	"	−	−40	"	− 1	−30 1	"	? 4	+90 4
15	1850	+	± 0	"	− 1	−30 1	"	+	± 0	"	− 2	−50 2	1900	− 3	−10 3

16	1850	—	—35	1850	— 2	—50 2	1850	— 1	—30 1	1850	— 3	—45 3	1900	+ 1	+10 1
17	"	—	—65	"	— 3	—45 3	"	— 2	—50 2	"	? 9	—100 9	"	? 4	+10 4
18	"	— 1	—30 1	"	? 9	—100 9	"	— 3	—45 3	"	? 4	—80 4	"	? 7	—15 7
19	"	— 2	—50 2	"	? 4	—80 4	"	? 9	—100 9	"	— 4	—60 4	"	+ 0	+25 —1
20	"	— 3	—45 3	"	— 4	—60 4	"	? 4	—80 4	"	— 3	—60 3	"	? 4	—5 4
21	"	? 9	—100 9	"	— 3	—60 3	"	— 4	—60 4	"	— 1	—40 1	1850	— 0	±0 —3
22	"	? 4	—80 4	"	— 1	—40 1	"	— 3	—60 3	"	? 7	—40 4	"	? 7	—75 7
23	"	— 4	—60 4	"	? 7	—40 4	"	— 1	—40 1	"	— 7	—65 7	"	? 5	—70 5
24	"	— 3	—60 3	"	— 7	—65 7	"	? 7	—40 4	"	— 0	—25 —1	"	— 2	—50 2
25	"	— 1	—40 1	"	— 0	—25 —1	"	— 7	—65 —7	"	— 4	—55 4	"	— 2	—45 2
26	"	? 7	—40 4	"	— 4	—55 4	"	— 0	—25 —1	"	— 0	±0 —3	"	? 4	—80 4
27	"	— 7	—65 7	"	— 0	±0 —3	"	— 4	—55 4	"	? 7	—75 7			
28	"	— 0	—25 —1	"	? 7	—75 7	"	— 0	±0 —3	"	? 5	—70 5			
29	"	— 4	—55 4	"	? 5	—70 5	"	? 7	—75 7	"	— 2	—50 2			
30	"	— 0	±0 —3	"	— 2	—50 2	"	? 5	—70 5	"	— 2	—45 2			
31	"	? 7	—75 7	"	— 2	—45 2	"	— 2	—50 2	"	? 4	—80 4			
32	"	? 5	—70 5	"	? 4	—80 4	"	— 2	—45 2						
33	"	— 2	—50 2				"	? 4	—80 4						
34	"	— 2	—45 2												
35	"	? 4	—80 4												

B.—*Target distance 2330 m.*

Current number.	1.			2.			3.			4.			5.		
	Range ordered. m.	Observation.		Range ordered. m.	Observation.		Range ordered. m.	Observation.		Range ordered, m.	Observation.		Range ordered. m.	Observation.	
		batt'y	target.		batt'y	target.		batt'y	target.		batt'y	target.		batt'y	target.
1	2000	—	— 315	2000	—	— 315	2000	—	— 315	2000	—	— 315	2000	—	— 315
2	2200	+	— 135	2200	+	— 135	2200	+	— 135	2200	+	— 135	2200	+	— 135
3	2100	—	— 265	2100	—	— 265	2100	—	— 265	"	—	— 165	2100	—	— 265
4	2150	—	— 190	2150	—	— 190	2150	—	— 190	"	—	— 140	2150	—	— 190
5	"	—	— 170	2200	—	— 120	"	—	— 120	"	—	— 120	" *)	—	— 170
6	"	—	— 175	"	—	— 125	2200	—	— 125	2400	+	+75	"	—	— 175
7	2200	—	— 150	"	—	— 150	"	—	— 150	2300	—	—50	"	—	— 200
8	"	—	— 115	2400	+	+85	"	—	— 115	2350	+	+35	"	—	— 165
9	"	—	— 145	2300	—	—45	2400	+	+55	2300*)	—	—45	"	$\frac{-}{2}$	$\frac{-190}{2}$
10	2400	+	+80	2350	+	+30	2300	—	—20	"	—	—20	"	$\frac{-}{3}$	$\frac{-210}{3}$
11	2300	—	—55	2300*)	—	—55	2350	—	— 5	"	—	—55	"	$\frac{?}{4}$	$\frac{-205}{4}$
12	2350	+	+45	"	—	— 5	2300*)	—	— 5	"	—	— 5	"	$\frac{?}{10}$	$\frac{-250}{10}$
13	2300*)	—	—65	"	—	—65	"	—	—65	"	$\frac{-}{2}$	$\frac{-40}{2}$	"	$\frac{?}{5}$	$\frac{-240}{5}$
14	"	—	—50	"	—	—50	"	—	—50	"	$\frac{-}{3}$	$\frac{-60}{3}$	"	$\frac{?}{5}$	$\frac{-220}{5}$
15	"	—	—10	"	$\frac{-}{2}$	$\frac{-40}{2}$	"	—	—10	"	$\frac{?}{4}$	$\frac{-55}{4}$	2250	$\frac{?}{4}$	$\frac{-120}{4}$

16	2300	—	—45	2300	— 3	—60 3	2300	— 2	—40 2	2300	? 10	—100 10	2250	— 2	—100 2
17	"	— 2	—40 2	"	? 4	—55 4	"	— 3	—60 3	"	? 5	—90 5	"	? 5	—100 5
18	"	— 3	—60 3	"	? 10	—100 10	"	? 4	—55 4	"	? 5	—70 5	"	? 8	—125 8
19	"	? 4	—55 4	"	? 5	—90 5	"	? 10	—100 10	"	? 4	—70 4	"	— 0	—85 0
20	"	? 10	—100 10	"	? 5	—70 5	"	? 5	—90 5	"	— 2	—50 2	"	? 5	—115 5
21	"	? 5	—90 5	"	? 4	—70 4	"	? 5	—70 5	"	? 5	—50 5	2400**	+	+55
22	"	? 5	—70 5	"	— 2	—50 2	"	? 4	—70 4	"	? 8	—75 8	2300	—	—40
23	"	? 4	—70 4	"	? 5	—50 5	"	— 2	—50 2	"	— 0	—35 0	2350	—	— 5
24	"	— 2	—50 2	"	? 8	—75 8	"	? 5	—50 5	"	? 5	—65 5	2300*	—	— 5
25	"	? 5	—50 5	"	— 0	—35 0	"	? 8	—75 8	"	— 0	—10. — 2	"	—	—65
26	"	? 8	—75 8	"	? 5	—65 5	"	— 0	—35 0	"	? 8	—85 8	"	—	—50
27	"	— 0	—35 0	"	— 0	—10 — 2	"	? 5	—65 5	"	? 6	—80 6	"	—	—10
28	"	? 5	—65 5	"	? 8	—85 8	"	— 0	—10 — 2	"	— 8	—60 3	"	— 0	—10 — 2
29	"	— 0	—10 — 2	"	? 6	—80 6	"	? 8	—85 8	"	— 3	—55 3	"	? 8	—85 8
30	"	? 8	—85 8	"	— 3	—60 3	"	? 6	—80 6	"	? 5	—90 5	"	? 6	—80 6
31	"	? 6	—80 6	"	— 3	—55 3	"	— 8	—60 3				"	— 3	—60 3
32	"	— 3	—60 3	"	? 5	—90 5	"	— 3	—55 3				"	— 3	—55 3
33	"	— 3	—55 3				"	? 5	—90 5				"	? 5	—90 5
34	"	? 5	—90 5												

** At this shot (21 of firing record number 5) percussion shell fire was resumed, according to paragraph 64 of the firing regulations, in order to re-determine the fork.

firing regulations stands last and gives the poorest results. This last method required in both cases four more observed shots than method four.

Without a full and complete test, however, I would not care to advocate the above method. In all those cases where the short fork is established by two shots observed to strike in front of the target and two beyond, the checking of the long fork shots may be dispensed with; for in that case the narrowing down of the fork serves exactly that very purpose. On the other hand, this method—the checking of the long fork *before* proceeding to narrow it down—has, however, the great advantage that we still have a safe basis for the opening of shrapnel fire even if for any reason the narrowing down of the fork does not succeed, and we are compelled to fall back on keeping the entire space between the two limits of the fork under shrapnel fire, increasing or decreasing by successive steps of 50 or 100 m. at a time.

It remains to be determined what delay in the opening of shrapnel fire will be caused in case the checking of the limits of the fork should turn out to be superfluous, in consequence of the fact that the fork has already been correctly determined. With this object in view, we will compare the five firing records under the supposition that the fork has been correctly determined. Let the target distance be 2020 m. The record of drawings of lottery numbers on page 612 will be used again, but of course column three only can be used. On the assumption that the fuses burn 20m. too long, the mean point of bursting, for elevation and fuse 2000 m., will be at $\frac{-50}{3}$. See page 620.

The fact that the method prescribed by the firing regulations is the most expeditious, in case the checking of the doubtful shot turns out to be superfluous is not surprising; indeed, it is more surprising to see what little time is saved, amounting at times to only one or two shots, and, if the firing of percussion shell is continued as prescribed by the firing regulations, rising to but five shots. While, therefore, under favorable circumstances, by opening shrapnel fire at the short fork range without verification or checking, we *may* have effective shrapnel fire one or two shots earlier, we are always running the risk of not reaching that point by some fifteen shots later, and then only in case the enemy does not make use of the advantage he thereby has gained.

In my opinion the choice of method cannot for a moment remain in doubt. I consider the opening of shrapnel fire *without verification or checking* of the distance, at *mean* ranges, permissible only when in the establishment of the short fork it becomes evident that no important error has been made, *i. e.*, in case two shots have been observed in front of the target and two beyond. If we cannot decide on checking both long fork shots *before* proceeding to narrow down the fork,—the reasons *pro* and *con* have been discussed above,—then it appears best, after narrowing the fork, to check that shot which was observed as deviating widely from the other three.

2. FIRING WITH TORPEDO-SHELL ON COVERED TARGETS.

In the two examples of firing with torpedo shell which were given above (pages 279 and 389), the mean point of bursting at the end of the preliminary firing to determine the range and fix the point of explosion, notwithstanding the fact that it was conducted strictly according to the firing regulations and only correct observations were made, was found to be in such a disadvantageous position with reference to the target, that an effective action of the firing was not to be expected. It may, therefore, be considered an open question whether the results were accidental or legitimate,—in accord with the law applying in such cases.

The methods prescribed by the firing regulations are briefly as follows: Determining the range with percussion shell c/82 with all possible accuracy,—neglecting corrections as small as 25 m.,—accurately fixing the distance of the point of bursting in front of the target by increasing or decreasing by steps (50 or 100 m. at a time) with torpedo-shell furnished with time-fuses, in such wise that points of bursting are obtained in front of the target as well as beyond it; and finally, raising the point of bursting to a height of 10 or 15 m.

The first and last operations involve not the slightest difficulty, moreover it is quite immaterial whether the first succeeds or not, since the process of more accurately locating the points of bursting in front of the target would correct any error which might

Current number.	1.			2.			3.			4.			5.		
	Range ordered. m.	Observation. batt'y	Observation. target.	Range ordered. m.	Observation. batt'y	Observation. target.	Range ordered. m.	Observation. batt'y	Observation. target.	Range ordered. m.	Observation. batt'y	Observation. target.	Range ordered. m.	Observation. batt'y	Observation. target.
1	2000	—	— 5	2000	—	— 5	2000	—	— 5	2000	—	— 5	2000	—	— 5
2	2200	+	+175	2200	+	+175	2200	+	+175	2200	+	+175	2200	+	+175
3	2100	+	+45	2100	+	+45	2100	+	+45	"	+	+145	2100	+	+45
4	2050	+	+20	2050	+	+20	2050	+	+20	2000	—	—30	2050	+	+20
5	2000	—	—10	"	—	—10	"	+	+40	2100	+	+90	2000*)	—	—10
6	"	—	—25	2000	—	—25	2000	—	—25	2050	+	+25	"	—	—25
7	2050	+	+10	"*)	—	—40	"*)	—	—40	2000*)	—	—40	"	—	—40
8	"	+	+45	"	—	— 5	"	—	— 5	"	—	— 5	"	—	— 5
9	"	+	+15	"	—	—35	"	—	—35	"	—	—35	"	$\frac{-}{1}$	$\frac{-30}{1}$
10	2000*)	—	—10	"	$\frac{-}{1}$	$\frac{-30}{1}$	"	—	—10	"	—	—10			
11	"	—	—45		etc.		"	$\frac{-}{1}$	$\frac{-30}{1}$	"	$\frac{-}{1}$	$\frac{-30}{1}$			
12	"	+	+ 5					etc.			etc.				
13	"	—	—55												
14	"	$\frac{-}{1}$	$\frac{-30}{1}$												
15	Etc. Mean distance of the points of bursting in front of the target. $\frac{-90}{3}$														

have been made, assuming of course, that this *latter* operation is actually successful. But just herein the real difficulties of the case lie, and it is not saying too much to assert that in most cases an accurate fixing of the points of bursting is not practicable, merely because the assumptions which must be made are not true.

In every firing the tacit assumption is made that all shots not observed are distributed in front of and beyond the target, in the same way as short shots and over shots in general. Should this assumption prove untrue, we cannot of course, get a correct idea of the position of the mean point of bursting from our observations, and *must* be led to adopt altogether false measures. But this is exactly the case in attempting to fix the distances of the points of bursting of torpedo-shell in front of the target.

If we inspect the two diagrams—Appendix 2—the matter becomes clear at once. If we assume, for example, in the diagram that the mean point of bursting lies at $\frac{\pm 0}{+4}$ with reference to the target, it is readily seen that, although one-half of all the points of explosion lie in front of the target, the other half beyond, only an *insignificantly small number* of the points of explosion lying *in front of* the target can be observed at all, while *almost* all points of explosion or ground hits lying *beyond* the target will be observed. From Appendix 1, column E, it is seen that in this case forty-two points of explosion cannot be observed on account of having too great a height of explosion (over 4 m.*); but of *these, thirty-nine are in front of the target and only three beyond;* eight points of explosion lie just over the target, and only fifty shots are capable of observation. *Of these last only seven lie in front of the target and forty-three* (including fifteen ground hits) *beyond the target.* The chances are, therefore six to one that the battery commander, on the strength of his observation, will come to the conclusion that his points of explosion lie beyond the target, and that he will consequently go back 50 m. There he will naturally obtain only points of explosion in front of the target, and will alternate between these two ranges (paragraph 73 of the firing regulations) and thereby sacrifice nearly half the effective action.

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* Should, under particularly favorable circumstances, points of explosion lying higher than this admit of observation, the actual numbers will, indeed, be altered somewhat, but the relative numbers will still remain the same.

For the range 3000 m. this applies with particular force. With the same position of the mean point of explosion there will be, out of one hundred shots, forty-five points of explosion, forty-two *in front of* the target and three *beyond*, not admitting of observation on account of having too great a height of explosion; eight points of explosion have a distance in front of the target equal to zero. Forty-seven points of explosion admit of observation, four of which lie *in front of* the target, forty-three *beyond* it, the latter including twenty-six ground hits. The chances are, therefore, ten to one that the battery commander will attempt a false mode of correction.*

To these modes of procedure it may be objected that a height of explosion of 4 m. is too great, as it gives too few points of bursting admitting of observation. I am of that opinion myself and believe too that in practice we will generally be concerned with lower points of explosion. Let us see, therefore, how the matter appears in case of a mean height of explosion and distance from the target of zero. A glance at Appendix 2 shows that in this case the number of points of bursting *beyond* the tar-target, admitting of observation, becomes exceedingly small, while that of those lying in front of the target becomes greater. However, a careful study of columns E and F of Appendix 1, is of especial interest in this connection, and may throw light on the subject of the probable causes which led to the failure of getting the correct effective range in the examples above.

At the distance of 2000 m. we obtain in one hundred shots nine, the height of explosion of which is over 4 m., and which, therefore, do not admit of observation (lottery numbers 1 to 6, 8, 11 and 15), four shots give ground hits exactly at the target (lottery numbers 49 to 52). Twenty-nine points of bursting, having a height admitting of observation, lie *in front of* the target (numbers 7, 9, 10, 12 to 14, 16 to 18, 20 to 30, 32 to 36 and 39 to 42); two points of bursting *directly over* the target (numbers 47 and 48) and three *beyond* the target (numbers 55, 63 and 70).

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* It is hardly necessary to call attention to the fact that all the numbers possess but a limited degree of reliability. Should the deviation, or the height up to which the position of the points of bursting still admit of observation, or the angle of fall, change, these numbers will also naturally change.

Of *ground hits in front of* the target, as is clearly apparent, there are eight to be expected (numbers 19, 31, 37, 38 and 43 to 46). Furthermore, by the application of the formula on page 137 in case of those shots which, with points of explosion lying *beyond* the target, have a negative height of explosion, we find that twenty-seven more shots make ground hits *in front of* the target (numbers 53, 54, 59 to 61, 67 to 69, 73 to 76, 80, 81, 84 to 86, 88 to 90, 92, 93 and 95 to 99). Only eighteen ground hits lie *beyond* the target.

Should the battery commander fail to discriminate between ground hits and low points of bursting—in my opinion he cannot distinguish between them at all—he will observe sixty-four bursting clouds in front of the target and twenty-one beyond. The chances are therefore three to one that, in case the distance from the target and the height of the points of explosion are both zero, he will increase by 50 m., instead of retaining the time of fuse burning, which is already greater than necessary or desirable. Should he succeed in distinguishing the points of bursting from the ground hits the trouble would only be magnified; because, for the twenty-nine points of bursting in front of the target he would have but three beyond. Should, however a sandy soil and dry weather favor in an exceptional manner the observation of very high points of explosion, then his observations, quite correct in themselves, will all the more certainly lead him to make a false correction; because, for thirty-eight points of bursting in front of the target he will observe but three beyond.

That these errors will grow if the point of explosion is lowered, is readily perceived. And yet it is generally impossible to avoid this. At 3000 m. we will probably have the choice only between points of bursting at a height of from 6 to 7 m., which will very likely give but a very few points of bursting admitting of observation, and those at a height of from minus 3 to minus 4 m. The most advantageous mean height of + 2m. can be obtained only in the rarest cases.

The cause of all these phenomena is the fact that the trajectory is not horizontal. Were this the case the points of bursting in front of the mean point of bursting and those beyond would equally admit of observation, and the ground hits would lie in exactly the same relative positions in front of and beyond this point. The fact that the fixing of the position of the points of bursting in front of the target is possible in case of shrapnel fire, but almost impossible in case of torpedo-shell, is due to the fact that in the former no accurate fixing of this distance is required; it is sufficient to have the mean distance between 25 and 100 m., whereas, the very nature of the torpedo-shell requires an *accurate* fixing of this point.

Having thus, in my opinion, clearly shown the inadequacy of the method prescribed by the firing regulations, I feel compelled to submit propositions of a more practically useful nature. We will concede that the method proposed must be perfectly simple and follow the rules for shrapnel firing as clearly as possible.

If we have determined the effective range *exactly* by means of percussion shell, and then pass to torpedo-shell—with time fuses —at a range greater by 50 m., then, in case of fuses which burn correctly, the mean point of bursting will lie directly over the target, provided the trajectories of the percussion shell and the torpedo-shell coincide. But, since the torpedo-shell have a trajectory from 10 to 20 m. shorter, the mean point of explosion will also lie from 10 to 20 m. in front of the target, and will therefore have the most favorable position that could be desired. By inserting plates the proper height of explosion may be obtained. For ranges of from 1600 m. (short of which it would hardly become necessary to fire on shelter trenches, etc.) up to 2500 m. one plate is required. For greater ranges *such* high points of explosion are obtained (about 9 m.), that any further raising will put the point of explosion too high. (At 2600 m. the insertion of one plate produces a change of about 8½ m. in the height of explosion.

If the determination of the range and the attainment of effective fire were always successful, and the fuses always burned correctly, there could hardly be anything simpler than firing with torpedo-shell. We must, however, investigate what will be the effect of unavoidable errors and how these are to be met. According to the firing regulations we may regard the range as determined and the firing as effective when from one-third to two-thirds of all shots are observed as lying in front of the target.

If we assume mean deviations (25 m. mean probable longitudinal deviation), then the centre of impact, in case one-third are short shots, will lie about 15 m. *beyond*, in case two-thirds are short shots the same distance *in front of* the target. With fuses which burn *correctly* the mean point of explosion in the most unfavorable case will therefore be transferred to 5 m. beyond the target in the first case, or 36 m. in front of it in the second. It therefore still lies so that every correction of 50 m. will only make the position of the point of explosion worse. Smaller corrections—of 25 m.—which are often spoken of as desirable in our firing, I regard as useless in actual field service. The reason is that delicate corrections have a meaning only when we have accurate data as to the exact amount of the error to be corrected. But this necessary information can hardly be obtained in the face of the large deviations that will occur, and the more or less uncertain character of the observations. We can convince ourselves of this very readily by taking examples in illustration from the fire game. Example number one (page 264), indeed, is very instructive on this point. I would recommend to all doubters that they work this example out once more, and that under the assumption of greater deviations and more unfavorable observation relations.

Furthermore, we must take into consideration points of explosion, which, in consequence of the behavior of the fuses, deviate by as much as 25 m. from the normal distance in front of the target, without our having been able to bring about by means of any correction a more favorable position. Should these *most unfavorable* circumstances happen to *combine* and add their effects together, the mean point of explosion may possibly, without any blame attaching to the battery commander, lie as much as 60 m. in front of the target or 30 m. beyond it. In this case, at 2000 m. (assuming our previously adopted deviation) only nine per cent. of effective shots is to be expected, not a very large amount to be sure. Such relations, which can only be brought about by a *concurrence* of the most unfavorable circumstances, will on that very account be of very rare occurrence.

There will be cases no doubt, in which, in the determination of the range with percussion shell one elevation will furnish too many short shots, and another 50 m. greater, too many over shots, or, in which at *both* elevations the ratio of short to over shots is a proper one for effective fire. In both these cases the *greater* range is to be selected and taken as a starting point; but we must alternate in firing, with one still greater by 50 m.

In case the behavior of the fuses is not normal, *i. e.*, should they burn too long (which fact may be recognized by the large number of ground hits made) or too short (in which case the height of explosion will become too great), we must bring the point of explosion to the right point in height by raising or lowering (as the case may be) the trajectory by means of plates. *Every such raising or lowering, the object of which is to produce a normal height of explosion* (about $\frac{1}{800}$ of the range), *corresponding to a correct behavior of the fuse, must be accompanied by a corresponding going back or ahead.*

In the *later* raising of the trajectory, the only object of which is to bring the height of explosion up to the desirable mean of 12 m., there is of course no accompanying decrease, as the distance of the point of explosion in front of the target is already fixed. Whether this difference in the methods to be pursued after the insertion of the plates will not open the way to errors in practical field firing, only a long continued trial with troops can determine. Should this prove to be the case, then we must find some way, by giving a different command or by some other means, to avoid mistakes. In such a case I might even advocate a direct correction in the fuse setting, which method I am not ordinarily very enthusiastic about.

The following examples are given to illustrate the foregoing propositions and to show their practicability. The same lottery drawing list is used in all the examples, all observations are regarded as correct, and it is assumed that the torpedo-shell has a range 10 m. shorter than the percussion shell c/82.

Five examples are here given, the following assumptions being made in the different cases:

1. Target distance, 1950 m., fuse normal.
2. " " 1965 m., " "
3. " " 1935 m., " "
4. " " 1965 m., fuse burning 25 m. too short.
5. " " 1935 m., fuse burning 25 m. too long.

In examples four and five the most unfavorable circumstances are combined.

The mean point of explosion, with elevation and fuse-setting as indicated, is located as follows:

1. 2000 m. at $\frac{-10}{6}$, $\underline{2000}$ m. at $\frac{-10}{12}$, 1950 m. at $\frac{-60}{6}$, $\underline{1950}$ m. at $\frac{-60}{12}$.
2. 2000 m. at $\frac{-25}{6}$, $\underline{2000}$ m. at $\frac{-25}{12}$, $\underline{2050}$ m. at $\frac{+25}{12}$,
3. 2000 m. at $\frac{+5}{6}$, $\underline{2000}$ m. at $\frac{+5}{12}$, 1950 m. at $\frac{-45}{6}$, $\underline{1950}$ m. at $\frac{-45}{12}$.
4. 2000 m. at $\frac{-50}{8}$, $\underline{2000}$ m. at $\frac{-50}{15}$, $\overline{2050}$ m. at $\frac{\pm 0}{2}$, 2050 m. at $\frac{\pm 0}{8}$,
5. 2000 m. at $\frac{+30}{3}$, $\underline{2000}$ m. at $\frac{+30}{9}$, $\underline{\underline{2000}}$ m. at $\frac{+30}{16}$, 1950 m. at $\frac{-20}{3}$, $\underline{\underline{1950}}$ m. at $\frac{-20}{16}$.

Lottery-drawing List.

Percussion-shell.						Torpedo-shell.					
Current number. 1.	Lottery number. 2.	Deviation m. 3.	Current number. 1.	Lottery number. 2.	Deviation m. 3.	Current number. 1.	Lottery number. 2.	Deviation m. 3.	Current number. 1.	Lottery number. 2.	Deviation m. 3.
1	89	+45	13	44	− 5	1	24	−20 + 1	13	61	+ 5 − 1
2	57	+ 5	14	86	+40	2	44	− 5 ± 0	14	94	+40 − 3
3	49	± 0	15	60	+10	3	76	+15 − 4	15	3	−50 + 6
4	78	+30	16	12	−45	4	58	+ 5 ± 0	16	14	−30 + 1
5	98	+75	17	72	+20	5	30	−15 + 1	17	6	−40 + 5
6	86	+40	18	42	−10	6	82	+25 ± 0	18	79	+20 − 2
7	11	−45	19	96	+65	7	5	−45 + 5	19	35	−10 + 1
8	25	−25	20	13	−45	8	46	− 5 − 1	20	70	+15 + 1
9	20	−30	21	73	+20	9	97	+45 − 6	21	48	± 0 + 1
10	36	−15	22	48	± 0	10	86	+25 − 5	22	20	−20 + 4
11	67	+15	23	92	+50	11	38	−10 − 1	23	54	± 0 − 2
12	76	+25	24	28	−20	12	55	+ 5 + 1	24	15	−25 + 5

Current number.	1. Target distance 1950 m.			2. Target distance 1965 m.			3. Target distance 1935 m.			4. Target distance 1965 m.			5. Target distance 1935 m.		
	Range ordered. m.	Observation.		Range ordered. m.	Observation.		Range ordered. m.	Observation.		Range ordered. m.	Observation.		Range ordered. m.	Observation.	
		batt'y	target.		batt'y	target.		batt'y	target.		batt'y	target.		batt'y	target.
1	1800	—	— 105	1800	—	— 120	1800	—	—90	1800	—	— 120	1800	—	—90
2	2000	+	+ 55	2000	+	+ 40	2000	+	+70	2000	+	+ 40	2000	+	+70
3	1900	—	— 50	1900	—	— 65	1900	—	—35	1900	—	— 65	1900	—	—35
4	1950	+	+ 30	1950	+	+ 15	1950	+	+45	1950	+	+ 15	1950	+	+45
5	1900	+	+ 25	1900	+	+ 10	1900	+	+40	1900	+	+ 10	1900	+	+40
6	"	—	— 10	"	—	— 25	"	+	+ 5	"	—	— 25	"	+	+ 5
7	"	—	— 95	"	—	— 110	"	—	—80	"	—	— 110	"	—	—80
8	"	—	— 75	"	—	— 90	"	—	—60	"	—	— 90	"	—	—60
9	"		— 80	"	—	— 95	"	—	—65	"	—	— 95	"	—	—65
10	1950	—	— 15	1950	—	— 30	1950*)	?	± 0	1950	—	— 30	1950*)	?	± 0
11	"	+	+ 15	"	?	± 0	"	+	+30	"	?	± 0	"	+	+30
12	"	+	+ 25	"	+	+ 10	"	+	+40	"	+	+ 10	"	+	+40
13	"	—	— 5	"	—	— 20	"	—	—50	"	—	— 20	"	—	—50

14	1950	+	+40	1950	+	+25	1950	? 7	−65 7	1950	+	+25	1950	— 4	−40 4
15	"	+	+10	"	−	− 5	"	? 6	−50 6	"	−	− 5	"	— 3	−25 3
16	2000*)	+	+ 5	2000*)	−	−10	"	— 2	−30 2	2000*)	−	−10	"	— 0	− 5 − 1
17	"	+	+70	"	+	+55	"	? 6	−40 6	"	+	+55	"	— 3	−15 3
18	"	+	+40	"	+	+25	1950	? 13	−60 13	"	+	+25	"	— 4	−35 4
19	"	+	+115	"	+	+ 100	"	? 8	−20 8	"	+	+ 100	"	+ 3	+ 5 3
20	"	? 7	−30 7	"	? 7	−45 7	2000	? 17	−40 17	2000	? 9	−70 9	2000	? 14	−15 14
21	"	? 6	−15 6	"	? 6	−30 6	"	? 11	± 0 11	"	? 8	−55 8		? 8	+25 8
22	"	+ 2	+ 5 2	"	— 2	−10 2	"	? 6	+50 6	"	— 4	−35 4		+ 3	+75 3
23	"	? 6	− 5 6	"	? 6	−20 6	"	? 7	+30 7	"	? 8	−45 8		+ 4	+65 4
24	2000	? 13	−25 13	2000	? 13	−40 13	"	? 11	− 5 11	"	? 9	−65 9	2000	? 15	+20 15
25	"	? 12	+15 12	"	? 12	± 0 12	"	? 12	+10 12	"	? 11	−25 11		? 17	+35 17
26	"	? 17	−55 17	"	? 17	−70 17	1950	? 11	−40 11	2000	? 20	−95 20	1950	? 15	−15 15

Current number.	1. Target distance 1950 m.			2. Target distance 1965 m.			3. Target distance 1935 m.			4. Target distance 1965 m.			6. Target distance 1935 m.		
	Range ordered. m.	Observation.		Range ordered. m.	Observation.		Range ordered. m.	Observation.		Range ordered. m.	Observation.		Range ordered. m.	Observation.	
		batt'y	target.		batt'y	target.		batt'y	target.		batt'y	target.		batt'y	target.
27	2000	? 11	−15 11	2000	? 11	−30 11	1950	? 9	− 5 9	2000	? 14	−55 14	1950	? 13	+20 13
28	"	? 6	+35 6	"	? 6	+20 6	"	? 18	−95 18	"	? 9	− 5 9		? 22	−70 22
29	"	? 7	+15 7	"	? 7	± 0 7	"	? 13	−75 13	"	? 10	−25 10		? 17	−50 17
30	"	? 11	−20 11	"	? 11	−35 11	"	? 17	−85 17	"	? 14	−60 14		? 21	−60 21
31	"	? 13	− 5 13	"	? 13	−20 13	"	? 10	−25 10	"	? 16	−45 16		? 14	± 0 14
32	"	? 11	− 5 11	"	? 11	−20 11	2000	? 13	− 5 13	"	? 14	−45 14	2000	? 17	+20 17
33	"	? 9	+30 9	"	? 9	+15 9	"	? 13	+20 13	"	? 12	−10 12		? 17	+45 17
34	"	? 18	−60 18	"	? 18	−75 18	"	? 13	+ 5 13	"	? 21	−100 21		? 17	+30 17
35	"	? 13	−40 13	"	? 13	−55 13	"	? 16	−15 16	"	? 16	−80 16		? 20	+10 20
36	"	? 17	−50 17	"	? 17	−65 17	"	? 10	+ 5 10	"	? 20	−90 20		? 14	+30 14
37	"	? 10	+10 10	"	? 10	− 5 10	"	? 17	−20 17	"	? 13	−30 13		? 21	+ 5 21
38	"	? 13	−20 13	"	? 13	−35 13				"	? 16	−60 16			
39	"	? 13	+ 5 13	"	? 13	−10 13				"	? 16	−35 16			
40	"	? 13	−10 13	"	? 13	−25 13				"	? 16	−50 16			
41	"	? 16	−30 16	"	? 16	−45 16				"	? 19	−70 19			
42	"	? 10	−10 10	"	? 10	−25 10				"	? 13	−50 13			
43	"	? 17	−35 17	"	? 17	−50 17				"	? 20	−75 20			

Current number.	1. Target distance 1950 m.			2. Target distance 1965 m.			3. Target distance 1935 m.			4. Target distance 1965 m.			5. Target distance 1935 m.		
	Range ordered. m.	Observation.		Range ordered. m.	Observation.		Range ordered. m.	Observation.		Range ordered. m.	Observation.		Range ordered. m.	Observation.	
		batt'y	target.		batt'y	target.		batt'y	target.		batt'y	target.		batt'y	target.
1	2000	? 7	−30 7	2000	? 7	−45 7	1950	? 7	−65 7	2000	? 10	−70 10	1950	— 4	−40 − 4
2	"	? 6	−15 6	"	? 6	−30 6	"	? 6	−50 6	"	? 9	−55 9	"	— 3	−25 3
3	"	+ 2	+ 5 2	"	— 2	−20 2	"	— 2	−30 2	2000	— 0	−35 − 1	"	— 0	− 5 − 1
4	"	? 6	− 5 6	"	? 6	−20 6	"	? 6	−40 6		— 3	−45 3	"	— 3	−15 3
5	"	? 7	−25 7	"	? 7	−40 7	"	? 7	−60 7		— 4	−65 4	"	— 4	−35 4
6	"	? 6	+15 6	"	? 6	± 0 6	"	? 6	−20 6		— 3	−25 − 3	"	— 6	+ 5 6
7	"	? 11	−65 11	"	? 11	−70 11	"	? 11	−90 11	2050	? 7	−45 7	2000	? 8	−15 8
8	"	? 5	−15 5	"	? 5	−30 5	"	? 5	−50 5	"	— 1	− 5 1	"	+ 2	+25 2
9	"	+ 0	+35 0	"	+ 0	+25 0	"	? 0	± 0 0	"	+ 0	+45 − 4	"	+ 0	+75 − 3
10	"	+ 1	+15 1	"	? 1	± 0 1	"	— 1	−20 1	"	+ 0	+25 − 4	"	+ 0	+55 − 2

Current number.	1. Target distance 1950 m.			2. Target distance 1965 m.			3. Target distance 1935 m.			4. Target distance 1965 m.			5. Target distance 1935 m.		
	Range ordered. m.	Observation.		Range ordered. m.	Observation.		Range ordered. m.	Observation.		Range ordered. m,	Observation.		Range ordered. m.	Observation.	
		batt'y	target.		batt'y	target.		batt'y	target.		batt'y	target.		batt'y	target.
11	2000	? 5	—20 5	2000	? 5	—30 5	1950	? 5	—35 5	2050	— 1	—10 1	2000	+ 2	+20 2
12	"	? 7	— 5 7	"	? 7	—20 7	"	? 7	—40 7	"	+ 3	+ 5 3	"	+ 4	+35 4
13	1950	? 5	—55 5	2000	? 11	—20 11	2000	? 5	+10 5	2050	? 7	+ 5 7	2000	? 8	+35 8
14	"	— 3	—20 3	"	? 9	+15 9	"	+ 3	+45 3	"	? 5	+40 5	"	? 6	+70 6
15	"	? 12	— 110 12	"	? 18	—75 18	"	? 12	—45 12	"	? 14	—50 14	2000	? 22	—20 22
16	"	? 7	—90 7	"	? 13	—55 13	"	? 7	—25 7	"	? 9	—30 9	"	? 17	± 0 17
17	"	? 11	— 100 11	"	? 17	—65 17	"	? 11	—35 11	"	? 9	—40 9	"	? 21	—10 21
18	"	— 4	—40 4	"	? 10	—45 10	"	+ 4	+25 4	"	? 6	+20 6	"	? 14	+10 14
19	1950	? 13	—70 13	2050	? 13	+15 13	2000	? 13	— 5 13	"	? 13	—10 9	1950	? 17	—30 17
20	"	? 13	—45 13	"	? 13	+ 0 13	"	? 13	+20 13	"	? 10	+15 9	"	? 17	— 5 17
21	"	? 13	—60 13	"	? 13	+25 13	"	? 13	+ 5 13	"	? 10	± 0 9	"	? 17	—20 17
22	"	? 16	—90 16	"	? 16	+ 5 16	"	? 16	—15 16	"	? 13	—20 12	"	? 20	—40 20
23	"	? 10	—60 10	"	? 10	+25 10	"	? 10	+ 5 10	"	? 7	± 0 6	"	? 14	—20 14
24	"	? 17	—85 17	"	? 17	± 0 17	"	? 17	—20 17	"	? 14	—25 13	"	? 21	—45 21

On the firing records, numbers one, two and four, there are no special remarks to be made. In firing record number three, although 1900 m. seemed at the beginning to be the approximate distance for percussion shell, c/82., the firing was continued with torpedo-shell by alternating between the ranges 1950 and 2000 m., because the battery commander drew the conclusion from shots 10 to 13 that the target must lie between 1900 and 1950 m.—Firing record number five gave the most unfavorable results; the fact that the fuses burned longer than the normal time was not recognized in the first fuse-setting, because only one ground hit occurred.

But the most interesting point is the question as to what would have been the result, under exactly the same conditions, which, for the method proposed by me in examples number four and five are as unfavorable as they can possibly be, had the rules of the firing regulations been strictly followed. Since the firing with percussion shell in the two methods would have proceeded in exactly the same way, and the differences only become apparent in the firing of torpedo-shell (with time fuses), we need consider in the firing records only the twenty-four torpedo-shell (see pages 631 and 632).

A comparison of the firing records shows that three times (in examples number three and number five) the result is exactly the same, whether the firing is conducted according to the firing regulations or according to my proposed method. But while the principal part of the measures taken for obtaining effective fire,—the determination of the proper length of fuse,—is in my proposed method, practically accomplished when the last percussion shell is fired, in the method prescribed by the firing regulations this operation is then just beginning. Aside from the fact, however, that effective fire is obtained later in every case, a higher demand is also made on the judgment and intelligence of the battery commander. In example number one, in which, by following my proposed method the most favorable position imaginable for the point of explosion, $\frac{-10}{12}$, is obtained, by following the firing regulations we are compelled to alternate between two ranges, whereby the effect is reduced by nearly one-half. The same may be said in regard to example number two, in which the position of the point of explosion is not, indeed, the most favorable imaginable, but perhaps under the circumstances the best. Only in example number four is a better result obtained. By following my proposed method the mean point of explosion in this is at $\frac{-50}{15}$, by following the firing regulations at $\frac{\pm 0}{9}$. The former promises about 16 per cent.,* the latter 31 per cent.** effective shots. While therefore, in two cases the result was the same for both methods, it was twice worse and once better when the firing regulations were applied. It must be noted, however, that examples number four and five illustrate in my proposed method, a most unfavorable combination of the position of the target and the behavior of the fuse, whereas in the firing according to firing regulations, we have in both cases for the purposes of observation almost the most favorable mean heights of explosion of + 2 and + 3 m., respectively.

Furthermore, I would recommend the working out of all the examples in firing . . . . according to my proposed method. Any one will then be convinced how smoothly the firing progresses, how rapidly effective fire is attained, and what favorable positions of the mean point of explosion are obtained.

It remains now only to show how the firing shapes itself in its progress when the fuses burn so much too long or too short that the correct relation must be restored. We will select for this purpose example number one, in which the target distance was 1950 m., and will assume that the fuses in the first place burn 50 m. too long, and in the second place 50 m. too short, and construct firing records one and two to correspond to my proposed method, and three and four to correspond to that of the firing regulations. We will commence at once with torpedo-shell (with time-fuses).

Mean position of the point of explosion with an elevation and fuse.

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* Appendix 1, column E, lottery numbers 82 to 97.

** Appendix 1, column E, lottery numbers 15 to 46, excepting 19, which shot has too small a height of explosion.

Firing records 1 and 3.	Firing records 2 and 4.
of 2000 m. at $+\frac{40}{0}$;	of 2000 m. at $-\frac{60}{11}$;
of $\underline{2000}$ m. at $+\frac{40}{7}$;	of $\overline{2000}$ m. at $-\frac{60}{5}$;
of 1950 m. at $-\frac{10}{0}$;	
of $\underline{1950}$ m. at $-\frac{10}{7}$;	at 2050 m. at $-\frac{10}{11}$;
of $\underline{1950}$ m. at $-\frac{10}{13}$;	at $\overline{2050}$ m. at $-\frac{10}{5}$.

In this case as before, comparison entirely favors my proposed method. In the firing records numbers two and four the final result is, indeed, the same exactly; except that my proposed method again accomplishes the object sought more quickly than the firing regulations. While in firing record number one an exceptionally favorable position of the point of explosion is obtained, in the third firing record the *correct* observation of the shots at the second elevation and fuse setting, leads to the adoption of an alternating fire between the ranges $\underline{1950}$ m. and $\underline{2000}$ m., *i. e.*, the target is under the fire of but half of all the shots. It may be held that it was wrong at the first elevation and fuse setting after the second ground hit, not to insert a plate. But I do not admit this. It is however, very interesting to note how entirely different the character of the observation at the second elevation and fuse setting would have turned out had a plate been inserted after shot three. In that case all the shots, except nine and ten would have been observed as doubtful, and these two not now *in front of* the target but *beyond* it. In consequence of which it would have become necessary to go back to 1900 m., and finally to alternate between $\underline{1950}$ and $\underline{1900}$ m. The effect however, would not have been increased at all, since the trajectory at the latter elevation would have been located entirely in front of the target, and not a single fragment of a shell would have reached the target.

Current number.	1. Target distance 1950 m.			2. Target distance 1950 m.			3. Target distance 1950 m.			4. Target distance 1950 m.		
	Range ordered. m.	Observation.		Range ordered. m.	Observation.		Range ordered. m.	Observation.		Range ordered. m.	Observation.	
		batt'y	target.		batt'y	target.		batt'y	target.		batt'y	target.
1	2000	$\frac{+}{1}$	$\frac{+20}{1}$	2000	$\frac{?}{12}$	$\frac{-80}{12}$	2000	$\frac{+}{1}$	$\frac{+20}{1}$	2000	$\frac{?}{12}$	$\frac{-80}{12}$
2	"	$\frac{+}{0}$	$\frac{+35}{0}$	"	$\frac{?}{11}$	$\frac{-65}{11}$	"	$\frac{+}{0}$	$\frac{+35}{0}$	"	$\frac{?}{11}$	$\frac{-65}{11}$
3	"	$\frac{+}{0}$	$\frac{+55}{-4}$	2000	$\frac{-}{1}$	$\frac{-45}{1}$	"	$\frac{+}{0}$	$\frac{+55}{-4}$	2000	$\frac{-}{1}$	$\frac{-45}{1}$
4	2000	$\frac{?}{7}$	$\frac{+45}{7}$	"	$\frac{?}{5}$	$\frac{-55}{5}$	"	$\frac{+}{0}$	$\frac{+45}{0}$	"	$\frac{?}{5}$	$\frac{-55}{5}$
5	"	$\frac{?}{8}$	$\frac{+25}{8}$	"	$\frac{?}{6}$	$\frac{-75}{6}$	"	$\frac{+}{1}$	$\frac{+25}{1}$	"	$\frac{?}{6}$	$\frac{-75}{6}$
6	"	$\frac{?}{7}$	$\frac{+65}{7}$	"	$\frac{?}{5}$	$\frac{-35}{5}$		$\frac{+}{0}$	$\frac{+64}{-4}$	"	$\frac{?}{5}$	$\frac{-35}{5}$
7	1950	$\frac{?}{12}$	$\frac{-55}{12}$	2050	$\frac{?}{16}$	$\frac{-55}{16}$	1950	$\frac{?}{5}$	$\frac{-55}{5}$	2000	$\frac{?}{10}$	$\frac{-105}{10}$
8	"	$\frac{?}{6}$	$\frac{-15}{6}$	"	$\frac{?}{10}$	$\frac{-15}{10}$	"	$\frac{-}{0}$	$\frac{-15}{-1}$	"	$\frac{-}{4}$	$\frac{-65}{4}$
9	"	$\frac{+}{1}$	$\frac{+35}{1}$	"	$\frac{?}{5}$	$\frac{+35}{5}$	"	$\frac{-}{0}$	$\frac{+35}{-6\text{*)}}$	"	$\frac{-}{0}$	$\frac{-15}{0}$
10	1950	$\frac{?}{8}$	$\frac{+15}{8}$	"	$\frac{?}{6}$	$\frac{+15}{6}$	"	$\frac{-}{0}$	$\frac{+15}{-5\text{*)}}$	"	$\frac{-}{1}$	$\frac{-35}{1}$

*The ground hits on both these cases lie *in front of* the target.

11	1950	? / 12	−20 / 12	2050	? / 10	−20 / 10	1950	— / 0	+20 / − 1	2000	— / 4	−70 / 4
12	"	? / 14	− 5 / 14	"	? / 12	− 5 / 12	"	— / 1	− 5 / 1	"	? / 6	−55 / 6
13	"	? / 12	− 5 / 12	"	? / 10	− 5 / 10	1950	? / 6	− 5 / 6	2050	— / 4	− 5 / 4
14	"	? / 10	+30 / 10	"	? / 8	+30 / 8	"	+ / 4	+30 / 4	"	? / 2	+30 / 2
15	"	? / 19	−60 / 19	"	? / 17	−60 / 17	"	? / 13	−60 / 13	"	? / 11	−60 / 11
16	"	? / 14	−40 / 14	"	? / 12	−40 / 12	"	? / 12	−40 / 12	"	? / 6	−40 / 6
17	"	? / 18	−50 / 18	"	? / 16	−50 / 16	"	? / 16	−50 / 16	"	? / 10	−50 / 10
18	"	? / 11	+10 / 11	"	? / 9	+10 / 9	"	? / 5	+10 / 5	"	+ / 3	+10 / 3
19	"	? / 14	−20 / 14	"	? / 12	−20 / 12	2000	? / 8	+30 / 8	2050	? / 12	−20 / 12
20	"	? / 14	+ 5 / 14	"	? / 12	+ 5 / 12	"	? / 8	+55 / 12	"	? / 12	+ 5 / 12
21	"	? / 14	−10 / 14	"	? / 12	−10 / 12	"	? / 8	+40 / 8	"	? / 12	−10 / 12
22	"	? / 17	−30 / 17	"	? / 15	−30 / 15	"	? / 11	+20 / 11	"	? / 15	−30 / 15
23	"	? / 11	−10 / 11	"	? / 9	−10 / 9	"	? / 5	+40 / 5	"	? / 9	−10 / 9
24	"	? / 18	−35 / 18	"	? / 16	−35 / 16	"	? / 12	+15 / 12	"	? / 16	−35 / 16

3. DIRECT AND INDIRECT CORRECTION OF THE LENGTH OF FUSE.

In the same way we might investigate by means of the fire game the question as to whether the direct or the indirect method of correcting the length of fuse deserves the preference in shrapnel fire. This question, discussed so energetically in the "Archiv" some two years ago has lost much of its interest, and to bring it up again in this connection would lead us too far astray. To those who are interested therein this reference may be sufficient to induce them to consider it from this point of view.

POSTSCRIPT.

Those of my respected readers who have followed me to this point, have probably been conscious of the utility of the fire game for the officer serving with troops and the teacher at the military schools, as well as for the development of the art of artillery fire. It will be a simple matter to propose an unlimited number of problems in firing and to solve them, or to have them solved by means of the fire game.

The fact that there are still some weak points in the game, no one can be more thoroughly convinced of than the author; but in time we will probably succeed in perfecting it. The careful reader will not have failed to observe that all the examples in which the firing was conducted with time fuses were selected for ranges lying near 1000, 2000 or 3000 m. The reason is that for these ranges only are the tables, relating to the dispersion of the points of explosion and represented in the vertical side elevation, constructed. Should the game be generally adopted, as I hope it may be, it will be no great matter to construct tables for the intermediate ranges—1500 and 2500 m.—by which it would become possible to represent firing at *any* desired range. It would then also be possible to combine the fire game with Kriegsspiel, and have the artillery combat, which is now generally decided at the pleasure of the director, or in favor of the battery which arrives first on the field, or by mere numerical superiority, brought to an issue by means of the fire game. That this is possible only in a Kriegsspiel involving but small subdivisions of troops, and which can be worked out to the minutest details, is self-evident.

Much more important and much simpler appears to me the possible combination of the fire game with fortification Kriegsspiel. That for this purpose certain alterations and adaptations must be made therein, which will represent a very comprehensive amount of labor, is evident. But it also appears to me quite certain that thereby fortification Kriegsspiel will itself become more interesting and instructive.

FIRE-MANOEUVRES OF ARTILLERY MASSES, AND THE INSTRUCTION TO BE DRAWN THEREFROM.

Revue d'Artillerie for November, 1892. By Lieutenant Colonel COHADON, Second Regiment of French Artillery. (Officially designated to attend the artillery mass manœuvres at Chalons, in August, 1892.)

Translated by First Lieutenant CHARLES W. FOSTER, Third Artillery, U. S. A.

It is not intended, in this article, to relate in regular order the operations of the artillery brought together in the camp at Chalons, August 1st to 14th, 1892, and to give a full detailed account of the same, but simply to show how these manœuvres were conducted, and to indicate them as a whole. Afterwards, the conclusions drawn from the circumstances observed during these manœuvres will be stated, together with the reflections suggested by them.

General Character of Mass Manœuvres of Artillery.—These, as is known, are the manœuvres as a whole, of the artillery units (batteries and ammunition trains) which accompany an army corps. This considerable force of artillery manœuvres independently of troops of the other arms, and when it takes a combat position, instead of firing blank cartridges, opens a real fire upon objectives which from their position, shape, and number, simulate, as completely as possible, an actual enemy. Such manœuvres are therefore absolutely distinct in character from the autumn manœuvres, and constitute, so to speak, the crown of technical and professional instruction for artillery officers. Moreover, very great interest attaches to them from the fact that instruction is then imparted by the highest officers of the French artillery.

Their Aim and Utility.—Their aim is to indicate how to manage the large artillery units; and, in this respect, they are the school of the colonels and generals of this arm. But, aside from these larger lessons, they are also the source of much information of a minor cast, but which is nevertheless extremely interesting and useful, and which may be reflected upon with advantage by artillery officers of all grades.

Again, they serve to resolve certain practical tactical or technical questions which could not be experimented upon did the batteries manœuvre with the other arms.

Composition of the Artillery which executed the Mass Manœuvres of 1892.—The artillery troops brought together in 1892, at the camp at Chalons, in order there to execute mass manœuvres under direction of the Division General, President of the Artillery Committee, comprised seven groups distributed into divisional and corps artillery as follows: The artillery of two divisions, composed in each case of two groups of three mounted batteries each (9 cm. guns), and two ammunition sections; the corps artillery, composed of a group of three mounted batteries (9 cm.), a group of three horse batteries (8 cm.), a group of two horse batteries (8 cm.), and two ammunition sections.

The artillery staffs of the army corps and the divisional and corps artillery were constituted according to regulation methods.

General Prescriptions.—At the outset, the following prescriptions were ordered:

1st: The various elements of the batteries will march in the order set down in the *Regulations of December 28, 1888, for Field Batteries*, which should be consulted in all matters of detail.

2nd: Batteries and ammunition sections, in column upon the roads, will occupy the places assigned them in the Staff Officers' Campaign Hand-book (3rd Edition, May 1, 1890).

3rd: For the execution, regulation, and conduct of fire, and the replenishment of ammunition, the ministerial orders in force will be conformed to.

Manœuvres of the first week.—During the first week, each force of divisional artillery and the corps artillery manœuvred separately; then each divisional force, reinforced by one or two groups from the corps artillery.

The different schemes for the manœuvres of this first part may be presented under the following general form:

"*A division covered by a normal advanced-guard (a group of batteries) or a reinforced advanced-guard (two groups of batteries) is marching upon . . . . by the road from . . . .*

"*It receives orders to deploy in order to meet an attack coming from . . . . The artillery of the advanced-guard establishes itself at . . . to fire upon the enemy's artillery posted at . . . . The batteries of the main body go to the support of the advanced-guard artillery, and take position at . . . . The enemy is repulsed; the infantry moves forward; the artillery, in order to support the movement, advances to a second position where it continues the action against the hostile artillery, opposes itself to counter-attacks of the adversary, and, finally, paves the way for the assault of the infantry by concentrating its fire against the point of attack.*"

In the first combat positions, the artillery opens fire against the enemy's batteries at distances varying from 2500 to 3500 metres. The distances from the first to the second positions varied from 1200 to 1800 metres. The latter were so chosen that the artillery was able to co-operate during the entire development of the combat, up to and including the preparation for the assault, without being obliged to shift its position. The range was never less than 1200 metres.

Manœuvres of the second week.—During this period, the various parts of the artillery of the army corps manœuvred together.

Following is a general type of the scheme for these manœuvres:

"*The army corps is moving in two columns from . . . . to . . . . the first division on the . . . . . road; the second division and the corps artillery is following the . . . . . road. (Generally the advanced-guard of this second column will be reinforced, and its artillery will be composed of two groups of batteries.) At the moment the heads of column reach . . . . . (or arrive upon the line of . . . . .), the enemy is observed at . . . . . (Details upon the position and strength of this enemy.)*

"*The corps commander gives orders for the deployment of the first division (or the second with the corps artillery, or the entire army corps) upon the position . . . . . facing towards . . . . . .*"

For the execution of each manœuvre, the scheme indicated the hour at which each artillery grand unit was to occupy certain prescribed positions of rendezvous.

To the scheme for each manœuvre was joined an order for its development, which comprised three or four phases.

The artillery of a division engaged first of all, and was then successively reinforced by the other groups, the whole of the artillery of the corps thus deploying upon a first combat position. The fire, with rare exceptions, was directed against the enemy's artillery.

Upon the supposition that the infantry had in the meantime gained ground, the artillery was then to support this movement, by pushing forward in fractions of greater or less size for the occupation of a new position from which the artillery combat could be brought to a decisive issue. The objectives, as has just been intimated, were first of all the enemy's batteries; but, during the fire, some of the groups were directed to train their guns upon the hostile infantry. Superiority over the adversary's artillery having been obtained and the moment for the decisive attack approaching, the entire artillery concentrated its fire upon the point to be assaulted, in order to pave the way to success; and finally, the attack having succeeded, a group of horse artillery sprang forward at a gallop to occupy the conquered ground and to oppose itself to any counter-offensive thrusts that might be attempted.

The ranges at the first positions were from 2800 to 3000 metres, on an average, and the front of the deployed artillery was generally from two to three kilometres.

The distances from the first to the second positions varied from about 1000 to 2000 metres.

At the second positions, the ranges were from 1000 to 1500 metres. Against infantry, rapid and salvo fire were several times employed, particularly for the fire of concentration.

The second positions were so chosen that the batteries without changing their posts, could take part in the combat during its entire development, and, for the most part, co-operate in the fire of concentration.

Such, in general outline, were these mass manœuvres. It would be departing from the end here proposed to enter more in detail into their preparation and execution.

After this general exposition of the manœuvres at the camp at Chalons in 1892, we come to a consideration of the instruction that the writer drew therefrom; and the clearest and simplest method of presenting the same appears to be to group the remarks to be made in the order in which the events themselves were unrolled during the development of the combat.

Agents de Liaison.—But first of all, it is well to speak of the agencies through which the command is exercised, for absolute silence in this respect might excite surprise.

It was not possible to form a clear and accurate idea of the rôle of *agents de liaison*, of the advantages and inconveniences incident to their employment, or of other agencies that might be substituted for them. Indeed, in order to obtain a just view of the questions to which the exercise of command gives rise, it is not enough to have beheld the commander for a few hours and at a distance; it is necessary to have actually commanded oneself, in order to be really acquainted with the material difficulties which arise upon the manœuvre ground or the field of battle in consequence of the distance of the point at which the order is to be executed, the greater or less intelligence with which it will be transmitted, and the events liable to happen during the time of its transmission.

However, it is proper to state that no criticism on the employment of *agents de liaison* was made, and that apparently no great embarrassment was experienced in the exercise of the command.

Marches near the Enemy.—The regulation prescriptions relative to the way in which the battery shall march, and the arrangement to observe in each of its elements, respond well to the exigencies of actual service. However, it may be asked if when the carriages of mounted batteries in the field are in column of files, it would not be preferable to adopt the following as the normal order of march, as is the case with horse batteries: The six pieces of the battery, then the three caissons under charge of the chief artificer. But this question is of little importance.

It is known that the battery combat trains have sometimes been the cause of false movements, on account of their not being formed in time. The assembling of the combat trains of three batteries of a group is not always easily effected; moreover, it should be remarked that when these trains are brought thus temporarily together, they do not constitute a sufficiently homogeneous whole, and cannot be as effectively commanded as could be desired, especially with the new current of ideas which assigns to the major the duty of watching the expenditure of ammunition and assuring its replenishment. These trains ought then to be absolutely in his hands, and be taken entirely from the control of the battery commanders. Therefore, it appears to me to be preferable, if it is possible to do so, to consolidate these trains, thus forming of them a new unit of supply,—the group combat train, under the direct authority of the major.

This modification appears to me to have the following advantages:

1st: Lightening of the battery in the field, so that in case of need it could be reduced to the battery of fire and its regimental train.

2nd: Lightening of the entire group, the carriages of which could be somewhat reduced in number: it is evident that the combat train of the group—the organ of replenishment for the three batteries taken as a whole—will not require the total of the trains necessary for the batteries acting separately.

3rd: The service of supply will be better assured and better directed: it will be entirely in the hands of the major, who will be responsible for this service.

4th: Simplification in marches and manœuvres. This rule may be set down as fixed and absolute. The group combat train will always march immediately after the three batteries of the group in movements to the front and immediately before them during retreats.

The limits of this study will not permit a deeper examination of this question, which, moreover, presents certain difficulties, though of a nature foreign to the considerations with which we are here concerned.

Positions of Rendezvous and of Waiting.—A distinction is made between these, although they are frequently confounded in practice.

The position of rendezvous is that assigned to a force at the beginning of an operation or manœuvre; in the field it is the position in which, in certain cases, a force is halted preparatory to deploying. The position of waiting is that taken up by a battery, when, having arrived near its combat position, it is desirable to remain concealed from the enemy before coming into action.

Here are, according to my experience, the considerations which should be presented upon the selection and occupation of these positions. The rendezvous position should generally be at quite a distance from the enemy, and be screened from his view and sheltered from his blows. The troops there should assume the formations best suited to the character of the ground; and it is there that the combat trains should be formed, if this has not been done previously. The preparatory combat dispositions should also be there made, if it does not seem practicable afterwards to take up a position of waiting.

The position of waiting, when it ought to be or can be taken, should be in as close propinquity as possible to the combat position. It is essential, in every case, that it be out of view of the enemy, and that the batteries be able to reach it unseen by him.

All prescriptions relative to secrecy with respect to positions and marches deserve great consideration, for it is an established principle that surprise of the adversary is one of the best guarantees of success in artillery engagements.

In the position of waiting, the batteries usually are formed in mass or in line, with open or closed intervals, facing the combat position which they are soon to occupy. The choice of formation depends especially upon the character of the terrain and upon tactical conditions; but it should never be lost sight of that the formations with closed intervals necessitate subsequent rather long spreading-out movements, which may, moreover, lead to uncertainties and irregularities in coming into battery.

The batteries should make preparatory dispositions for the combat, if this has not already been done. As it is of extreme importance to open fire as quickly as possible after the pieces are in battery, it is well to prescribe that they be loaded as a part of the preparatory preparations. This measure has hitherto been sometimes employed. It is one that has never presented inconveniences, and it is expedient to make its employment general.

Selection of the First Combat Position.—This position, as respects artillery, will usually be a crest, behind which the batteries will be established, so far as possible unknown to the enemy. The slope upon which they are installed should not be so steep as to render it too difficult to place them there; yet, on the other hand, if the incline be too gradual, the batteries, in order to be put in place without being seen, must be moved by hand a considerable distance, and when the nature of the soil is unfavorable, such an operation will necessarily be performed with great slowness. The direction of this crest should not be too oblique with respect to the line of fire. During the manœuvres at the camp at Chalons, this obliquity was the cause of much embarrassment to the officers who had not taken sufficient account of it. It produced regrettable confusion in the objectives; and several times necessitated partial movements of the batteries, occasioning thus a tardy opening of fire, and a faulty disposition of the caissons and limbers with respect to the line of fire of the adversary, who was able to enfilade them.

For the purpose of reducing the effects of the enemy's fire to the minimum, and also to facilitate supervision in the battery and the service of it, it is recognized that in the order in battery, the limbers and caissons should be in prolongation of the piece carriages. If, therefore, the crest to be occupied is not perpendicular to the line of fire, and if (as will naturally happen unless care is exercised) the battery is moved up in a direction nearly normal to the crest, a vicious disposition of its elements will necessarily result, or if it is thought proper to bring the battery into a regular formation, it will be necessary to move guns, limbers, and caissons,—a matter that may involve serious consequences. The disposition by which fire would be opened with the pieces placed obliquely with respect to the front of the battery and with the limbers and caissons obliqued so that their axes would be parallel to those of the gun-carriages (these various elements remaining practically on their own ground), would be an insufficient palliative, because in the trace of each gun-carriage would be the limber or caisson of another section, and this disposition would result later in confusion and disorder.

Other opportunities will present themselves for returning to this very important question.

The plan of taking position behind the crest has been erected into an absolute principle. The facility with which batteries formerly moved beyond the crest is thus suppressed,—a disposition made use of on account of the possibility of obtaining a better view and of abolishing the dead angle beyond the front.

The rigor of this rule implies that the artillery shall be protected from all enterprises on the part of hostile infantry and cavalry on its front and also upon its flanks. This security is obtained by the concurrence of the other arms, which should, under all circumstances, aid and protect the artillery in their vicinity. However, it may, without rashness, be said that a strict application of the principle of putting the artillery in position behind the crest, must lead to the revival of the old question relative to artillery supports.

Notwithstanding all that may be laid down on the subject, it will sometimes be absolutely necessary to take post beyond the crest. It appears to me then essential that the battery should see well the objectives and the surrounding terrain, and have a clear field in its front,—in a word that it profit from its position to develop its offensive qualities, while at the same time it should, if possible, endeavor to conceal itself from view. In the latter respect, and leaving out of consideration the cover afforded by the terrain occupied, the mass manœuvres we are considering showed that artillery is little visible when placed in front of a wood, as in this case it projects itself upon it; that the position upon the crest itself is less defective than it appears to be at first sight, because the estimation of the range is often erroneous, and the long shots of the adversary will furnish no clew for its correction; and that such a position is always to be preferred when the ground is of a light hue, either naturally or on account of the vegetation covering it.

Again, it was attempted at the camp at Chalons, to take post within the border of the wood. This position, when it is possible to assume it, may be very advantageous, especially with the employment of smokeless powder.

Reconnaissances.—A good reconnaissance of an artillery position requires that it be made with discretion, and that it be complete. These are the essential characteristics. Moreover, the reconnaissance should be made rapidly, and, under some circumstances, this requisite outweighs all other considerations.

Discretion should be exercised in making reconnaissances to the end that the attention of the enemy may not be drawn to them and the advantage lost of an unexpected coming into battery and opening of fire.

Reconnaissances should be complete in order that the batteries as soon as they arrive may be perfectly well acquainted with the position, and thus avoid all hesitation and confusion and everything tending to delay their movements and their fire.

In order that a reconnaissance may be discreetly made, the party engaged should be small, and the movement should be as much disguised as possible. In consequence, only the personnel strictly necessary should be employed (the staff officers and the orderlies not essential in executing the work, being left at some distance in rear of the crest), and the reconnaissance should be made on foot, if the condition relative to rapidity will permit.

Here is the complete mechanism of the reconnaissance of a battery position. It is a type which should be approached as nearly as the conditions of a particular case will permit; but it should be understood that there is nothing of an absolute character in what is to be stated, and that the reconnaissance is, above all, subordinate to the exigencies of the combat.

The reconnaissance of battery sites should be made by the commander of the divisional or corps artillery, the group commander and the battery commander. These three successive reconnaissances are made from different points of view, according to the functions and duties of each of these officers.

The reconnaissance of the first bears at the outset upon the part of the hostile position that is to become his target, and upon the extent of front that his groups are to occupy. These points having received his attention, he calls up his group commanders and indicates to them the portion of the opposing lines that is to become the objective of the batteries of each, and distributes between them the front to be occupied by the artillery. These are two essential prescriptions, and negligence in their application is likely to involve either an imperfect distribution of fire or great disorder in coming into battery, arising from the fact that the group arriving first will take the most plainly visible objectives or will not think to leave sufficient space in the line for the succeeding groups.

After giving these directions to the majors, the colonel commanding the artillery continues his study of the terrain, having in view the subsequent steps of the combat and the movements which he will have to order later.

It is evident that, in the majority of cases, the colonel, but he only, will be obliged to show himself. This will be done without inconvenience, for the presence of a single horseman upon a crest will not seem to the enemy an indication of any importance. When the colonel is joined by the group commanders, the party thus formed, if seen, is likely to arouse the suspicions of the adversary; it is therefore necessary that these join him covered from hostile view.

The reconnaissance of the major should, at the outset, be for his batteries, what that made by the colonel was for the groups, that is to say, his first care should be to select each battery's objective and to fix for each the extent of front it is to occupy. This reconnaissance will be less summary than the preceding. If the direction of fire is oblique to the crest, the major will precede his batteries into place, and indicate the dispositions to be made in order to obviate this inconvenience. Depending upon the character of the terrain and the degree of obliquity of fire, he will prescribe that the batteries establish their fronts respectively parallel to the crest, the limbers and carriages being in the track of their respective guns; or that the batteries place themselves in echelon, their fronts perpendicular to the direction of fire, one of their wings resting on the crest; or he will direct such other dispositions as the circumstances of the particular case suggest to him.

It is recommended to the major to estimate as exactly as possible the distance of the points to be aimed at, and, to this end, to make use of all means at his disposal, including the range-finder, if the group staff possesses one. This is an evident means of accelerating the regulation of the fire, and of rendering it quickly efficacious.

After these matters have received attention, the major will concern himself with the places to be occupied by the combat trains.

When all these various questions have been decided, the major calls up the battery commanders to give them their instructions. To each is indicated the objective of his battery, the formation to assume, the extent of front to be occupied, and the position of the reserve ammunition caissons.

After having thus instructed his battery commanders, the major continues his study of the terrain with reference to the approaches to the position, the more or less dangerous dead angles which may be on the front or the flanks of his group, and the means of remedying defects in the position and of avoiding surprise. He establishes relations with the commanders of the neighboring troops, in order to assure himself of their support in case of need. He devotes himself particularly to the means to be adopted to change the position of his batteries, either to the front or to the rear, without discovering their movements to the enemy.

The battery commander makes reconnaissance of the ground assigned to his battery. This should always be executed on foot, and to this end he halts with the mounted men who accompany him, far enough in rear of the crest to avoid being seen from the front, and he and those with him who are to take part in the reconnaissance, dismount.

The reconnaissance on foot is indispensable, not only from the point of view of discretion, but also in order to assure the prompt opening of fire by the avoidance of all useless movements of the guns by hand. The captain should, as it were, trace the line on which the wheels of his gun-carriages are to stop, and for this it is necessary that he be dismounted and that he stoop to the front as does the gunner in laying the piece in order to assure himself that the objective will be seen from each gun. It is essential that he indicate clearly to his lieutenants and even to his chiefs of sections, if not the ground to be occupied by each piece, at least the positions where the extreme pieces are to be located, and even, although this may seem a superfluity, the interval between pieces. Also, he ought to indicate and even to actually mark out, in the center of the battery position, the direction of the line of fire.

The captain is left to decide, according to the circumstances of a particular case, as to who should accompany him in reconnoitering. On the one hand, there is an evident advantage in restricting the size of the party to the minimum; but, on the other, it is well that the greatest possible number of officers and non-commissioned officers of the battery should receive directly from the captain, upon the very ground to be occupied, all details relative to coming into battery there and to the fire of the battery. Experience in the mass manœuvres we are considering clearly showed the exceptional importance of a well-conducted reconnaissance, the results of which are well known in advance by all, especially as a means of assuring a proper direction to the carriages in coming into battery.

Occupation of the First Combat Position.—All preliminary dispositions are made; everything is prepared for coming into action. It is essential to prolong the enemy's ignorance up to the last moment and to strike him with great suddenness and at the same time as effectively as possible. These are the conditions which render all the preliminaries so important, and which make the favorable occupation of the combat position and its concealment from the enemy, one of the surest elements of success, as well with respect to material effects as to the moral influence arising therefrom.

Here, still, everything depends upon the ground, the weather, and the enemy. If absolute rules cannot be fixed, one may at least affirm that this is the moment when it is more than ever necessary to act quickly and to the purpose. It is well here to recall and to practice the advice of a celebrated physician who, when about to perform an operation in the presence of his students, in an urgent case, said to them: "At such a time we must act quickly, but let us not hurry."

Experience at the camp at Chalons demonstrated that a precipitate coming into battery was generally faulty, notwithstanding the terrain was singularly favorable to rapid gaits, and batteries which assumed this formation in a methodical way after due preparation had been made and with a slowness apparently inadmissible, were seen to open fire before those that came into battery at a rapid pace.

In this connection, I cannot but express regret at the suppression, in the regulations relative to mounted batteries, of the method of coming into battery at a walk. The general practice of the battle field, which will seldom permit a faster gait at this time, is thus sacrificed to a vain parade display on the manœuvre field. Lack of excitement as respects men and horses, the preservation of order during the movement, and precision in halting, make for more than a rapid gait in insuring a quick coming into battery and opening of fire.

The first question which presents itself is, Who is to lead the battery to its position?

The captain is already there, the Regulations even assign him a place; the battery is in its position of waiting, which is at a greater or less distance to the rear; is the captain to go there to seek his battery while stationing someone else at his regulation post, or will he send his first lieutenant the necessary order for conducting the battery to its assigned position? Here again there are no fixed and absolute rules. My opinion is that the captain should be left free to act according to the distance, the character of the terrain, and the orders relating to details which he finds it necessary to prescribe. It will be sufficient in every case, that accuracy and promptness in coming into battery be assured.

At the camp at Chalons, the most varied dispositions were employed by the batteries in reaching the first combat position and coming into battery. I shall here set them forth, at the same time giving some information relative to the conditions of their employment. Each of the methods tried has advantages in particular cases, and it will be useful to officers who may be called upon to execute such operations, to have the benefit of the experience resulting from the manœuvres in question.

Among the regulation methods the most frequently employed for coming into battery, may be cited the deployment of the column of platoons, and immediate coming into battery; and the same deployment followed by a march in line with full intervals, and a subsequent regular coming into battery. I take occasion here to express regret that in the Regulations, the formation formerly known as column of attack has been suppressed.*

The center platoon being at the head of the column and each of the wing platoons being in column of sections in rear of the nearer section of the leading platoon, line is formed by deploying the sections of the wing platoons to the right and left. The reasons which led to the rejection of these movements are of secondary importance in comparison with the advantages which they present, especially in the case of actual evolutions. This formation, indeed, furnishes the most rapid mode of forming line of columns and of masses, at the same time that it permits the most rapid deployment of these two formations and upon ground of minimum depth.

The column of attack presents still another advantage from the point of view of coming into battery. As is known, and as has already been insisted on in this article, the captain, during his reconnaissance of the terrain, should indicate in the plainest manner possible the point where the center of the battery is to rest, and the direction to be taken by the carriages in reaching their places. With the column of attack, the chief of the center platoon, marching at the head of the battery, will evidently have every facility for properly guiding himself by the indications furnished by the captain, since he has only to follow a line actually marked out, and to halt at a well-defined point. This is only a detail, but a detail that nevertheless has its value.

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* In the new manœuvre regulations for the German field artillery, of June 27th, 1892, we find a method of ploying the battery into column of platoons with the center platoon in advance, and a corresponding deployment to the right and left on the head of the column. —Editor *Revue*.

The following methods were also employed during the manœuvres: Upon favorable ground, the battery marched in line with open intervals, and then went into battery in the regulation manner. Again, it marched in line with closed intervals, taking open intervals as it approached the designated position, and then went regularly into battery. In the latter case, it was necessary to see to it that the carriages were properly dressed, and that they marched in parallel directions, before giving the command to form in battery, under penalty of bringing the battery into position in disorder. This manœuvre requires ground to a great degree open, and of considerable extent, between the position of waiting and that of combat.

Concerning the regulation method of coming into battery, the following inconveniences, in the light of present ideas upon the manner of engaging artillery, may, in general, be noted.

1st: The piece before being brought to a stand upon the position in which the gunner will be as little exposed as possible in pointing, will, with the limber and its teams, arrive too near the crest, will sometimes, indeed, even pass it, and thus the battery will be unmasked before the opportune time. It is proper to remark also, that this inconvenience is still further aggravated by the mistake which is almost always made by the limbers in moving more or less to the front before making their two successive wheels to the left to gain their places in battery. This serious fault results from the fact that the drivers are instructed to move off abruptly at a trot from a walk in wheeling to the left, a thing that is generally impossible. To remedy this, it should be prescribed to the lead and swing drivers to turn their horses with force to the left without tightening the traces, immediately after the carriage is halted; and for the wheel drivers, after the piece is unlimbered, to do likewise, turning the limber thus to the left without advancing; the pairs being again in column of files, the limber will then make its second left wheel in order to move to its place in battery, taking up the trot if this increase of speed be necessary.

2nd: The pieces moving at a trot do not halt exactly upon the designated battery front. As a rule they go beyond it, and there result useless by-hand movements, and a premature disclosure of the battery position.

3rd: When marching at a trot, especially on difficult ground, the carriages do not always preserve a good direction; in consequence the limbers and caissons cannot put themselves in the track of their pieces, and the in-battery formation is so far defective.

The methods we are considering were also employed with the following modification, which served to prolong the invisibility of the battery. The pieces were halted in rear of their position in such a way that the personnel remained completely concealed, and were then unlimbered and run by hand to the front to their respective positions, the other elements of the battery taking their proper places in battery. This is an excellent mode of operating when the form and nature of the ground are such that movements by hand do not become too prolonged and laborious.

At other times, in order to render the movement less exposed to view, the drivers and chiefs of section were dismounted, and the teams led to the battery position.

Under still other circumstances, the guns may come into battery, with closed or open intervals, in rear of the real position to be occupied; every one is then dismounted; the chiefs of section go forward to the points where the wheels of their piece carriages are to rest; the piece teams are then led to the front by the drivers, who cause the pieces to execute a wheel to the right or left, and to halt upon the line marked for the front of the battery, the carriage wheels close to the chiefs of section; the pieces are then unlimbered, and come into place no longer by an about but by a simple turn to the right or left; the limbers take their posts, and the caissons close up.

This method will be advantageous under many circumstances, particularly on heavy soil, where movements by hand would be very difficult.

If the character of the ground lends itself thereto, the same method may be employed with the drivers mounted.

The manœuvre is more simple with open-intervals; and in all cases care should be exercised during the movement that the caissons do not become too far separated from their pieces.

The manœuvre will be still further facilitated if the guns can be led into battery, not from a point behind the position actually to be occupied, but from one a little in rear of one of the flanks of this position.

When the guns have come into battery and opened fire, the sheltering of the limbers may be ordered. The commander of the artillery is alone competent to give directions for this, because only he has sufficient information to judge whether or not it is advisable. To shelter the limbers is to produce the serious inconvenience of rendering the battery stationary, leaving it thus in a critical position while exposed to the hazards of a battle field.

It has been recognized as dangerous to shelter the caisson teams. By not unhitching from the caissons, the inconveniences attending the *eloignment* of the limbers are in part made up for. Let us suppose, for example, that cavalry, by a fortunate dash, is on the point of over-running the battery. The limbers and caissons will be able to beat a retreat, and the pieces remaining in place cannot be used by the enemy in default of ammunition nor be removed for lack of teams.

In concluding this important question relative to the occupation of the first combat position, a word remains to be said upon the place of the combat trains. These have almost always been placed in rear and outside of one of the flanks of the group. This position is, in principle, good, although it renders replenishment of ammunition in the opposite wing somewhat slow, and obliges the caissons executing this work to make flank marches in rear of the guns, over ground covered by the enemy's fire. But is there not still another inconvenience to be feared? The intervals left between the artillery groups are spaces reserved to the other arms and to the auxiliary services.—Will such ground therefore be at the disposal of the artillery? For these various reasons, I prefer to assign to the combat trains a sheltered position in rear of the center of the group.

[TO BE CONTINUED.]

NOTES ON ARTILLERY.

Long Guns. Translated and summarized by Lieutenant Cornélis DeW. Willcox, 2nd Artillery, from *La Marine de France*, Vol. I, No. 6.

For many years, investigators of explosives have sought to reduce rapidity of combustion. The efforts made have resulted in an increase in the length of guns and hence in the muzzle velocity.

Four or five years ago, a length of 35 or 36 calibers was considered very great. In 1889 and 1890 the French Navy constructed pieces of 40 and 45 calibers, while the Canet guns of those dates were longer yet.

We are naturally led to dwell upon the latter, for they were the first built and installed on board ship, and they have always, both in France and abroad, formed the basis for discussion in respect of length.

In 1889, M. Canet built guns of 32 cm., L/40., giving a M. V. of 730 m. to a projectile of 450 kg. In 1889 and 1890, he experimented with guns of 10 cm., 12 cm., and 15 cm., L/48, giving a M. V. of 880 m. with high pressure, and of 800 m. in service, without exceeding 2400 atmospheres. Always advancing, he has since built guns of 70 and 80 calibers, with a M. V. of 1000 m. and over.

Various objections have been made to long guns.

I. *Resistance of the piece.*—In the first place, it has been argued, that the chase of a long gun is inherently weak. To this it may be replied, that the vibrations of the metal and of the piece do not affect the life of a long more seriously than that of a short gun, so long as permissible service pressures are not exceeded. And similarly of erosion. The vibration of the gun is hurtful in direct proportion to the number of elements of which it may be composed, and not in proportion to the length.

II. *Deflection of the muzzle.*—As regards the rigidity of the chase, it is a fact, that in certain navies even medium lengths have been found imperfect. Thus certain guns, L/35, furnished to Russia by Krupp, have revealed after being fired, a permanent droop varying from 3 to 13 mm. Such deviations of the axis, when permanent and exceeding certain limits, affect accuracy of fire, and may produce accidents, in consequence of the jamming of the projectile. In any case, the balloting and friction injure the rifling.

Deflection may be due, however, to causes other than repeated vibrations. For example, and especially in the case of older guns, the chase bends often under its own weight. After noting a very slight deflection in one direction, one in the opposite may be noted if the gun be turned through 180°.

We must guard, here, against confounding elastic with permanent deflection. The former manifests itself in all guns: it cannot be avoided, but must be reduced to a minimum by a *tracé* rationally investigated. The thinner the tube, and the more it is loaded with hoops, the greater the tendency of elastic deflection to display itself. Hence the unhooped tube of the Canet system, and of the new navy guns.

Vibrations have a permanent effect upon the chase proper, apart from the dislocation of hoops, only when the metal itself has been subjected to irregular initial tensions. The consequent defects, therefore, depend directly on the mechanical treatment of the metal itself. This question affects long guns only in so far as their greater length imposes greater difficulties of treatment, and furnishes no reason in itself against their existence. If the metal be defective, the gun rapidly deteriorates, but this is absolutely independent of the length of the gun. Hence special precautions are necessary in the manufacture of very long guns.

The present tendency is to lengthen guns. The French navy is building them 45 calibers long, up to a caliber of 30 cm. Colonel de la Roque, the present director of artillery has ordered from Canet pieces 55 calibers in length. At Ruelle a piece of 15 cm., L/90, has been successfully tried. Krupp has got up to 40 calibers, and will probably go further. Elswick has gone up to 100 calibers, but this piece, composed of parts screwed together end to end is hardly a service gun.

It appears that in the future, great length will be the rule.

III. *Installation on board ship.*—This question involves serious difficulties. Taking actually existing ships, it is no easy matter to equip them with very long pieces. If installed, they are hard to work. A solution may be reached by substituting pieces which, while of inferior caliber, have counterbalancing advantages. Evidently, however, the question of emplacement will have to be investigated from the point of view of the gun—that is, if the expression may be allowed, the ship must fit the gun, and not the gun the ship.

IV. *Advantages of great length.*—The disadvantages are far outweighed by the advantages of great length. We have first a notable increase in muzzle velocity and hence in energy, perforating power, and flatness of trajectory. For the same angle of projection, the range is greater, as well as the dangerous zone. If fire be opened on a target 6 m. high, with a 57-mm. gun, M. V. 1000 m., projectile 2.7 k., there will be first a dangerous zone from the muzzle to the point of fall for the trajectory whose maximum ordinate is 6 m. This zone is 1524 m. wide. Next there will be a second zone up to the point of fall for the trajectory whose ordinate is 6 m. at the end of the first trajectory, with a width of 1806 m. For a freeboard of 2.5 m. (torpedo-boat), the extreme points of the corresponding trajectories will be distant 1101 m. and 1403 m., respectively. If we suppose two sight-notches, answering the one to the first, and the other to the second trajectory, the latter will be used from 1800 m. (target 6 m. high), and from 1400 m. (target 2.5 m.). Supposing the target to approach 200 m., the gunner will use the first notch, after running the slide down by a simple pressure of the hand. Point blank fire is thus up to 1500 m. and 1100 m. completely, and up to 1800 m. and 1400 m., satisfactorily, realised. This result is of great importance.

For the 10-cm. Canet, L/80, projectile 13 k., M. V. 1000 m., we have:
6-m. target. 1st dangerous zone, 1835 m.
2nd dangerous zone, 2240 m.
2.5-m. target: 1st zone, 1262 m.
2nd zone, 1761 m.
This gun at the muzzle will pierce 50 cm. of wrought iron.
at 1500 m. will pierce 30 cm. of wrought iron.
at 2500 m. will pierce 20 cm. of wrought iron.
This piece, therefore, all things considered, is superior to those [of the same caliber] firing a heavier projectile with a smaller M. V.

Passing by the increased accuracy resulting from increased velocity, we may finally note the importance of rapidity of fire. A great deal has been already accomplished by simplifying the service of the piece. But the gunner must be enabled to follow the target by simple changes in azimuth and in angle of sight. In particular must he be freed from adjusting the sight to the varying range. In other words point blank fire must be approximated to as closely as possible, thus minimizing the importance of the sight, and making it almost unnecessary under 1800 m. This is the important result of increased velocity. The considerations given, viz.: increase of power, accuracy and efficacy, special facilities in aiming, emphasize the significance of muzzle velocity, and justify all efforts made to increase it.

From my diary: Memoirs of the siege of Diedenhofen in November, 1870. Translated and summarized by Captain William A. Kobbé, 3rd Artillery, from *Jahrbücher für die deutsche Armee und Marine*, October, 1892.

Diedenhofen (Thionville) was a fortified town astride the Moselle about 20 miles north of Metz and 15 from the neutral frontier of Luxemburg. The place had 8000 or 9000 inhabitants and a garrison of 4000 regular troops. The works consisted of an elaborate bastioned enceinte by Vauban and Cormontaigne and belonged, therefore, to the "cut and dried systems of fortification" which, according to Major Clarke, "have no longer any place in military science." They were, moreover, tactically indefensible; for, while they commanded the railway and valley, they were, in turn, commanded by the hills on both sides,—some good artillery positions being within 1500 meters. After the battle of August 6th had uncovered the fortress, "a few weak and insufficient detachments of landwehr" promptly (August 8th) occupied these hills to "observe" it. Later, especially when it seemed likely that Bazaine might attempt to break through in that direction, the observing force was strengthened until it consisted of five regiments of cavalry, three landwehr battalions and one horse battery. To these, early in October, two infantry battalions of the line were added and in one of them the anonymous diarist served as a subaltern. About the middle of November a division of regular infantry was available, the place was closely invested and, finally, bombarded for 52 hours from 128 siege guns and 30 mortars, when it surrendered with 120 officers, 4000 men, 187 guns, together with depots of munitions of war,

&c. About 9000 hostile shell had been flung over the ramparts with the accuracy born of deliberation and leisure.

The operation thus slightly sketched merits no other mention than the page or two it receives in the German official account. It was the merest episode in an epoch. Not so, however, with the soldierly, lifelike and altogether charming narrative, made up from notes jotted down from day to day by this young officer bivouacking in the mud of interminable rains. All that can be done here, however, is to give a few extracts from them and to express eternal regrets that the whole art of war cannot be re-written in the light of notes of this kind, whether they cover a reconnaissance, a campaign, or, as do those of de Marbot, a lifetime in the field.

"We were excessively bored; for there was little of honor or glory to be had from outpost duty in mud and rain, especially as the enemy, immediately after our arrival, took back some broken heads from a sortie made against us, and left us thereafter entirely alone. After this lesson any investing troops wearing the helmet were unmolested while, for the same reason, the landwehr men, who wore forage caps, were incessantly harassed, &c."

And thus the Prussian helmet was of some service, after all. Solitary instance!

Thereafter, whenever a sortie seemed imminent, the helmets were quickly transferred to the point where it was expected.

"And wonderful to relate! wherever troops of the line took position there reigned the most profound tranquillity: we slept at night as if in Abraham's bosom and during the day had only to look out for the shells which the French fired at us with great regularity once after each meal,—apparently to amuse the ladies of the garrison, who, with the aid of a field-glass, could be seen, looking on."

Some days were noisier in the fortress:

"With the dawn began the continuous drumming and bugle-blowing which had puzzled us the whole previous afternoon. One 'call' followed another: one could even hear the words of command, the driving of nails, the noise of falling boards in the work of constructing bomb-proof shelter. They make a devil of a racket, these French! What a contrast to the stillness at our outposts, where no 'calls' are allowed in active service"

One night there was an alarm and the troops stood to their arms:

"About 8 o'clock in the morning we went back to quarters, after standing three hours in the cold grumbling and swearing."

Just like the human beings they were and like the American volunteers,—which they were not.

When all was ready for the bombardment the diarist's company and another were assigned to the support of a battery, their only available shelter being a masonry garden wall directly over which the hostile shells would pass:

"This wall concealed us; but in order to protect the men from indirect fire they were placed in one rank behind it and ordered to sit with their backs close against it. Only those fragments might hit which were driven backward or which had a large angle of fall. My own company was the more exposed as, from lack of room, it was obliged to sit, mostly, in double rank. The sticky, ankle-deep mud made any movement difficult, but during the night we had emptied the barns of straw and had strewn it thickly all along the line. * * Of course our two infantry companies caught everything that went over the guns. Such a hail of fragments, humming like bees, I never saw before, even at Königgratz. * * * The most interesting part of a newspaper which I was reading was torn out by a piece of the wall driven through it and I was expressing my annoyance when the man next to me jumped up crying: 'Herr Lieutenant! I'm hit!' 'Have the goodness to keep your seat, it probably don't amount to much,' I replied, pulling him down by his coat at the same time. 'Where's the trouble?' 'I don't know sir, but I felt a powerful blow in the back.' 'Off with your knapsack—let's examine into it!' I ordered. Then I found the whole upper part of the knapsack torn, and a fragment of shell, still hot, lying between shirt and undershirt. * * The man was uninjured."

Later on the lieutenant was ordered, with his platoon, to occupy a large village near the glacis,—which, in spite of infallible German maps, he had much difficulty in finding:

"I had great trouble in keeping the men up to their work, for they were worn out with fatigue, short rations and lack of sleep. * * * It will give an idea of their exhaustion, to state that I was obliged, personally, to fetch every relief of patrols and sentinels and post them, no non-commissioned officer being able to keep awake. I could not even rely on their vigilance if they were left without supervision * * and I have spent the whole night between posting reliefs and actually standing guard with the sentinels."

Finally the fortress capitulated, the first duty of the new German garrison being the protection of the inhabitants from the drunken and demoralized French soldiery.

"There were but few noticeable traces of the effect of the bombardment on the works * * and but few damaged guns. * *

Of all the 8000 *or* 9000 *inhabitants,—men, women and children,—not one was injured. The loss of the* 4000 *troops of the garrison was* 17, *including the wounded.*

Ce n'est pas magnifique, mais c'est la guerre.

Mathematical Aiming, by Contre-Amiral Reveillère. Translated from *La Marine Française*, December 4, 1892, by Lieutenant Charles C. Gallup, 5th Artillery.

The article, "Future War," which appeared in the publication by the German General Staff, contains this phrase: "France has reached the limit of her military power, every Frenchman being summoned to and trained in the service."

This is not exact. Certainly, in war matériel, man surpasses all, but capital must not be forgotten. Money is also a military force, because it is that which assumes the form of the most perfect armament, which is always expensive.

Now, of all the instruments of warfare, the most perfect, the most expensive, but also the most powerful, is certainly the man-of-war. The ship is, *par excellence*, the weapon of industrial and wealthy nations.

We must not lose sight of the fact that if we were able to prolong the war of 1870 with certain honor, it was only because we were masters of the sea.

It is necessary to admit frankly, as the Germans say, "that on the frontier the struggle is uncertain." We must hope for the victory, we must even believe it, but we must act as if the chances were equal, as our adversaries also affirm.

Now, if the chances are equal, superiority at sea assumes immediately an importance of the first rank. With a doubtful struggle on the frontier, and conquerors on the sea, we remain masters of the situation.

If on land money is the "sinews of war," it is much more so on the seas. The empire of the sea can only be acquired by the perfection of personnel and matériel, a perfection always burdensome.

We must acknowledge that at any given instant, the sea may be our last stronghold, but we must also acknowledge that the sea power is expensive.

On the other hand, it is evident that a nation bled to death by taxation, will soon succumb under the weight of its armament, as a sick man clothed in heavy armor.

It is for parliament to decide how much may be devoted to armament without exhausting the nation. It is for the experts to determine the nature of this armament. Number is important, but quality more so. Let us not hesitate to prefer quality to numbers. If we are not rich enough to have many ships, let us have few ships, but the greatest number possible of perfect ships.

It is in artillery above all, and in its manner of employment, that we must strive to reach the maximum. Without disparaging the torpedo, artillery will always remain the main weapon of the man-of-war.

Such as it is, has the rapid fire gun said its last word? No, if the rapidity of fire is not accompanied by a corresponding accuracy.

If there exists a more accurate system of fire, expensive or not, we must adopt it with the shortest delay; because on the day of battle, it will be still more costly to have magnificent ships armed with admirable cannon which have but one defect: missing the target. Tireless study and the pursuit of perfection in the numerous details can alone give us the victory over our competitors who, in this epoch of transition, start free of the weight of old things: matériel, personnel, ideas. While admiring an honorable past, we cannot persist in wishing to live amongst the dead, we must have confidence in new creations and in a forward movement.

The optical sight of Commandant de Frayssex is a beautiful example of the result of persevering study. To replace rapidity of fire by accuracy of fire, has been his object.

That is to say, to replace the apparent rapidity by the true rapidity, since in the same time more hits are made although firing fewer shots. It is then with rapid fire guns and small arms, that optical fire or accurate fire is the most necessary.

Do we imagine that we can frighten our enemy by deafening him with a useless noise? Unfortunately we have before us adversaries who do not tremble so easily.

A ship can only carry an extremely limited quantity of ammunition; rapid fire without accuracy will empty the magazines with as much promptness as uselessness.

Do not forget that with the present system, it is exceedingly difficult to fire accurately, and the proportion of hits to shots fired is very small.

To limit the use of optical fire to closed turrets, is to underrate the limits of the new invention. The use of the optical sight must be generalized as soon as possible.

I repeat it, because the importance of the subject excuses the repetition: what is rapid fire without accuracy, if not the waste of ammunition.

With the new system we will be able, as it appears, to form excellent gunners in a few weeks, a result that we do not obtain at present in many months. This is not a small advantage. Because, if being able to aim accurately does not suffice to make a true gunner, it is certainly the most difficult quality to acquire. The old procedure demands a long and costly education. and exceptional abilities; the new method can be promptly put into use by the first comer.

The optical sight, already adopted in principle for closed turrets, can, slightly modified, be applied to all arms. The question may be put thus: which system is preferable, the one where the individual faculties play a preponderant part or the mathematical and mechanical system leaving almost nothing to personal qualifications? Without a doubt, skill and instruction will always be necessary, but here the inherent fitness is not necessary. Pointing becomes a scientific question.

The Italians, according to the reports of a very intelligent officer, just returned from a visit to our neighbors, have already applied optical fire to their closed turrets; that was all he could ascertain, because our adversaries hide their proceedings with a jealous care.

On the other hand, Captain Akland of the R. A., has taken out a patent on optical fire and doubtless will soon supply all Europe. As has happened with us many times, after having been the first to invent, will we be the last to apply the invention?

Is it worth the trouble to apply the principle of optical fire to all arms, especially small arms? We think so, but it is after all only a belief based on the great possibilities. It is for experience to solve the question finally.

The question is worth the effort of solving and solving in such a manner as to leave no doubt. It is necessary to proceed without delay with a conclusive experiment. What can this experiment be?—Evidently to equip completely without exception all the arms of a man-of-war of the first rank according to this system and compare its fire to that of a similar ship under present conditions.

Suppose that the experiment pronounces in favor of the present armament, nevertheless, it will have been an excellent exercise profitable to all and, therefore, it will not be money badly employed.

It will be in any case an excellent subject for work, and it is very rarely that serious work is totally lost.

Gun trials of the Battleship *Ramillies*. From *Engineering*, August 25, 1893.

The new battleship *Ramillies*, which is being completed as the flagship of the Commander-in-Chief of the Mediterranean Fleet, and which has been fully described in *Engineering*,* has this week completed her gunnery trials with results eminently satisfactory, alike to the several constructors of the guns and the builders of the ship and engines—Messrs. J. and G. Thomson, Limited, Clydebank. In the first place, the diameters of the circles turned by the vessel were measured under various conditions of helms and propelling power, the ship being steered round a buoy, angles being taken at every four points turned by observers stationed at the bow and stern, using the known length of the ship as a base line. The gunnery trials were proceeded with on Wednesday. The main armament of the *Ramillies*, it may be said, consists of four 13½-in. 67-ton guns, Mark III. The secondary and auxiliary armaments comprise ten 6-in. 100 pounder quick-firing guns, sixteen 6-pounder and nine 3-pounder quick-firers, eight machine guns, and a couple of 9-pounder field-guns—an aggregate about 500 tons heavier than the secondary armaments carried by battleships of the *Trafalgar* class. The 6-in. quick-firing guns are mounted in a central battery, and are double-banked. Four are disposed on the main deck within armour casemates 6 in. in thickness at the face, and having athwart screens for the protection of the gun crew. The forward guns are arranged to train 60 deg. ahead, and the after guns 60 deg. astern. The four 67-ton guns, which are of the same pattern, though constructed by different manufacturers, are mounted in pairs in a couple of barbettes erected at each end of the secondary battery, and consequently well apart. Although they tower to a height of not less than 23 ft. above the water line, their tops protrude only 2 ft. 9 in. beyond the level of the upper deck; and as the structures are screened by the top sides of the ship, they present an indifferent target to an enemy. The axis of the guns when laid horizontally is about a foot and a half higher than the parapets of the redoubts, or a total height of 4 ft. 6 in. above the deck, which is believed to be sufficient to preserve it intact when the guns are fired direct ahead. The guns have a total length of 36 ft 1 in., with a length of bore of 405 in., equal to 30 calibers, while the rifling extends throughout a length of 333.4 in. The powder chamber is 18 in., the jacket 57 in., and the chase at the muzzle, which has a slight bulge, 23.4 in. in diameter. The full charge fired weighed 630 lb., S.B.C. powder, and the reduced charge 472½ lb., while the projectile had an approximate weight of 1250 lb. The general details of the hydraulic machinery and arrangements are precisely of the same character and design as those employed on board the *Royal Sovereign*, it having been found impossible to improve upon them. The great object aimed at has been to combine quickness of fire with perfect safety in the working. The hoists are loaded with shot and powder from different sides simultaneously. This economises time in feeding the guns; but as the path from the bogey to the lift has an upward inclination corresponding with the plane of the guns when the breeches are depressed for loading, the new system also offers additional security against accident, as there is no danger of the projectiles taking

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* *Engineering*, vol. liv., pages 197 and 412; vol. lv., page 716. See also *Ibid.* vol. li., pages 251 and 283; vol. liii., pages 287 and 530.

charge when being forced up the gradient and striking the stops against which they are to rest. It may be interesting to state that each of the 67-ton guns forming the main armament costs 13,000*l*, exclusive of its mounting, and that every shotted round fired represents an expenditure of 114*l*. The whole of the hydraulic machinery was designed, manufactured, and fitted on board by Sir William Armstrong, Mitchell, and Co., of the Elswick Ordnance Works.

Firing, according to the *Times* report of the trials, commenced with the machine, Hotchkiss, and 6-in. quick-firing guns on the upper deck. Fifty rounds were discharged from the first-mentioned in pulls of five each, four 7¾-oz. charges from the 6-pounders, four 6⅜-oz. charges from the 3-pounders, and two charges of 13 lb. 4 oz. each from the 6-in. quick-firers. The mountings withstood the strains perfectly, and it is only necessary to record with respect to this part of the programme, that cordite was exclusively used for the quick-firing guns. The trial of the 67-ton guns afterwards took place. The following is a tabulated record of the order and conditions of firing, with the recoils of the guns for each round:

After Barbette.

Gun.	Rounds.	Charge.	Elevation.	Bearing.	Recoils.	
			deg.	deg.	ft.	in.
Left gun	1	Reduced	5 elevation	Port beam	2	3½
	2	Full	5 "	10 before beam	4	1
	3	"	Horizontal	10 abaft "	4	1
Right gun	1	Reduced	"	Port beam	2	3
	2	Full	5 elevation	10 before beam	4	0
	3	"	Horizontal	10 abaft "	4	0
			Fore Barbette.			
Left gun	1	Reduced	Horizontal	Starbo'd beam	2	8½
	2	Full	Extreme elevation	10 before "	3	5
	3	"	5 elevation	10 abaft "	3	3
Right gun	1	Reduced	Horizontal	Starbo'd "	2	10½
	2	Full	10 elevation	10 before "	3	2
	3	"	5 "	10 abaft "	3	7½

The hydraulic connections were worked at a pressure of 1000 lb., and it was understood that the maximum pressure in the recoil presses was about 2700 lb. The third rounds from the guns in the after barbette were fired simultaneously, and the whole of the others independently. The second round from the left gun in the fore barbette was fired with extreme elevation for the purpose of determining the maximum recoil. This was reported to be 41 in. The recoils were, on the whole, eminently satisfactory, those of the guns in the after barbette uniformly so. There were no accidents of any kind, and with the exception of the breaking of a few panes of glass no damage was inflicted upon the ship's fittings by the heavy concussions. The hydraulic machinery proved perfectly reliable under the demand made upon it, and showed no signs of distress. The 6-in. guns on the main deck were subsequently fired. The guns, in consequence of their great length, are fitted with an arrangement for running them in and completely housing them. The gear was not tried, but previous experiments had shown that the guns beneath deck can be disconnected, suspended and brought inboard in 3 minutes 42 seconds.

American High Velocity Shooting. From *The Engineer*, September 1, 1893.

At Sandy Hook, on August 18th, a gunnery trial is reported in the *New York Herald* to have been made with the following results. A Brown segmental wire 5-in. gun, 19 ft. long, was fired with the Leonard smokeless powder. In all, fourteen rounds were fired, beginning with a 7-lb. charge, and increasing up to 20 lb. With 7 lb. the muzzle velocity was 1720 ft. per second. The last round was fired with a projectile of 62 lb. and a 20-lb. charge, when a muzzle velocity of 2865 ft. per second was obtained. This result is described as a "record breaker," and it is prognosticated that when the charge is increased until the pressure of 50,000 lb.—22.3 tons—is reached, the velocity will be in excess of anything yet achieved, including the 3711 foot-seconds obtained by the experimental Elswick 6-in. gun, 50 ft. long—100 calibers. Very probably the result above reported is without precedent, for it may be observed that not only is the velocity very high for a gun of 45.6 calibers long, but the projectile is unusually heavy, 50 lb., not 62 lb., being the weight of the service projectile for the English 5-in. piece. The combination of a wire gun and smokeless powder charge is that which naturally might be expected to give the highest result, but it is satisfactory to obtain it at what appears to have been a comparatively low pressure. There is no magic in these matters, however, and we may naturally raise the question, to what is the high result due? The wire gun supplies the strength, and the powder is the element to which we must look for the high velocity. If the pressure is low throughout, then it follows that the gun might have been a gun of ordinary strength. The value of the combination of powder and wire gun is only brought out by the development of such energy as is only to be achieved by a pressure which is too great for ordinary guns. We are not told the exact pressure recorded on this occasion, but it appears to be assumed that it was very much below the 22.3 tons, which it is hoped may increase the velocity by more than 846 ft. This would at first sight look as if, so far, the power of the wire gun had not had much to say to the matter. This does not follow, however, for the pressure was probably kept up to an unusual extent, and thus the forward part of the gun exposed to a strain which may well have called for special strength. The question is, what will happen when the charge is increased? Before the additional 850 ft. is obtained, the forward pressure in the gun will be necessarily very great, and it is also possible that with a piece of this length so much of the powder will be blown out unburned that disappointment may be experienced. Supposing, however, that success is achieved in the measure that is looked for, it is much to be hoped that the conditions may not be left in the obscurity that has already done mischief with pieces firing slow powder, but that means may be taken to investigate exactly what pressures fall on the forward parts of the gun, the maximum, which acts at the strongest part of the gun, being in such a case only one element, and very likely not the one of greatest importance. While looking forward with much interest to future results, we are unable to regard the question as having yet got beyond the region of experiment. Erosion is a very serious matter with smokeless powder, and under the conditions above, if it is such as can be ordinarily incurred on service, we think that the Leonard powder ought to have a great future before it. Of this, however, we know nothing at present.

Tests of the Brown Wire Segmental Gun, by the Engineer of the Company.

Assuming that some record of the test of the 5-inch Brown segmental wire gun will be of interest to the readers of the *Journal*, herewith a synopsis of the first one hundred rounds fired from the gun is given.

Twenty-six rounds have been fired from the gun with service pressures of 40,000 lbs. per square inch, or thereabouts.

Twenty-five rounds with pressures of 50,000 lbs. per square inch, and four rounds with pressures exceeding 70,000 lbs. per square inch.

The maximum record of pressure ever obtained in the gun being something over 75,000 lbs. per square inch.

The gun has stood the test in an entirely satisfactory manner, and as stated in a report in the *Army and Navy Journal*, the last star gauging showed not the slightest enlargement of the bore of the gun.

Probably the most interesting data will be that obtained with the Leonard smokeless powder on August 18th.

The first point of interest will be the peculiar shape of the grain used in this experiment. Each grain was a round rod of smokeless powder ⅝ inch in diameter, and 40 inches long; being about the length of the powder chamber. These grains were tied up in bundles like a fascine. Through the center of each bundle was placed an igniter of black powder, that is a tube 40 inches long filled with rifle powder. The object being to produce instantaneous ignition throughout the entire length of the cartridge. The following table shows the report of the firing:

Weight of Charge, lbs.	Weight of Shot, lbs.	Instrumental Velocity, ft. sec.	Muzzle Velocity, ft. sec.	Pressure, lbs. per sq. in.
11	62	1,965	1,981	20,900
13	"	2,197	2,236	28,700
15	"	2,368	2,399	32,850
17	"	2,490	2,523	35,100
19	"	2,770	2,807	46,500
21	"	2,839	2,875	46,800

The last shot gave a muzzle energy of 3,557 ft. tons, or 857 ft. tons of energy per ton of weight of gun, or 169 ft. tons of energy per pound of powder. This, it may be stated, exceeds any record yet obtained for any gun or powder.

BOOK NOTICES.

Construction der Gezogenen Geschuetzrohre, by Georg Kaiser, K. und K. O. Professor am Höheren Artillerie-Curse. *Mittheilungen über Gegenstände des Artillerie- und Genie-Wesens.* **Price from publishers, 6 fl.; from book sellers, 10 fl.**

An indication of the contents of this book is best given by the author's preface,—"This work is composed of some of my lectures on the study of gun construction delivered before the classes taking the higher artillery course. In preparing these lectures I believed, in order to thoroughly understand the present mode of gun construction, it to be necessary to have a preliminary knowledge of the early construction of rifled guns. I began, therefore, by giving such details of construction, as were first made use of and which sometimes are very primitive; then I pass on to the various improvements that were gradually made, ending with the details of the construction as now adopted and which have undergone the various trial tests. I made an exception in regard to the breech mechanism, because to dwell on all heretofore constructed breech mechanisms would fill a book by itself. I confined myself to those breech mechanisms that are now actually used, simply preceding them by a description of the breech mechanisms of Wahrendorff, Cavalli and Schenkl-Saroni, because the principles involved in the construction of these hold good for all succeeding ones. I did not take cognizance in this book of the latest and most important breech mechanisms of the rapid firing guns, as I expect to publish a separate pamphlet on this subject.

"In regard to the manipulation of the material, I closely followed the information as laid down in so many good books on the manufacture of machinery. Wherever possible, I have made use of measured dimensions, because they make the beginner in gun construction familiar with important points; in such cases where obsolete or condemned measurements are given, those now applied may readily be substituted. All theoretical and empirical formulæ are based on practical application and have been upheld by actual experiment, so that the strength and the life of a gun tube can be figured out with great accuracy. As the construction of the bore depends on the kind of projectile to be fired from it, Appendix 'A,' which treats of the dimensions of armor piercing projectiles and shrapnel, is added.

"In regard to the rifling and the twist it is important to understand the resisting forces brought into play in giving the rotary motion, and Appendix 'B' dwells at length on these resisting forces.

"Books containing only technical information soon get out of date owing to the rapid advance made nowadays in technology and the great endeavor made to bring forth new and better arrangements. In order to keep this book up to date, I shall publish in the *Mittheilungen ueber Gegenstænde des Artillerie- und Genie-Wesens* any new developments that may be reported on gun construction."

The book is divided into fifteen chapters and has two appendixes.

Chapter I treats of the subject of the determination of the caliber and discusses the different kinds of guns and the classes into which their use divides them. The author then goes into detail regarding each of the three classes, viz.—Field artillery, sea-coast and water-battery artillery, and siege artillery.

Chapter II treats of the different kinds of rifling and goes into detail in the description of the following systems: 1st. When the rifling is made effective by means of a band of softer metal around the projectile making the diameter greater than that of the bore; 2nd. Where studded projectiles are used; 3rd. The expansive system; and, 4th, the polygonal system. The first system, embracing modern modes of procedure, is very interesting. In it are shown how deep the grooves should be, their number and their form. The other systems are the older ones, including those employed in the United States; the description of many other forms is of interest only to the beginner who is not already thoroughly acquainted with the old systems.

Capter III treats of the size of the chamber.

Chapter IV treats of the form of the chamber of breech-loaders and muzzle-loaders.

Chapter V considers the determination of the length of the bore. Here the author enters into a general discussion and determines mathematically the best length to be employed. Use is made of Erb's and Sarrau's formulæ for velocity.

Chapter VI treats of "twist." A general discussion is given similar to that in our modern text books; it includes the subject of rapidity of twist and the use of either uniform or increasing twist.

Chapter VII. The theory regarding the elasticity and rigidity of all tube-like bodies is here discussed. It includes a thorough discussion, both general and mathematical, of the elastic strength of guns. It involves the same theories and discussions as are laid down in our own pamphlets on gun construction used in the artillery course at the Artillery School.

Chapter VIII describes the built-up guns composed of concentric cylinders shrunk one on the other and also the system of concentric cylinders assembled without shrinkage. The mathematical discussion of both systems is complete and illustrates how closely the methods employed in Germany resemble our own.

Chapter IX treats of the different metals employed in gun construction and starts out by defining the properties which a metal must possess in order to be fit for use as gun material. Full details are given and the completeness of the chapter on the subject will be fully understood when it is mentioned that the following gun metals and subjects bearing thereon are discussed and described:—Gun bronze, Lavroff's compressed bronze, Laveissière's method of casting bronze, phosphor-bronze, steel bronze (hard bronze), cast iron, wrought iron, puddled, crucible, Bessemer and Martin steel; Whitworth's homogeneous iron, the hardening of steel and steel free from air holes before being worked. In the production of this last steel two methods are mentioned, the first of which refers to the addition of ferro-manganese with a certain per cent. of silicon and the second to the addition of "aluminum iron."

Chapter X treats of the construction of gun tubes. A theoretical discussion of the subject is interwoven with a description of the actual manufacture of tubes of different kinds—simple and built-up tubes. In describing the different systems employed, that of the Spanish navy guns (Hontoria tubes) appears to be quite different from those of other nations. Considerable space is devoted to the subject of wire wound guns and the chapter ends with a comparison between the wire wound and the built up systems.

Chapter XI treats of vents and primers. The subject of vents is discussed theoretically as to direction and size; also as to the necessity for bushings in some constructions. Primers of various kinds are described, including Krupp's, those used in the Austrian service, the French percussion, the De Bange, those of the English artillery and those of the Swiss 8.4 cm. guns.

Chapter XII contains a thorough description of gas checks, fermetures and the locking mechanism of different systems. The chapter starts out with a discussion of the advantages and disadvantages of breech-loaders and states the conditions that must be fulfilled in order to obtain the necessary breech mechanism. The subject of gas checks is gone into at length. As with other subjects a theoretical discussion precedes the whole and the different methods employed to obtain obturation are discussed both as to advantages and disadvantages. Finally, those used in different services are mentioned and discussed. The information given in this chapter on the subjects involved is probably as complete as can be desired and forms interesting reading to all students of modern artillery.

Chapters XIII, XIV and XV are short; in them are discussed mathematically the determination of the weight of the gun tube and the strength and dimensions of the trunnions; the procedure in making the calculations for the tube of a gun is then given.

Finally, there are two appendixes and, as already stated in the author's preface, the first discusses the subject of armor piercing projectiles and the second is a discussion of the resistances offered to projectiles by the rifling of the guns.

The book is accompanied by fourteen large plates and throughout the text reference is made to numerous illustrations which are both clear and accurate and of great assistance to the student.

HERMAN C. SCHUMM,
2nd Lieutenant 2nd Artillery.

The Present Development of Heavy Ordnance in the United States, by W. H. Jaques, Ordnance Engineer. Reprinted from the *Journal of the Franklin Institute*, July, 1893.

A lecture delivered before the Franklin Institute, January 6, 1893, in which the lecturer illustrated his discussion by lantern views. He confines his remarks to the period since the organization of the gun foundry board. It appears that no important change in gun construction has been made since this board made its report, except that of increasing the size of the parts of the gun, which brought with it a consequent reduction in the number comprising a gun. In this lecture the author restricts himself to the built-up forged steel gun, since he is convinced that it "can be made a perfect machine" and, while not dampening the enthusiasm of advocates of other systems, he regards this type of gun as safe and not liable to do "more harm to its friends than to its enemies." The sentiment here is decidedly in favor of the steel built-up gun as against other designs now struggling for recognition. Since this lecture was delivered events have been moving forward and develments within the last eight months would indicate that there is, at least, a reasonable chance of the built-up forged steel gun being superseded by wire-wound guns within a few years. Details of casting and forging are given and the successive processes of obtaining the finished parts from the ore are clearly presented. Following the construction and assembling of the gun comes a consideration of the breech mechanism.

The writer places himself on the side of large guns and considers the defects of the English 110-guns as merely mechanical. In advocating guns of this size he places himself in direct opposition to present practice of European navies and especially the recent decision of the English Admiralty. In connection with these large guns it may be suggested that there may be tactical objectious to the use of such heavy guns and that, after all mechanical difficulties are removed, it is quite possible that tactical questions may be as important as weight and velocity of projectile.

In the closing pages the author gives some space to torpedo apparatus and its construction, wire guns, and very interesting data upon armor tests, and terminates the lecture with remarks upon the rapid growth of gun factories in the country. Numerous lantern views accompanied the lecture and greatly added to its clearness and value. J. W. R.

Duties of Outposts, Advance and Rear Guards, with manual of Guard Duty, U. S. Army. By Lieutenant W. P. Burnham, 6th Infantry. 171 pages. Published by C. W. Bardeen, Syracuse, N. Y. Price: bristol board, 35 cents; flexible cloth, 50 cents; leather, 70 cents.

The author has been able to put a great deal of useful and necessary information into a very small volume. The book contains, in addition to a complete manual of duty for outposts, advance and rear guards, the manual of guard duty, U. S. Army, flags of truce, the U. S. signal and telegraph code, and much other useful information not suggested by the title. The principal subject matter is illustrated by numerous plates and shows careful and intelligent work on the part of the author. C. T. M.

Naval Annual, 1892. Edited by T. A. Brassey, B. A., F. R. G. S., 1892. Portsmouth: J. Griffen & Co., 2 The Hard.

It is hardly possible that within convenient limits more or fuller information could be placed and it is so concise and well arranged as to be easily found.

Practically, all that can be given here is a synopsis of chapters and side notes or headings..

Chapter I gives the progress of the British navy, 1891-92, and shows number and description of vessels completed, launched or reconstructed both by the government and by contract, and the number retired. Under the head of personnel, the naval reserve and naval volunteers are discussed. Trials of Sims-Edison torpedo are given in full and the naval maneuvers touched upon.

Chapter II is introductory to the progress of foreign navies and includes these sub-heads: Rapidity with which a ship of war becomes obsolete. Objects of maintaining navies. Importance of rapidity of construction. Lessons of Chilian war. Improvements in armor and guns. Ships now demanded by navy. Admitted supremacy of British navy.

It then gives in a manner similar to that of England, the progress of the navies of France, Germany, Italy, Russia, Austro-Hungary, Denmark, Greece, Holland, Norway, Portugal, Morocco, Spain, Turkey, United States, Mexico, Argentine Republic, Brazil, Chili and Japan.

Chapter III treats of British naval maneuvers very fully.

Chapter IV: French, Russian, Austrian and German maneuvers.

These two chapters are very interesting to all artillerymen.

The following is a brief synopsis of these maneuvers. With the English the operations were tactical and as no instructions are given it is hard to judge of their results. The method of division was different from former years giving homogeneous commands. There were four fleets, the Northern, Western, Red and Blue, acting out two different plans. Northern and Western were iron-clads. The Northern was the more modern and faster. The principal point brought out was the difficulty of scouting, as is shown by the following: The Northern fleet was to prevent the Western fleet passing the Straits of Dover, and to do this established a scouting line of nine vessels seven miles apart, between the Isle of Wight and Cape Barfleur; three of the nine were in line south of the *Royal Sovereign* light ship, sixty miles behind the first line. As to the results, the following paragraph gives them; the *Immortalité*, *Medea* and *Tartar* being in the second line:

"The *Mersey*, at the Cape Barfleur end of the line, between 9 and 10 P. M. on the 31st of July, sighted five steamers coming down in two groups, which led to the belief that they might be a portion of the enemy's fleet. This was communicated to the *Medusa*. The latter closed and passed on the word to the senior officer in the *Aurora*, who, as soon as he could signal to her, sent the *Pallas* to communicate it to the *Immortalité* in the second line of scouts.

Later on, the *Aurora* sighted the *Iris* steaming fast to the eastward, apparently on the heels of the enemy's ships. The *Aurora* accordingly followed her, until the *Pallas*, returning from the *Immortalité*, was met with. The last-mentioned ship had received information from a German steamer that five men-of-war had been seen south of Brighton. The next intelligence was a report from the *Tartar* that four of the enemy's cruisers, one judged to be the *Narcissus* of the Western fleet, had passed to the eastward. The *Medea* had informed the *Tartar* that an enemy's cruiser had challenged her, and, as she did not answer, had put out her lights and had disappeared. Then came the *Pallas*, announcing that she had been sent by the *Aurora* to report that five steamers, believed to be the enemy, had passed between the southern scout and the French coast. Three independent sets of witnesses agreed that five steamers had passed going to the eastward." Thus it was reported to the admiral of the Northern fleet that the enemy had passed to the east of the scouts "nevertheless, there had been no cruisers except the Northern fleet's own scouts anywhere near."

The Red and Blue squadrons carried out the following program:

"(a) To ascertain the tactics which would probably be adopted by flotillas of torpedo boats stationed at several points on one shore of a channel in order to harass or destroy an enemy's ships, &c., operating in the channel, or lying at anchorages on the other shore.

"(b) To ascertain the measures which should be taken to give security against the attacks of these torpedo boats."

The results show that catchers are the best means of defense against torpedo boats, long days are unfavorable to them, also moonlight nights. Smooth water necessary for success.

The scheme of French maneuvers was as follows:

A, coming from Gibraltar, to pass between Spain and Balearic Islands to operate against coasts of France and Corsica. B covers French coast. B learns by telegraph of enemy's passing Cap de Gatte and proceeds to the west to intercept A between Majorca and Barcelona. A has advantage in speed. B in numbers and relative strength.

As to results, A slips past B. B pursues and follows sufficiently near to frustrate A's attacks on Corsican ports.

Russia's maneuvers were quite complicated and need to be read to give a clear idea of them.

Germany's consisted of a night naval attack on Kiel which was an utter failure and, as is aptly remarked, "similar attack impossible in real warfare."

Chapter V gives very full descriptions of the newer designs of vessels now building in England, France, Germany, Russia, United States, Brazil, Chili, and Japan.

Chapter VI is devoted to marine engineering, giving general descriptions of the newest and most powerful engines and boilers, trials, successes and failures. Only English make considered.

Chapter VII describes the naval exhibition.

Chapter VIII: the naval episodes of the Chilian civil war. This is divided as follows:

1. The *Blanco Encalada* and the forts.
2. The attempt on the *Imperial.*
3. Operations in the north.
4. The *Itata* affair.
5. The sinking of the *Blanco Encalada.*
6. The *Aconcagua* and the gun vessels.
7. The final operations.

Conclusions drawn from Chilian war:

"a. The value of speed and consequent mobility in warships of a certain class in certain circumstances.

"b. The importance of sea power.

"c. The difficulty of effectively using the Whitehead torpedo save when it is in the hands of people thoroughly familiar with it, and the untrustworthiness of the human element in torpedo warfare.

"d. The usefulness of the Whitehead torpedo when properly handled.

"e. The enormous waste of projectiles that may be expected in modern warfare.

"f. The destructiveness of good heavy shell-fire.

"g. The unsuitableness of torpedo gun-vessels for artillery action with other ships."

Next comes Part II which gives first in tabular form the class, name, tonnage, horse power, draught, length, beam, where built, maker of engines, date of completion, cost of hull, machinery, armor, backing, deck plating, armament, torpedo tubes, speed, coal capacity in tons and knots of all the vessels of Great Britain, Argentine Republic, Austria, Brazil, Belgium, Bulgaria, Chili, China, Denmark, Egypt, France, Germany, Greece, Hayti, Italy, Japan, Mexico, Morocco, Netherlands, Norway, Peru, Persia, Portugal, Roumania, Russia, Sarawak, Siam, Spain, Sweden, Turkey, United States, Uruguay and Venezuela.

Then come a series of 89 plates giving elevations and plans of the different classes of war vessels of the more important powers. These drawings are all to the same scale unless otherwise stated, thus giving an idea of relative size. They also show armor protection both in thickness and extent and location of guns. There are 10 plates descriptive of U. S. vessels. They comprise the *Atlanta*, *Baltimore*, *Charleston*, *Chicago*, Commerce Destroyers 12 and 13, *Maine*, *Monterey*, *Newark*, *Oregon* and *Texas* classes.

Part III. Armor and ordnance.

I. Armor and armor experiments.

Under this head comes the Japanese trial of attack on steel decks, showing them to be vulnerable to high angle fire from comparatively light guns. Working trials of Spezzia turrets. 111-ton gun's penetration of built-up target. American armor plate trials at Annapolis and Indian Head. French steel plate trials. Compound Brown-Tresidder plates tried at Brown's works and Portsmouth. Comparison of English and American plates. Resistance of new armor. Armor piercing projectiles. Rule of thumb for penetration of armor for normal impact and for oblique impact. Diagrams showing penetration of British M. L. and B. L. guns and French and German B L. guns up to 3000 yards. These penetrations are for wrought iron and this work gives steel the advantage of 5 to 4.

II. Ordnance. This begins with a discussion of the relative powers of primary guns and the quick firing armament of a ship; then comes accidents and casualties occurring with guns. Life of a heavy gun. Maxim on erosion. Krupp, Canet, and Armstrong guns. Heavy guns *versus* light. The working of heavy guns. Engagements between ships and coast batteries. Trials of shell effect on H. M. S. *Resistance*. Effect ot position finder on coast defense. High explosives tested in the U. S.

III. Quick-firing guns. Introduction of quick-firing guns in French Navy. Relative power of quick-firing guns. New tables of same. High velocities and variations in different formulæ for penetration. Rate of fire. Energy of quick-firing guns. Canet quick-firing guns. Detailed descriptions, with drawings, of the mechanism of the Canet 12 and 15-cm., 45 cal. long, very instructive. Personnel required for their service. Characteristic features and construction of Canet system. Initial velocities not up to date. Breech mechanism. Advantages of screw over wedge. Canet carriage. Canet coast defense quick-firing guns. Tables of naval ordnance: British rifled, Austrian, British, Dutch, French, German, Italian, Russian, Spanish, Sweden and Norway, United States, Elswick quick-firing, Canet, Krupp.

Tables of pressure, weight, energy and perforation; showing conversion to and from English to metric.

Part IV. Statistics, official statements and papers.

I. Statement of First Lord of the Admiralty explanatory of navy estimates, 1891-92.

1. New construction. Contract and dockyard built ships. Dockyard work. New program. Torpedo boats and torpedo gunboats. Reconstruction. Renewal of engines and re-arming of old battleships. Stranding of *Victoria*. Summary.

2. Steam trials and machinery. Ship trials. Boiler troubles. Causes of same.

3. Naval Defense Act (its cost and results). Cost of boats. Objects of act. Cordite (no experiments given).

4. Armor plate experiments. Compound armor. Nickel steel armor.

5. New works. Portsmouth. Malta. Haulbowline. New magazines. New works proposed.

6. Mobilization and arrangements for increasing efficiency of Reserves. Ships mobilized. Reserve drawn upon. Naval volunteers. Reorganization of steam reserve, of personnel.

7. Personnel and condition of active list.

8. Past and future naval expenditure.

9. Report on Royal Naval Reserve.

II. Royal Naval Artillery Volunteers. Report on their employment.

IV. Navy estimates for 1892-93.

V. 1892-93. Program of works in progress on ships building &c., in H. M. dockyards and by contract.

VI. New construction. And 12 other tables of naval information on British navy. French navy estimates, German, Italian and Russian. Condensation of report of U. S. Secretary of Navy for 1891. Naval bibliography.

Part V. Chapter I. Manning and training. Naval education. Training at sea. Navigation and pilotage. Training in masted ships and flying squadrons. Advocates training in vessels provided with sail power.

Chapter II. Shipbuilding policy. 1. Battleships. Dimensions. Growth of. Moderate dimensions. 2. Coast defenders. 3. Rams. 4. Reconstruction and armament. 5. Cruisers. Dimensions. Value of sail power. 6. Machinery and boilers. 7. Torpedo cruisers. 8. Torpedo gunboats. 9. Torpedo boats.

Chapter III. Navy estimates.

The work is then completed by a very full index, by which any subject or vessel named can be immediately found.

There is much in the book of value to artillery officers and it will well repay those who have the opportunity, to go over it. The plates showing disposition of armor on vessels may give some suggestions in regard to coast defense.

Charles C. Gallup,
2nd Lieutenant 5th Artillery.

War Series No. IV. Information from Abroad. The Chilian Revolution of 1891, by Lieutenant James H. Sears and Ensign B. W. Wells, Jr., U. S. N.

The report of Lieutenant James H. Sears and Ensign B. W. Wells, Jr. U. S. Navy, "prepared from personal observation, from the statements of participants, from official papers, and from presumably authentic publications," has recently been issued by the office of Naval Intelligence in the form of War Series, No. IV.

In a comparatively small compass the causes, progress and incidents of the recent revolution are reviewed, to which is added in the form of appendixes other valuable and pertinent information.

The ultimate success of the constitutional party was assured as soon as it secured the naval superiority which enabled it to secure its communication in rear, utilizing as it saw fit the various ports as bases of operations.

Of the various combats and skirmishes, both on land and sea, very little is added to the daily reports that appeared at the time.

From a naval and military point of view, however, two incidents mentioned are of special interest and worthy of study.

The first refers to the several reports from both sides on the subject of the sinking in Caldera Bay of the iron clad *Blanco Encalada* by the torpedo cruisers, *Lynch* and *Condell.*

The second relates to the use of the modern small caliber repeating rifle. At Concon, although the fighting was done at close quarters, of 1,057,700 rounds fired only about 2200 reached their mark as shown by the number of killed and wounded; or, in other words, but one hit was recorded for every 500 shots fired. The rifles used were Gras and Mannlicher.

At La Placilla, however, from the beginning of the fight "a veritable rain of fire" was poured into the ranks of the army of the Gobernistas.

In the first mentioned battle, the ranks of the constitutional army, a large proportion of which was armed with the new rifles, contained a large percentage of recruits who had not been instructed in the handling and use of their weapon, and who began firing before the enemy were within range, and finally became "carried away with this kind of hand-machine gun" and pumped away their ammunition without aim or reason.

At La Placilla, however, these same recruits having become somewhat accustomed to their weapon, and profiting from the experience at Concon, used their rifles with judgment and effect.

With each and every innovation in military and naval equipment, new and important conditions are introduced, and it behooves those upon whom the responsibility of success or failure will rest, when brought to the test, to study these conditions, and profit by the experience of our South American neighbors, and "in time of peace prepare for war." W. W.

SERVICE PERIODICALS.

Revue d'Artillerie.

JUNE.—General Eblé (continued). Note upon the organization of the inferior lists in batteries. Developments upon certain particular cases of the methods of fire of siege and position artillery,—IV. Placing of the shots by the observation of time fuze shell (continued).

Time fuzed shell, are advocated in the following particular cases:

1. The position of the object inaccurately known is visible from the battery or point of observation, but the percussion shells which fall in the region of the object are not visible from any available point.

2. The position of the object inaccurately known is invisible, but its place is indicated by smoke.

3. The object's position known is invisible and the points of fall of percussion shell are not visible from any available position.

The article is treated under the following heads: Principle of the method. 1st Case. Lateral point of observation. a.—Determination of the first event in the development. b.—Rules to follow for lowering or raising the point of burst. c.—Rules of the fire as soon as the range of a time fuzed shell has been observed. d.—Examples. 2nd case. The observation made from a point without the battery. Cuts given showing method. The paper is illustrated in each case, making the different processes clear.

A new ballistic table.

The essential difference between this table and preceding ones is that it is extended to include the problems resulting from the high velocities which have been recently obtained. The table computed is a double entry table with arguments α and V and corresponds to the double entry table, *Auxiliary A* in the *Handbook of problems in direct fire* by Captain James M. Ingalls, 1st U. S. Artillery. $\alpha = \frac{X}{C}$ varies by steps of 200 from 0 to 8000. V varies by differences of 10 m. from 1100 m. to 150 m.

JULY.—The determination of a portable reconnaissance instrument.

This article deals with the subject of field reconnaissance and shows plans, etc., of an instrument which is designed to fulfill the following requirements: Scales for the purpose of reading maps of foreign countries. The compass card and needle. The measurement of horizontal angles and bringing forward the distances. Measurement of vertical angles and heights and differences of level. Measurement of distances vertical and horizontal. Picturesque sketch, perspective picture and reduction of angles to the horizon. Solution of problems.

The German field artillery regulations.

II. School of the battery. III. Group school. Part IV. The combat.

Developments upon certain particular cases of fire methods for siege and position artillery.

August.—Study upon the efficacy of time fuze fire.

This consists of a discussion of the efficacy of shrapnel fire. The writer considers the efficacy of a single shot and then proceeds to the consideration of any number of shots. In treating the subject the writer shows how to ascertain the useful shots, points out the difficulty of applying theories to the subject and endeavors to lay down a method for calculating the efficacy of a regulated fire. He also considers the influence of the probable deviation in direction, the influence of the probable deviation in height and the influence of the curvature of the trajectory and loss of velocity in the fragments. The writer assumes the three ranges, 1500, 2000 and 3500 metres, works out the probable deviations for these ranges and determines the probable efficiency.

Methods and formulas of experimental ballistics.

Experimental methods. (1) The establishment of a programme of experiments. The writer considers the advisability of determining a few points in a trajectory with a large number of shots in preference to many points with a few shots, when ammunition is limited. He lays out tables giving ranges etc., to be determined in experimental ballistics. (2) *Execution of the experiments.* Determination of the initial velocity. Measure of the angle of departure. Measure of the resistance of the air. The discussion closes with two notes, one upon the determination of the experimental functions between given limits, and the other upon the use of acoustic interrupters.

General Eblé. J. W. R.

Revue Militaire de l'Etranger.

June.—The new project of maneuver regulations for the German cavalry. The present situation of the railroads of the Ottoman empire.

July.—The new military law of Germany. The great maneuvers of 1892 in Italy.

August.—Instruction upon the work in the field for the German cavalry.

The principal additions to these new instructions are: (1) With respect to the use of explosives for the destruction of bridges, railways, works of all kinds, and guns; (2) The passage of streams by any means whatever. The article is a review or resumé of the German instructions and covers the heads; General principles, Method of practical instruction, Instruction material, Supply of boats and engines of destruction, Passage of water courses (swimming and with regimental material and improvised material), Passage upon ice. The German regulations hold that their cavalry should be self-supporting under all circumstances and capable of doing all kinds of work such as constructing field works, bridges, roads, telegraph lines, etc., even in contact with the enemy and likewise capable of destroying all kinds of obstacles and constructions. To aid in the work of destruction each regiment carries with it 32 cartridges in packages of four, in a leather sack, also 40 strings of slow match composition and 40 fulminate caps. The most careful instruction in swimming etc., and all other means of crossing streams are given.

The great maneuvers in Italy in 1892. The new fire manual for the German field artillery.

The adoption recently of new regulations for maneuvering field artillery in Germany necessitated a change in their firing manual. Since the adoption of the old firing manual their material has undergone many modifications. The common shell with percussion fuze has been dropped from the ammunition supply. A new shrapnel has been adopted and the artillery has been furnished with a new apparatus for indirect laying (*Richtfläche*). The article proceeds to give the reasons for the adoption of the new fire manual which is to be made the subject of reports during next year's exercises, which are to be submitted before 1st of December, 1894. The review compares the new with the old and brings forth the defects of the old system and enters exhaustively into Colonel Rohne's book, *Das Artillerie Schiessspiel*, and his criticism of the firing regulations. The treatment of the questions of torpedo-shell fire and indirect fire are interesting.

The augmentation of the lists of the Austro-Hungarian infantry reserve battalions. J. W. R.

Revue du Génie Militaire.

MAY–JUNE.—Tactics and fortification,—ideas of an engineer officer in 1774. Note upon Duportail. Railway curves of small radius. An account of an experiment of breaching walls by mines, executed at Arras in 1892.

The experiment here described is a valuable one, since it furnishes data upon sloping revetment walls, that is, upon walls which are drawn well back from the vertical towards the top. The experiment was made with view of obtaining information upon the destruction of such walls. The great value of the results rests upon the fact that this kind of wall is frequently used in modern methods of fortification. The experiment is described under the following heads: (1) *Description of the revetment.* The revetment consisted of a retaining wall 13.5 m. above the bottom of the ditch with vaults in rear 4.35 m. center and 9.50 m. depth. The arches rested upon piers 1.65 m.

thick, with the exception of the two vaults adjacent to the left abutment, which had 5.80 m. centers and piers of 2.55 m. thickness. Over the vaults a gentle slope of earth was placed and the main parapet reduced in width and drawn back so as to be no longer supported by the revetment. From the foot of exterior slope proper to the face of the scarp revetment a thick layer of asphalt had been placed to prevent infiltrations into the casemates. (2) *Scheme of demolition adopted.* The mines could not be placed too near the scarp on account of the small resistance that would obtain. It was finally decided to place the charges in the piers about two-thirds the distance from the scarp. The charges were located about .30 m. above the level of the foot of the scarp, so as to avoid loss in the galleries or vaults. The object was to destroy the piers and cause vaults and parapet to fall in upon the broken walls. The abutment being a mass of masonry 12.4 m. wide, 9.5 m. deep and 14 m. high, was mined in its center. Mines were placed under the piers 1, 3, 5, 7, etc., from the left abutment. There being 20 vaults, 11 mines were established. They were on the average 5.20 m. below the floor of casemates. (4) *Determination of the charge of the mine chambers.* The charge was determined from the formula $C=2.4(5.3)^3$. 2.4 being a coefficient for the earth beneath the casemate and 5.3 the line of least resistance. This gives in round numbers 350 kg., and for the abutment $C=1.5(6.5)^3=412$ kg., in round numbers 400. In the 1st and 3rd, each 400 kg.

In the	1st and 3rd, each	400 kg.
"	6th, 7th and 8th,	325 kg.
"	6 others,	350 kg.

(5) *Establishment and priming of the mine chambers.* Two methods of placing the charges could be followed. They could be inserted through galleries run under the work from the ditch or through holes sunk within the casemates. The latter was followed, since it offered the advantage of a closed cavern into which the explosion could take place. The holes leading to the chambers formed double elbows, thus adding greatly to the strength of tamping and compensating in a degree for the reduced length of tamping, which is only equal to the line of least resistance. The priming was in wooden boxes containing 3 to 4 kg. The charges were also in wooden boxes. To each priming box were connected two lines of detonators. The two lines branched from a main line running along the gallery and turning back from the end mines joined at the central one and then connected to an electrical firing machine. Each mine was doubly primed. (6) *Personnel and time employed.* The work was done by 26 sappers, not thoroughly skilled in such work, working 29 sessions of 3 hours each, which includes all transportation of material; rest and time of going and coming to the work is deducted. This work was done under the greatest difficulties and discouragement. (7) *Effects of the explosion.* The whole wall was thrown into the ditch; with its fall came a large portion of the ramparts and parapet. The breach was 132 m. long, but was practicable only at the extreme left and for a distance of 20 m. and near the center over a distance of from 10 to 15 m. The whole breach however could soon have been made practicable. Only a light trembling was noticed by people

within 100 m. of the mines and no pieces were thrown into the air. That no parts of the parapet masonry should be projected into the air was one of the conditions to be fulfilled.

An account of the operations of rescue of a detachment of men imprisoned in a mine executed at Chalillon-in-Dunois in January, 1893. The fortification of Spezzia. The wells of Ouargla. J. W. R.

Revue Maritime et Coloniale.

JUNE.—Essay with respect to the left bank and the navigability of the middle Me-Kong. Essay upon the research for the best order of combat. Indication and control of the course by means of a compass with luminous marks,—description of a new compass. The circulation of the winds and rain in the atmosphere. Historical study of the military marine of France.

JULY.—General considerations upon the electrical installations on board war-ships. The ministry of marine of the Duke de Choiseul and the preparation of the ordinance of 1765. A study upon the organization of the defense of the United States.—Sea-coast guns and steel armor. Mechanical theory of marching and running. Congress of the French association for the advancement of science. Study upon the civil and military organization of China and upon the province of Kwang-Si. The inaguration of the statue of François Arago at Paris, June 11, 1893.

AUGUST.—A vocabulary of powder and explosives. Study upon the organization of the defense of the sea-coast of the United States.

This is a note appended to the same subject discussed in the preceding number of this *Revue* and relates directly to the ballistic power of guns. The following are the principal divisions of the discussion:

1. Measure of the ballistic power of guns. Simplification of the formula of Jacob de Marre.
2. Considerations upon the progress of artillery.
3. Penetration in oblique fire.

Celestial mechanics.—Note upon the invariable plane of the solar system, Method of pointing sea-coast guns in order to use to the greatest advantage the instantaneous indications of the range-finder. Historical studies upon the military marine of France. J. W. R.

Revue du Cercle Militaire.

JUNE 4.—The new regulations of maneuver for German cavalry. The Italian army and the review of Centocelle in 1888 (continued).

JUNE 18.—The new maneuver regulations for the German cavalry (continued).

JULY 2.—Notes upon the mobilization of the Italian army.

JULY 16.—The friendly coöperative association of the officers of land and sea.

JULY 30.—The events in Siam. Project for the reorganization of the Italian army (continued). The bridge material for the German cavalry.

AUGUST 13.—The normal caliber of the infantry gun (continued). War dogs in the German army (continued).

AUGUST 20.—The Vosges army in 1871. The new portable tent of the Austro-Hungarian army.

AUGUST 27.—Ricciotti Garibaldi in the Cote-d'or. The schools of instruction at Paris and in the provinces.

SEPTEMBER 3.—New firing instruction for the Italian artillery. The field kitchen of Colonel Alexieff.

La Marine de France.

JUNE 4. The loss of *La Bourdonnais*. The armament of the *Capitan Prat.*

JUNE 11.—The native troops in the colonies. The armament of the *Capitan Prat* (concluded).

The conclusion of the article is treated under the following heads: Electrical maneuvering of the turrets. I. Lateral pointing. II. Shot-hoist. III. Distribution of electricity. General considerations.

A few notes upon the best order and the most accurate method of reconnoitering for cruisers.

JUNE 18. The teachings of a dead man. The discussions of the society of naval architects. In march upon Tchad (continued).

JUNE 25.—The directing policy of the Admiralty.

The writer discusses the maritime position of France in Europe and brings forth a strong plea in favor of a strong navy. Five propositions are made with respect to the question. 1. The torpedo. 2. France and the offensive role. 3. Sufficient ships to remain masters of the Mediterranean in case of conflict with the Triple Alliance. 4. The loss of the Mediterranean would entail the loss of Corsica, Algeria and Tunis. 5. The criminality of not constructing the requisite number of cruisers.

Divisions d'Aventure.

Treats of the necessity of organizing into divisions, the torpedo boats which accompany a squadron. Considers the day combat and the night combat, and general considerations affecting both. The idea is to have the torpedo boats organized to maneuver as a body and move quickly and lightly to the attack. The writer shows that these boats as now controlled are useless appendages to a ship.

JULY 2.—The navy and parliament (continued). Discussion of the naval budget in the Italian chamber.

JULY 30.—The French naval maneuvers in the Mediterranean (continued).

AUGUST 13.—The trials of the warship *Magenta.* Recent progress of the navy.

AUGUST 20.—A last word.

Relates to a discussion of a previous article entitled *Essai de stratégie navale* and the application of principles there enunciated to the recent French naval maneuvers.

The maneuvers of the north.

SEPTEMBER 3.—The truth with respect to the role of the cruisers of the Gadaud division. J. W. R.

Journal de la Marine, Le Yacht.

JUNE 3.—Our naval forces outside of Europe. The commission for the safety of navigation.

JUNE 17.—The French squadron on the coast of Gallicia. The cruiser *d'Entrecasteaux.*

This cruiser will have a speed of nineteen knots with medium draft. It will be constructed at La Seyne by the Forges et Chantiers de la Méditerranée after the designs of M. Lagane, the constructor of the *Pelayo* and the *Capitan Prat.*

Length between perpendiculars, 117 m.; length at water line, 120 m.; maximum width, 17.85 m.; mean draft, 7.15 m.; displacement, 8114 tons; engines, 14,000 H. P.

Armament.—Two 24-cm., 40-caliber, cannon; twelve 14-cm. rapid-firing cannon; twelve 47-mm. rapid-firing cannon; four 37-mm. rapid-firing cannon; two submarine torpedo tubes; five torpedo tubes above water line.

Two of the torpedo tubes above water are in the stern. All auxiliary apparatus is sheltered under the armored deck and everything will be maneuvered by electricity. The 24-cm. guns are in closed towers, bow and stern, and protected by 250 mm. of steel. The towers are designed after Lagane's equilibrium system and maneuvered by electricity. The other guns are arranged so as to obtain the maximum fire in any desirable direction. This ship will be the largest of the French cruisers and has nearly the same tonnage as the *New York*. The protection for each gun is complete in itself and all arrangements are studiously designed to reduce damage from hostile shot to a minimum.

JUNE 24.—The great maneuvers of 1893.

Article which gives a statement of the program for the naval maneuvers of the coming month. The plan of operations for both the Mediterranean and Channel squadrons.

JULY 1.—The loss of the *Victoria* (continued). The stability and flotation of armored ships.

JULY 15.—The marine budget in the Chamber.

JULY 22.—The great naval maneuvers. The Paknam affair.

JULY 29.—The English naval maneuvers (continued). The raising of the English man-of-war *Howe*.

AUGUST 5.—Our naval maneuvers. The Siamese conflict. The cruisers of the 2nd class.

AUGUST 26.—The trials of the *Mousquetaire*. The aluminum yacht *Vendenesse*. The French armored ship *Le Charles Martel*. The launching of the *d'Iberville*. J. W. R.

Revue d'Infanterie.

JUNE.—History of infantry in France (continued). Infantry instruction (continued). Infantry fire (continued). Analytical tactics for infantry (continued). The mounted infantry in the colonial wars (continued).

JULY.—The Spanish model of the 7-mm. Mauser gun.

AUGUST.—A single rule for infantry instruction. The hygiene of European troops in the colonies and colonial expeditions. A methodical exposition and summary of infantry tactics in connection with artillery in the offensive defensive combat.

Revue Militaire Universelle.

JULY.—Tactics applied to the terrain. Regulations for cannon fire of the foot artillery in the German army, The influence of religious ideas upon the military state. General study upon the contemporaneous geographical movement. Algerian souvenirs.

SEPTEMBER.—The service of the engineer troops in armies.

The invasion of 1815. The siege of Mézières. The war of secession. Acts to preserve the civil interests of military men in the army. General study upon the contemporaneous geographical movement. Colonel de Monteyrémard.

Le Génie Civil.

August 12.—Electric crucible with controlling magnet for laboratories.

This is a description of an apparatus to be used for fusing substances. A strong current is passed through two suitable carbons which in all respects are similar to the carbons of the arc light. The apparatus contains a directing magnet which regulates the operation of the crucible. By the arrangement the arc can be brought gradually upon the matter in the crucible.

Telephotography.

September 2.—The launching of the *Suchet.*

J. W. R.

Mémoires de la Société des Ingénieurs Civils.

Revue Militaire Suisse.

June.—Administration of the military department in 1892. Critical remarks upon the Swiss Infantry organization. The day of October 31, 1870, at Paris.

August.—Critical observations upon the organization of the Swiss infantry. The question of the hour during the Franco-German war of 1870-1871.

Revue de l'Armée belge.

May.—Considerations with respect to the fundamental principles of different projects presented in Austria for the organization and use of the troops and general staff of the engineers. Study relative to the influence of new engines upon the fortification of the field of battle.

The writer considers that new engines of warfare will produce important changes in field fortifications, and proceeds to ascertain these changes.

I. Small caliber rifles and smokeless powders.—The small caliber bullet has such increased penetration that old dimensions giving security will no longer do so. Sand and earth parapets must be doubled at least and the penetration into wood is so great that its use is practically impossible except for revetting etc. Palisades will require greater thickness than before. Smokeless powder will render firing undiscoverable, since it cannot longer be seen clearly outlined by puffs and lines of white smoke and the feeble sound can be heard at a distance of 300 m. only under favorable atmospheric conditions. Ricochets and hits upon trees may in some cases indicate the direction of the enemy. This condition of affairs the writer considers is so advantageous to the defender that every possible effort should be made to preserve it. Hence, so construct the field works as to render them as indistinct as possible. This will be accomplished by the following means: 1. Give as small relief as possible. 2. Avoid commanding emplacements. 3. Give emplacements to such works only when the latter are not projected against a clear sky. 4. Avoid angular forms. 5. Preserve in front bushes, trees and grain such as do not interfere with the fire. 6. Re-cover the parapet with sod, straw, and boughs, in keeping with the surrounding ground. Avoid the use in front of any auxiliary defense which may be recognized from afar.

II. The use of violent explosives.—This part of the article is occupied in the discussion of effects of using violent explosives as bursting charges for shells on the battle field. The great difficulty in treating this subject is the secrecy with which all experimental results with torpedo-shells are guarded. From data obtainable and certain hypotheses the writer endeavors to give an idea of the effect these shells will have on the battle field and on works of various kinds. These shells are longer and contain more explosive than ordinary shells of the same caliber. It is assumed that of the different explosives used by different nations equal charges will give equal results and that each nation in selecting a particular substance has done so because it is considered safest for use. We learn that the French charge their shells with cresylite or nitrated melinite, the Germans now use picric-acid in place of paraffined gun-cotton formerly, the Austrians ecrasite, and that Belgium will soon experiment with tonite. The French torpedo-shell is carried with the 88-mm. gun; length 4 calibers, weight 8 kg., charge 1.4 kg. of cresylite; delay action percussion fuze: intended for action only against passive objects and with mine effects. The German has the same caliber: weight 7 kg.: bursting charge not known: double action fuze apparently for use against living objects. Time fuze is used up to distances which exclude shrapnel fire, after which percussion fuzés are used.

To study the different effects of these two shells upon field fortifications, the writer proceeds to study the two roles assigned to these two shells using percussion and time fuze fire respectively. In considering the question of the mine effect the writer holds that the explosive burns at the same rate under all circumstances [?] and that the shell will therefore absorb but little of the energy developed. This is not the case with common powder. The mine produced by the *poudre brisante* is regarded as differing from the crater formed by ordinary powder in that the radius of the maximum crater is more than three times the depth of the charge,—three times this depth being the radius of maximum crater with ordinary powder. According to the results of experiments made in Belgium with ordinary and *brisant* powders the former clears away more earth than the second whilst the results correspond to under-charged, ordinary or over-charged mines. For a less depth it appears that the *brisant* powder produces effects superior to those of the brown powder. These two conclusions are drawn from the discussion:

(1). The depth of explosion in earth with torpedo-shells ought to be comparatively small in order to obtain maximum clearing effects. (2). It is not sufficient to augment the charge nor to substitute *brisant* for common powder in order to produce the greatest destruction in parapets; it is still necessary to regulate in consequence the depth at which these projectiles burst in the earth. Can this be done? Assuming that the clearing effect is proportional to the respective bursting charges in the common and torpedo-shell the French shells give a ratio of 1 : 5. Considering the chances of successful shots with ordinary shell the artillerist cannot produce much effect upon a work of weak profile especially one whose parapet is low and nearly or quite invisible at ordinary battle ranges, without an enormous expenditure of projectiles. This difficulty is exaggerated in the use of torpedo-shells whose fire is less accurate owing to the great length of projectile. Experiments in England have shown that at 1100 m. 50 projectiles per running meter of parapet were required to destroy a parapet 2.65 m. high and 3.65 m. thick. Assuming effective fire and a comparative efficiency of fire for the torpedo-shell, 10 per meter of parapet would be necessary to produce the same effect. Considering the difficulty of a battery maintaining itself at 1500 m., obliquity to parapet in many cases, and inaccuracy of torpedo-shell fire, 15 shots per meter at least will be necessary and this is *certainly* much below the truth. The whole supply of an army corps would be necessary to produce a sensible result and then the cover would probably exist more or less and would probably be manned by infantry at the final moment. Torpedo-shells therefore cannot be regarded as the proper engine to destroy earthen parapets. It now becomes a question of the effect of these shells upon improvised shelter constructed of wood, trees, etc., obtained in vicinity of the works. It is concluded that shells arriving at smaller angles than 15° will ricochet and burst in air while others which happen to lodge in the over-head cover will do little damage to the work. It becomes a question of determining the minimum height of cover etc., which will afford protection to the defender. This is found to be about 1.5 m. Considering the penetration of shells into sand, average earth, etc., it is concluded that the thickness of the side exposed to the fire should not be less than 3.6 m. The conclusions show that torpedo-shells will render the construction of field works more difficult and will require more time and material than formerly. There will be no difference in their effect upon abatis from that of common shell.

Conclusions with respect to the destruction of all other obstacles are reached similar to those just given for breaching the parapet. Great expenditure of projectiles will be necessary. With respect to thin walls, it is held that the torpedo-shell will pass through before explosion will take place. That this may also happen with thick walls but that when explosion occurs within masonry the destruction will be very great, effecting the fall of the wall. All however will be accomplished only at great expense of projectiles. Passing to the effect of torpedo-shells upon the defense it will be observed that the shell will be broken into very small pieces, thrown at high velocity but losing it quickly. According to one, these pieces will not kill at distances greater than 10 to 15 m.; according to another, at about 75 m. These fragments will not be so effective as shrapnel. They will kill only a few men near the burst who will be riddled with missiles. The burst of a torpedo-shell at rest a little above the ground, on account of its comparatively weak sides and strong head and base, will cause the fragments to form upon the ground an ellipse with the transverse axis perpendicular to the line of fire. With a shell in motion it is different, the head only will be thrown forward, the base will be thrown backward with a velocity equal to the velocity impressed by the explosion diminished by the remaining velocity. The lateral fragments describe a cone of revolution whose vertex angle for range of 2500 m. is 65^{c}. Shots falling short will do no harm, those striking the parapet and ricocheting will explode above and will do effective work with their lateral fragments; while those bursting just beyond will be dangerous on account of the pieces thrown backward. The writer furnishes sections of parapets, etc., with the effect which will be produced upon them by the torpedo-shell. In one case is shown a double parapet for purpose of protecting from the rearward action of shells which burst beyond the line of works. The conclusions are that this kind of shell will be more deadly than any other in searching out men behind walls, etc., but it will be necessary to have the explosion take place very near the object. In firing upon buildings explosions within rooms or confined space will be terrible, rendering their occupation impossible.

III. The field mortar.—Mortars and howitzers will in future be used upon the battle field. The advantages allowed in use of mortars are, their use up to the last moment before the assault, the moral effect of the shells upon the defenders, the correction of the fire will be aided by the large quantities of smoke produced, the explosions in the earth of parapets will overturn bomb proofs and other protection, and the use of mortar shrapnel by which the balls will have great dispersion and will descend at such an angle as to reach all points in the defense. To counteract these advantages we find the following considerations: It will in general be difficult to obtain the best results from time fuze mortar fire since greater deviation will result from greater irregularity in burning of fuze on account of longer times of flight; on account of these deviations great care must be taken at the time just before the assault: the correction in range will be difficult on account of long times of flight; and the size of the mortar shell will restrict the shots to a few.

The Russians have already introduced this weapon into their service. Experiments at polygons have indicated that this kind of fire will be extremely murderous and that they destroy the parapets without completely destroying the defensive cover. These experiments were made against defenses visible from a distance, and under conditions much more favorable than those of actual service.

IV. Insufficiency of materials.—The defense has imposed upon it the problem of creating stronger works than formerly from insufficient means, but the defense may be able to make such dispositions that the attacking artillery can produce insignificant effects. It becomes essential that the position and character of the work be concealed. Low relief and all other means that will conduce to this end must be used. The former importance of the ditch is now replaced by a volume of fire and the ditch will no longer be used as an obstacle. The parapet will no longer form an obstacle to the assailants and accessory defenses from 30 to 50 m. in advance of the works will be depended upon to break the force of the assault.

Historical, political, and military history of Constantinople, and the peninsula of the Balkans. Offensive combat of the army division. Rapid-fire cannon of 7.5 cm. of Nordenfelt system. The revision of the regulations and unification of the instruction in the German field artillery. The new military hospital of Madrid. The nation and the Russian army.

J. W. R.

Memorial de Artilleria.

MAY.—Note referring to the cylindrical shells used in the 16th century. Rapid-firing cannon 42 mm., Sarmiento system.

This is a gun with a new breech mechanism. The description, illustrated by two plates, is treated under the following heads: the piece; the breech mechanism; manner of operating the mechanism; and recoil mount.

The automatic repeating rifle. Marches and fire exercises of the third battery of the fifth battalion of fortress artillery.

This is a continuation of exercises already mentioned. Second exercise: Indirect breaching fire. Third exercise: Bombardment fire. Fourth exercise: Night firing. The means of correcting the fire, using tables and find- the target are given: also the results of the exercises with tables of deviation in each case.

The progress of ærial navigation.

JUNE.—Proof of a 14 cm. gun at the Nervon ship-yards. Study upon a special plan for hollow projectiles.

This is a continuation of the subject begun several months ago. The discussion is analytical and seeks the best form of head and body, also the best dimensions and shape generally, for a projectile. The present discussion relates to the spherical and ogival forms.

A compromise solution.

Relates to a preceding decree re-organizing the field artillery. The author proposes several combinations of guns and carriages with permanent batteries of different strengths and points out a solution best suited to the circumstances.

The relative value of the present small caliber guns. An important discovery,—note referring to the chase of a culverin belonging to the first half of the XV century; found in the fortress of Segovia. Points upon the military organization of Great Britain in 1893.

JULY.—The equipments of the first section of the siege train.

First part.—The first section of the siege train as now organized consists of 68 pieces divided into 13 batteries. The division consists of light and heavy guns equal in number, the light pieces to form a reserve of field artillery. The writer shows that it will not be possible, on account of the large number of wagons required, to mobilize heavy siege guns with 200 rounds per gun and that 100 must suffice; the remainder must be carried in the movable park of the army similarly to the case of ammunition for light field batteries. The light batteries also would be mobilized with 100 rounds. It is estimated that at least 800 rounds for the heavy and 1000 for the light guns, per gun, will be necessary for the reduction of a place. Following this introduction are tables giving in detail the parts, equipments and necessaries of the train. The scheme is worked out with the greatest care.

Applications of electricity to artillery.

Projectors.—The writer recognizes two different conditions to be fulfilled in use of projectors for sea-coast work. 1. The recognition of distant points. 2. The illumination of extensive zones at short distance. The first requires great concentration, and the second dispersion of the light. The structure of the projector will depend upon which of these uses will be required. The former should be placed upon great elevations, the latter as nearly as possible on level with the sea. This separation of the projectors into different groups for different purposes imposes the necessity of directing the movement of each from a point distant from both. In this manner alone can the projectors be made independent of each other and can be directed from a central station although they may be placed in positions difficult of access. It has been proposed to signal to an operator of the projector what movements should be made; control from a distant point will remove all this dependence. The advantages of such a combination are the following: (1.) The focus of the light can be placed in the most suitable advanced position and manipulated without any exposure. (2.) The responsibility for direction lies in a single hand which can change objects at will. (3.) The projector can be located in places where by other methods it would not be possible to place them. (4.) The persons employed are reduced to a minimum and chances of error reduced. It is proposed to drive the projector with a small dynamo [motor] with the necessary switches and resistance boxes in the central station. Following this is a discussion relating to the different arrangements and uses of projectors with many valuable suggestions. The article is illustrated by three large folded plates showing different kinds of lights and the mechanism which operates them. One of the most interesting of these machines is one mounted on a kind of electric car which travels on an iron track. The operator sits upon the car and controls the light at will.

J. W. R.

Revista Cientifico Militar.

JUNE 1.—The military problem. Armament for our infantry. Armored infantry (continued).

JUNE 15.—The self-administration of armed bodies. The health of the soldier. The force of an empire. Review of the press and military progress.

JULY 15.—The self-administration of armed bodies.

Revista General de Marina.

JUNE.—The voyage of the *Santa Maria*. Cruisers: their functions and the conditions which they ought to satisfy. Arsenals and fleet of Japan. Vocabulary of modern powders and explosives (continued). Abacus for the determination of the position at sea. The important modifications which have been introduced into the Whitehead-Schwartzkopff torpedo. Trials upon the art of submarine navigation (continued).

JULY.—Spanish cosmography. Notes referring to the voyage of the caravels from Havana to New York. Manner of determining the position of the vessel by the methods of the new astronomical navigation.

Boletin del Centro Naval.

MARCH.—Project of a rapid cruiser (continued). The recent armor plate trials in the United States. Forms of musket balls. Bellville boilers.

APRIL.—The naval school and the fleet. The Argentine cruiser *Nueve de Julio*. Proposition to exchange the artillery of the Argentine cruisers.

The proposition relates to a replacement of the 28-cm. Armstrong muzzle-loaders by 15-cm. breech-loading rapid-fire guns. A ballistic comparison between these guns shows that the former has an initial velocity of 399 meters whilst the latter has 597 meters and that other elements are in favor of this exchange. A tactical comparison shows the rate of firing as 1 to 4. A statistical memoir accompanies the proposition showing weights, etc., and confirms the preceding arguments with figures.

Technical section of artillery.

A proposition to create a technical department of artillery. The writer claims that in their squadron artillerists no longer are found, and gives two reasons for this decline. 1. Officers are not sufficiently prepared. 2. The subalterns are a heterogeneous and unstable set, due to desertion and casualties. To remove these defects in the personnel he proposes to establish a technical section which will collect and study data and develop the most suitable means of preserving and operating the material.

The role and use of torpedo vessels according to English ideas. The Spanish-American military congress.

JUNE.—Court martial defense. The island of the States. Study of navigation. The hydrographic service of England.

J. W. R.

Circulo Naval, Revista de Marina.

APRIL.—Comparative study of rapid-fire cannon. Nets for defense against torpedoes. The application of electric motors on board war-ships.

This article deals with the introduction of electricity on board ship. It comprises a complete review of the subject from its beginning to the present time. Gives the kind of equipment of the *Capitan Prat* with the electrical arrangements on the ship. Describes the electrical installations upon our own ships giving in each case the kind of engines, dynamos and motors, and illustrates the wiring of circuits by cuts. The currents, voltages, and windings are given making the whole a very valuable contribution to the literature on the subject.

A reply to the pamphlet published by Messrs. Armstrong & Co., November, 1892, with respect to rapid-fire cannon. A vocabulary of powders and explosives.

MAY.—A course of selection in the naval school. Organization of the rowers in the galleys. Vocabulary of powders and explosives. Coral formations. The eclipse of the sun on April 16, 1893.

J. W. R.

Revista Militar.

JUNE 15.—The army and country. The theory and the practice of war. Infantry and its battle trenches (continued).

JUNE 30.—A selection of formations of the army (continued).

JULY 15.—Breaches of discipline and punishment. Scientific military expeditions of Portugal in Brazil (continued).

AUGUST 15.—Smokeless powders (continued).

AUGUST 31.—The army and the country. Practical school for infantry.

Revista Maritima Brazileira.

APRIL.—The autobiography of a Whitehead torpedo (continued). Powders and explosives. Naval maneuvers in 1892. The German war marine in 1892.

MAY.—Torpedo guns.

This is a brief review of the subject of ærial torpedo guns. The principal ones mentioned are that of the Pneumatic Dynamite Gun Co., that of Graydon and Reynolds. Only a short description is given of each.

Naval maneuvers in 1892. A plan for the distribution and equipment of the meteorological stations necessary to a new organization of our meteorological service. The United States navy. Instrument for the determination of the variation and declination of the needle with view to correcting the compass.

J. W. R.

Revista da Commissao Technica Militar Consultiva.

MARCH.—Uniformity of munitions for the arming of infantry and cavalry. Notes on artillery aluminum articles. German cupolas and armor. The present state of the war marine. The new Krupp artillery.

Revista do Exercito e da Armado.

JULY.—The bayonet and the resolution to attack (continued). Architects and Portugese military engineers in the service of Portugal (continued). Colonization (continued).

AUGUST.—The engineer practical school exercises in the spring of 1893. Our army in the eastern colonies. Fire exercises. Tactical problems.

Revista di Artiglieria e Genio.

JUNE.—History of siege warfare from the adoption of fire arms to the end of the year 1892 (continued). The elastic surface of metallic plates subjected to bending forces. Electrical illumination of works of fortification. The development of the kind of gaits of horses from the foot-prints left upon the ground.

JULY-AUGUST.—The school of fire for the German field and foot artillery. Proposition for a new width of tent copied from the regulation tent adpating it for four soldiers. The new fire regulations for the German field artillery.

Allgemeine Schweizerische Militaerzeitung.

JUNE 10.—The Austro-Hungarian war budget for 1894.

JUNE 24.—News from the French army.

JULY 8.—Heavy and light "tubular" projectiles.

JULY 15.—France's conflict with Siam.

JULY 22.—The Von Krnka "miniature gun." With respect to the plans and execution of the maneuvers.

AUGUST 5.—The new German reinforements.

AUGUST 12.—Military report of the German empire.

AUGUST 19.—The steel "tubular" projectile.

AUGUST 26.—The garrison of Paris.

SEPTEMBER 2.—The new German cavalry regulations.

Allgemeine Militaerzeitung.

JULY 2.—A few thoughts on the future infantry fire improvement.

JULY 8.—The French cavalry of to-day.

JULY 12.—The results of the French and the German army organization.

JULY 15.—The law against the betrayal of military secrets.

JULY 19.—The improvement of cavalry in pioneer service.

JULY 22.—The German and the French army.

JULY 29.—The impending increase in the German field artillery.

Die Reichswehr.

Kriegswaffen.

Razviedtchik.

No. 138.—Hesitation before smokeless powder (continued).

No. 139.—The new Austrian gun.

No 140.—Preparation for fire.

No. 141.—The establishment of the sight in guns by three lines model 1891.

No. 142.—The new regulations of fire instruction, edition 1893.

No. 146.—Are guns necessary for sappers?

No. 147.—The corps of Turkish officers.

No. 149.—Increase of the military forces of France of 1892 over 1891 and its cost.

Russkii Invalid.

No. 123.—The conditions of mobilization of the German army.

No. 128.—Note upon the mobile field kitchen.

No. 165.—Instruction with the lance in the cavalry.

No. 176.—The passage of the Vistula by the Cossacks of the Don.

No. 182.—The field artillery maneuvers at Chalons.

Nos. 186, 187, 188.—The present state of tactics of the three arms in the principal European armies.

No. 188.—Labors of the telegraph detachment upon the Pavier.

Journal of the Royal United Service Institution.

June.—Military organization best adapted to Imperial needs. The art of marching. Volunteer transport. Cruisers: their role and the conditions they should satisfy. Recent progress in marine machinery. Russian naval maneuvers of 1892.

July.—The military organization best adapted to Imperial needs. The best type of field gun for the British service, including the question of Q. F. guns. [Captain J. Headlam, R. A.]

The following is the author's synopsis of the article:

Part I. Introduction. How many natures are required: Uniformity of caliber. Tactical considerations. 1. Weight behind splinter-bar. 2. Number of rounds per gun.

Part II. Guiding principles in the choice of a type:

A. The gun.

B. The shell. 1. General requirements. 2. Considerations of shell in use.

C. The carriage. 1. Gun carriages. 2. Ammunition carriages. 3. Shields.

Part III. Quick-firing guns. 1. Definition. 1. Ammunition supply. 3. Rapidity of fire.

The mobilization of the volunteers. Battleships of England. A foreign notice of Mr. Williams. The steam navy of England.

August.—Universal compulsory service for the United Kingdom. On the photography of flying bullets by the light of the electric spark.

A lecture by C. V. Boys, Esq., F. R. S., on the photography of a bullet in flight. He enters into a discussion of the duration of light in order to photograph rapidly moving objects and explains the apparatus and points out some of the possible discoveries which may result from this kind of investigation. The wave lines in air in advance of the projectile are considered, with differences under different circumstances.

How best to secure continuity in the effective service of modern ships of war. An 18th century Thermopylæ. Submerged discharge for Whitehead torpedoes. J. W. R.

Journal of the United Service Institution of India.

APRIL.—The modern literature of cavalry tactics. Notes on convoy duty. Musketry training and its value in war. [Captain James Parker, 4th U. S. Cavalry; reprinted from the *Journal of the Military Service Institution.*] Russia and the invasion of India. The question of cavalry firing when mounted.

MAY.—The double company system. Economy in the management of the soldier's ration. A geography of the Turkestan country.

The Military Society of Ireland.

NOVEMBER 16, 1892.—The battle of Tashkessan.

DECEMBER 15.—Villars.

JANUARY 11, 1893.—The Rochelle expedition of 1627.

JANUARY 18.—The offensive tactics of infantry as exemplified by the battle of Spicheren.

FEBRUARY 1.—The ordnance survey.

FEBRUARY 24.—The American civil war, 1861-65.

MARCH 15.—The supply of water to troops on the march.

MARCH 22.—The supply and transport on active service.

APRIL 5.—Military topography.

APRIL 24.—Cavalry and horse artillery on the march and in the field.

The Aldershot Military Society.

XLI.—Wood operations. The battle of Gettysburg. Smokeless powder and its probable effect upon the tactics of the future.

Proceedings of the Royal Artillery Institution.

JUNE.—Memoirs, historical and biographical (continued). A method of concentrating the fire of a group of guns laid for direction by graduated arcs. Extracts from the diary of Lieut. Ingilby, R. H. A., during the Waterloo campaign. The artillery of the three armies.

JULY.—The attack of a coast fortress.

Three prize essays which treat of the subject of the attack of sea-coast fortresses.

AUGUST.—Remarks on making and breaking. The "lining plane" of the German field artillery. The Spanish gun factory and arsenal of Trubia. The value of mobility for field artillery.

J. W. R.

Engineering.

JUNE 16.—Portable engine fitted to burn liquid fuel. The Krupp pavilion at Jackson Park.

The Krupp exhibit at the Columbian exhibition is dwelt upon. The relation which Krupp holds to the ordnance world is briefly considered, and the buildings containing the exhibit described. The 42-cm. (16¼") gun is the largest gun ever brought to an exhibition. This gun is described, but it is sufficiently well known. The next gun considered is the 30.5-cm. (12".01) which is mounted, with all its appliances, upon a turret carriage. It has been fired 98 times. Its projectile weighs 1000 pounds, is fired with 226 pounds of smokeless powder, and attains an initial velocity of 2290 f.s. The 28-cm. (11".02) with its mountings, which are the very latest type, is mentioned; also the 24-cm. (9".45) is noticed. The 21-cm. coast-defense gun is represented and described. Smaller guns, R. F. guns, and siege and field artillery are noticed.

The first-class twin-screw cruiser *Gibraltar*. The fuel supply of warships. New smokeless powder. New torpedo craft. The new second-class cruiser *Fox*.

JUNE 23.—Model of 125-ton steam hammer by the Bethlehem Iron Co. The French navy program. The hardening of steel. H. M. Torpedo Gunboat *Speedy*. The manufacture of small-arms.

JULY 7.—The model Battleship *Illinois*. Transmission and distribution of power by compressed air.

JULY 14.—The Japanese cruiser *Yoshino*.

JULY 28.—The Pennsylvania Railroad exhibit at Chicago.

This article includes a description of the Krupp 120-ton gun and railway carriage upon which it was taken to Chicago.

150-ton electric traveling crane at Creusot. The naval maneuvers.

AUGUST 18.—The test of a Bethlehem armor plate.

This article gives details of test of 17'' plate at Indian Head July 11, 1893, with photograph showing effect of the shots.

AUGUST 25.—Gun trials of the battleship *Ramillies*. The Engineering Congress at Chicago. On the electric light of light houses.

SEPTEMBER 2.—The navy estimates. J. W. R.

The Engineer.

JUNE 16.—Armor question puzzles.

A comparative notice of the Harvey and Tresidder plates, with comments upon the renewed proposal to cover the heads of armor piercing projectiles with wrought iron. The same scheme was tried in England in 1878 but failed: the proposition now comes from Russia.

German armor constructions and French imitations. Launches and trial trips.

JUNE 23.—Launches and trial trips.

JUNE 30.—The loss of the *Victoria*. The first-class cruiser *Grafton*. Her Majesty's ships *Camperdown*, *Collingwood*, *Anson*, and *Howe*.

JULY 7.—Chicago exhibition,—triple expansion engine and dynamos.

JULY 14.—The naval maneuvers. H. M. S. *Endymion*. Launch of the gunboat *Antelope*.

JULY 21.—The society of Naval Architects. Naval rams.

While regretting the loss of life and cost of the experiment it is urged that the loss of the *Victoria* be regarded as an experiment and that all circumstances relating to this great disaster be carefully studied and suitable lessons drawn therefrom. In reference to stability it is concluded that water-tight bulkheads cannot save a ship which has been rammed; and that her chances in such case are simply better than if she had none. Generally speaking stability in such cases will depend upon the absence of top weight and this object can be obtained by lowering her guns and thus making them less efficient. The alternative of this is to replace 100-ton guns with lighter guns. It is considered suggestive that at this moment two of the 100-ton guns on one of the largest iron clads of the Italian navy are being replaced by two 10-inch 25-ton wire guns. It appears also that the *Camperdown* came near going down. The argument is here to the effect that the ram of the *Camperdown*, though long enough to sink the *Victoria*, was not long enough to fend off the latter from the upper works of the former. French war ships have rams projecting a long distance under water, which will enable the ship ramming to do so without coming in contact with armor belt.

The naval maneuvers.

June 28.—Trial of the American nickel steel plate.

An accurate account of the armor tests at Indian Head on July 11. The test of a 17-inch plate is considered a great step in advance. The trial is important in being made upon a plate which is practically the worst in the whole lot proposed for acceptance. The inspection branch of our navy have arranged to test chemically and mechanically the metal cut out of every bolt hole of every plate. The results of these analyses are recorded and the plate which shows the greatest irregularity is tested for acceptance. The series of trials are described and data in each case given. These plates had not been treated by the Harvey process, having been made in conformity with orders for nickel plate previous to the development of Harvey's discovery. The resistance to perforation was in all cases good and with respect to fracture perfect. All the plates were accepted, but without premium.

The naval maneuvers.

A brief description of the plan of the maneuvers and the rules for government of the same. The umpires this year will remain on shore and hear and decide all contentions after the termination of the exercises.

Trials of the Japanese cruiser *Yoshino.*

August 4.—Heat transmission through metal plates The Naval Annual for 1893 (final notice). The naval maneuvers. The U. S. battleship *Massachusetts.*

August 11.—The naval maneuvers. Bacteriological purification of a sewage.

August 18.—A new rifling machine. Lessons from the naval maneuvers.

August 25.—Lessons from the naval maneuvers (continued). -II. The new French battleship.

Relates to the proposition contained in the French naval estimates for 1894 to add thirty-two new vessels to their navy. Amongst these vessels of various types are to be three battle ships of 12,000 tons; the propelling machinery to be triplicate—driving three screws giving a speed under forced draught of 18 knots. The hulls to be protected with an armored belt of maximum thickness of 17½ inches. Instead of an ordinary splinter deck below an armored one, a second armored deck of lighter scantling is to be introduced. The armament will consist of 11″.7 guns in the central batteries and 6.5 and 3.9 quick firing in the auxiliary batteries. The two turret system, one fore and one aft, will be used for the heavy guns and all movements will be given by electricity as in the *Capitan Prat.* The smaller guns will be placed singly behind shields 2″.8 thick.

SEPTEMBER 1.—Ship building in America. The new battleships *Majestic* and *Magnificent*. The naval estimates. American high velocity shooting. J. W. R.

Engineering Review.

The United Service Gazette.

JUNE 17.—The new defenses of France. The artillery of three armies. Infantry efficiency. The coal endurance of warships.

JUNE 24.—The French naval estimates. Army mobilization.

JULY 1.—Coast artillery practice. Coast defense.

JULY 8.—The Duke of York from a naval standpoint. The new defenses of France. A compass card marked in degrees only. Skeleton exercises and their teaching.

JULY 15.—The relative strength of our navy. The value of the volunteer force.

JULY 29.—The French cavalry: its present organization, strength, and distribution. The *Victoria* court martial. The value of skeleton exercises.

AUGUST 5.—The naval maneuvers. Recruiting in the French army. A tremendous indictment.

An indictment or charge made by Sir Thomas Symonds against the British nation for so neglecting the requirements of the navy as to endanger the safety of the country. The admiral of the fleet in an article contributed to the *Fortnightly* presents a formidable array of facts and figures to prove that in *matériel* and personnel the nation is not prepared to meet its probable requirements. One of his claims of inferiority in the English ships is the unarmored ends, a fact which is strongly sustained by the *Camperdown-Victoria* affair. To help overcome this defect in comparison to foreign warships which are armored from end to end, he suggests the construction of six rams of 6000 tons displacement as strong as steel can make them and of great speed. The writer then goes on to show that England's sea power has relatively diminished from about 240 battleships to Europe's 180, in 1807, to 77 battleships to-day against 116 possessed by France and Russia. The writer holds that the country instead of insuring a coal supply is neglecting the matter; the armament of British ships does not compare favorably with these other nations. In reference to the *personnel* it appears that the navy is short of officers by at least 300. In numbers we find a total of 99,000 against France's total of 131,000 and Russia's 54,000.

British Federalism.

AUGUST 12.—The naval maneuvers (the Red side). With the coast of Ireland squadron. The Krnka "tubular" projectiles (continued). Naval maneuvers and their teaching. Gunnery, past and present.

August 19.—A Crimean reminiscence. The naval warrant officers. Army medical report.—I (continued). The army autumn maneuvers.

August 26.—The recruiting question. The naval expenditure of maritime powers. The relative strength of our navy.

September 2.—The late naval maneuvers. The navy estimates' debate. The health of our troops serving in India. Rum in the navy.—I. The relative strength of our navy.

J. W. R.

The Army and Navy Gazette.

June 1.—The naval mobilization. The education of officers.

June 24.—The new infantry drill. Russian cavalry regulations. The corps of commissionaires.

July 1.—The new infantry drill—II. Artillery organization.

July 15.—Mobilization for home defense.

July 22.—The German army bill. The Anglo-Egyptian question. The employment of reserve men.

July 29.—Coast defense. Drill and discipline. France, Siam, and England.

August 5.—Fire tactics. Egypt. Lord Roberts on "India for the Indians." France and Siam. The naval maneuvers.

August 12.—The lessons of the naval maneuvers. The naval maneuvers (the Red side). Non-commissioned officers' education.

August 19.—Our naval supremacy. The volunteers at Aldershot. India between two fires. Musketry in India. The Aldershot command.

August 26.—Army entrance examinations. Army medical efficiency. The French shipbuilding programme of 1894. The Italian naval maneuvers. The manufacture of cordite. The pell-mell firing line. The promotion examination. India under two fires.

September 2.—Non-combatants and the General-staff. The *Victoria's* stability. Artillery achievements. The French naval maneuvers. The services in parliament. The new first-class cruisers. Our naval literature. The rules of the late French naval maneuvers. The Indian army as it is. Smokeless powder. Education of non-commissioned officers.

Journal of the Military Service Institution.

JULY.—Military sanitation. Army regulations. The three battalion organization. Company papers. Organization of the armies of Europe The past the guide for the future. Drill. Some suggestions in regard to arms, etc. Comment and criticism. Reprints and translations.

SEPTEMBER.—Recruiting and desertion. Army organization. Annotations by General Sherman. Small arms firing. The Bear, the Lion, and the Porcupine. A special service corps for the Quartermaster Department. Practice *versus* theory in army training. Comment and criticism. Reprints and translations.

Journal of the U. S. Cavalry Association.

The Army and Navy Journal.

SEPTEMBER 2.—Army recruiting. Rifle competitions.

SEPTEMBER 16.—Torpedo boats. Formula for pitching tents. The question of small arms. Rifle competitions.

The Army and Navy Register.

Cassier's Magazine.

JUNE.—The life and inventions of Edison (continued). The blower system of heating and ventilating. Leading American engineers. Waste furnace heat under steam boilers. Steam engines at the World's Fair (continued). Progress in heating by electricity. Fast trains of England and America. Modern gas and oil engines (continued). The future of cast steel.

JULY.—From mine to furnace. Recent developments in power transmission.

Article treats of modern transmission in shops and factories. The use of the electric motor is shown in operating looms, lathes, and other small or individual pieces of machinery. The writer informs us that the uses of electric motors in connection with the transmission of power are becoming more widely extended all the time, and illustrates by the installation of the Page Belting Co., at Concord, N. H., where the power is distributed throughout their extensive new establishment by means of electric motors. The electricity for them is generated at works. According to the statement of the president of this company the whole cost was 20 per cent. less than for a steam plant for the same capacity. A valuable comparison with respect to shafting in the two cases follows which in all aspects indicates the great value of the new means of transmission over the old. The use of electric motors for driving printing machines is considered and the great value of this motor established. In conclusion it appears that the whole tendency at present is toward the successful use of large motors.

The life and work of Gustav Adolph Hirn, 1815-1890. Safety devices on railroad cars.

AUGUST.—From mine to furnace. Boilers at the World's Fair. Collection of dust in workshops. The life and inventions of Edison. Semi-portable engines in England. Modern gas and oil engines. Anhydrous ammonia gas as a motive power. The Buckley water tube boiler. Copper mining in Nevada. The Glasgow and west of Scotland technical college.

J. W. R.

Hammersley's United Service.

SEPTEMBER.—I. The geographical knowledge of the Atlantic in the time of Christopher Columbus.

III. Great Britain as a sea power. IV. The epidemic of militarism in Europe.

The Iron Age.

JULY 27.—Shipping armor plate. Fast foreign cruisers. The estimation of chromium in steel and iron.

AUGUST 24.—Brown wire gun and smokeless powders.

The Scientific American.

JULY 1.—Proposed submarine boats. The sinking of the British warship *Victoria*.

JULY 15.—The Krupp traveling crane.

SEPTEMBER 2.—Military ballooning in France. The great German search light at the World's Columbian Exposition. The new U. S. S. *Detroit*.

SEPTEMBER 9.—The latest armor trial at Indian Head.

Engineering Magazine.

JULY.—The financial situation. Limits of the natural gas supply. Sculptors of the World's Fair. Development of the modern steam pump. Weak points in trade unionism. Coke manufacture in the United States. International Engineering

Congress. Steam locomotion on common roads. Mechanical aids to building. The safety car coupler problem.

SEPTEMBER.—Some facts about the silver industry. A scientific analysis of money. The real condition of the farmer. The fallacy of municipal ownership. Steamboating in the west and south. Growth of commerce on the lakes. Need of uniform building laws. The development of the nickel-steel armor plate.

This is a valuable article on the subject of armor, taking one through the numerous tests which have developed the most recent types of armor. The article is well illustrated and brings the question up to date.

Electricity and electric generators. Distance not a factor in the cost of railway traffic. J. W. R.

The American Engineer and Railroad Journal.

JULY.—The U. S. protected cruiser *Olympia*.

SEPTEMBER.—The U. S. cruiser *Minneapolis*. 12-inch breech loading rifle mortars.

The Engineer, N. Y.

A new electric locomotive. An extraordinary armor plate and shell test.

The Electrical Review.

The Technology Quarterly and Proceedings of the Society of Arts.

APRIL.—The course in naval architecture at the Institute of Technology. The manufacture of heavy ordnance, with special reference to wire construction.

This paper, by Mr. W. H. Jaques, Ordnance Engineer, consists of a historical sketch of heavy gun construction and then devotes the principal part of the lecture to wire gun construction. This part of the paper relates principally to a short history of the development of the principles embraced in this system of gun construction and the difficulties to be overcome and defects of guns already tested. The Woodbridge and Crozier guns are considered and special space devoted to the Brown segmental wire gun.

Fire proof construction. High frequency electric induction [by Elihu Thomson]. Electrolytic reduction of nitro-benzene in sulphuric acid solution. Excursions of the diaphragm of a telephone receiver. J. W. R.

Jahrbuecher fuer die deutsche Armee und Marine.

JUNE.—The efficiency of the cavalry in battle. Review of the field of military science and literature.

JULY.—The German-French controversy on armored turrets. The present standpoint of field-fortification, and the "Manual of Field-fortification." The rules of war. The draft of a law concerning the national rifle-club and the military training of the young in Italy.

AUGUST.—The history of the small-caliber quick-firing field-pieces. The re-organization of the army in Spain. The method of attack of the Russian infantry.

Organ der Militær-Wissenschaftlichen Vereine.

No. 7.—The use of infantry or sharpshooters in the skirmish-duty of cavalry. Russian ideas on firing from horse-back.

Schweizerische Militærische Blætter.

JUNE.—The new system of the Swiss artillery. Establishment of an artillery proving station at Thun.

JULY.—Artillery as a principal arm. The new German military problem and its causes.

Internationale Revue ueber die Gesammten Armeen und Flotten.

JUNE.—The nature of modern war and the military problem. Naval armor and artillery, and marine artillery material.

JULY.—The manual of field-fortification.

Mittheilungen aus dem Gebiete des Seewesens.

Nos. 4 and 5.—Hydraulic gun-appliances in the French navy.

Nos. 6 and 7.—Naval landing-operations.

ERRATA—PAGE 542.

Eighth line, read "angle of elevation $= 3^\circ\ 33'.2 + .64 \times 6'.8 - 6' = 3^\circ\ 31'.6$."

Nineteenth line, read "angle of elevation $= 7^\circ\ 30' - 6' = 7^\circ\ 24'$."

TABLE OF ERRATA, VOLUME II.

Page 67, line 24—For "maintaining" read requiring.
Page 67, line 25—For "trains" read teams.
Page 67, line 32—For "maintains" read necessitates.
Page 68, line 4—For "trains" read terrain.
Page 68, line 35—For "used" read usual.
Page 70, line 21—For "from" read of.
Page 72, line 24—For "on" read for.
Page 75, line 8—(light field, walk) For "170" read 178.
Page 77, line 34—For "gun" read wheel.
Page 78, line 32—For "handled" read hauled.
Page 503—Maitland's formula should read:

$$t = \frac{v}{608.3}\left(\frac{w}{d}\right)^{\frac{1}{2}} - 0.14d$$

Page 505—Same formula should read:

$E = C(0.14+t)^2 d$ (fourth line; also same in table page 506.)
and $E = 2.8257(0.14d+t)^2 d$ (twenty-first line.)

The Maitland curve, plate I, should, in consequence of these changes, go to the point 7973 foot-tons, for $d=18$, and, on plate II, to the point 10635 foot-tons for $t=18$. Thus the Maitland formula interprets the law of resistance in about the same way as the Inglis formula.

Page 505, seventh line—The English Admiralty formula should read:

$$E = Cdt^{2.085}$$

Page 512, third line—The coefficient in the second member of equation B should be 0.024 instead of 0.0024.

Plate III was computed according to the Gâvre formula for wrought-iron armor and includes standard oak backing 36 inches thick. By subtracting the following velocities, Plate III will give the velocities for perforation of the plate alone:

8-inch	348 f. s.
10-inch	282 f. s.
12-inch	233 f. s.
16-inch	178 f. s.

The common value of E for $d=10$ and $t=10$ (3672 foot-tons), see table I, page 506, is given by the De Marre formula as quoted in Captain Ingalls's *Hand Book*, Fort Monroe edition, page 217.

The accompanying plate to replace that relating to Fire Game, page 140.

LIST OF SUBSCRIBERS FOR 1893.

Adjutant General's Department.

Colonel Samuel Breck.

Inspector General's Department.

Inspector General U. S. Army.

Colonel Robert P. Hughes.

Major Joseph Sanger.

Quartermaster's Department.

Captain Samuel R. Jones.
E. S. Dudley.

Subsistence Department.

Captain Tasker H. Bliss.

Medical Department.

Major Richard S. Vickery, Surgeon.

Corps of Engineers.

Colonel Henry L. Abbot.

1st Lieut. George A Zinn.

Ordnance Department.

Ordnance Office, Washington, D. C.

Lieut. Colonel William Marye.

Captain Henry Metcalf.
Rogers Birnie, jr.
Lawrence L. Bruff.
Charles H. Clark.
William B. Gordon ('94).
Sidney Stuart.

1st Lieut. Edwin B. Babbitt.
Ormond M. Lissak.
Beverly W. Dunn.
John T. Thompson.
Fremont P. Peck.
George W. Burr.
Colden L'H. Ruggles. (15)

U. S. Military Academy.

Associate Prof. Wright P. Edgerton.

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1st Lieut. Peter E Traub.

First Artillery.

Captain James M. Ingalls.
Edmund K. Russell.
John M. K. Davis.
Allyn Capron.
Henry W. Hubbell.

1st Lieut. Robert H. Patterson.
C. L. Best, jr.
Henry L. Harris.
John Pope, jr.
Arthur Murray.
John T. Honeycutt.
John P. Wisser.
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Albert Todd.
Adam Slaker.
Frank S. Harlow.
William C. Rafferty.
Millard F. Harmon.
George W. VanDeusen.
John W. Ruckman.
Charles F. Parker.

2nd Lieut. William Lassiter.
W. M. Cruikshank. (23)

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Lieut. Colonel Royal T. Frank.

Major William Sinclair.
Frank G. Smith.

Captain Carle A. Woodruff.
John H. Calef.
William P. Vose.
Frank C. Grugan.
George Mitchell.
George S. Grimes.
Louis V. Caziarc.
Robert M. Rogers.
Eph'm T. Richmond.
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1st Lieut. Alexander D. Schenck.
Medorem Crawford, jr.
Sebree Smith.
Henry A. Reed.
George F. E. Harrison.
Lotus Niles.
William A. Simpson.
Victor H. Bridgman.

1st Lieut. Erasmus M. Weaver, jr.
Edward E. Gayle.
Hamilton Rowan
Edwin St. J. Greble.
George F. Barney.
Louis Ostheim.
Isaac N. Lewis.
Cornelis DeW. Willcox.
Arthur F. Curtis.
T. Bentley Mott.
Ernest Hinds.

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Moses G. Zalinski.
George Montgomery.
Daniel W. Ketcham.
Leroy S. Lyon.
George Blakely. (38)

Third Artillery.

Colonel LaRhett L. Livingston.

Major Wallace F. Randolph.

Captain John L. Tiernon.
James Chester.
Frank W. Hess.
William A. Kobbé.
Edward C. Knower.
James O'Hara.
Ramsay D. Potts.
Charles Humphreys.

1st Lieut. Sedgwick Pratt.
Henry C. Danes.
Edward Davis.
Joseph M. Califf.
Charles W. Hobbs.
John D. C. Hoskins.
Benjamin H. Randolph.
John R. Williams.
Henry H. Ludlow.
Charles B. Satterlee.
Charles W. Foster.
Charles A. Bennett.
Edward A. Millar.
Henry C. Davis.
Elisha S. Benton.
John D. Barrette.
E. W. Hubbard.
John K. Cree.
Charles T. Menoher.
George O. Squier.

2nd Lieut Peyton C. March.
John P. Hains.
George LeR. Irwin.
Henry D. Todd, jr.
James Hamilton.

2nd Lieut. Frank G. Mauldin.
William S. McNair.
Jay E. Hoffer.
Kenneth Morton. (39)

Fourth Artillery.

Colonel Henry W. Closson.

Lieut. Colonel A. C. M. Pennington.

Major Henry C. Hasbrouck.
Jacob B. Rawles.

Captain John P. Story.
George G. Greenough.
Frederick Fuger.
William Ennis.
Richard P. Strong.
Constantine Chase.
Peter Leary.
Sydney W. Taylor.

1st Lieut. Harry R. Anderson.
John A. Lundeen.
Albert S. Cummins.
A. B. Dyer.
Charles D. Parkhurst.
George L. Anderson.
Clarence Deems.
Walter S. Alexander.
Frederick S. Strong.
Charles L. Phillips.
Clarence P. Townsley.
Adelbert Cronkhite.
Stephen M. Foote.
John C. W. Brooks.
Samuel D. Sturgis.
Harry L. Hawthorne.
Lucien G. Berry.
George F. Landers.

2nd Lieut. Alfred M. Hunter.
William L. Kenly, jr.
Walter A. Bethel.
Morris K. Barroll.
Thomas B. Lamoreux.
Samuel A. Kephart. (36)

Fifth Artillery.

Lieut. Colonel Francis L. Guenther.

Major Marcus P. Miller.

Captain Charles Morris.
Joshua A. Fessenden.
Samuel M. Mills.
Edmund L. Zalinski.
Anthony W. Vogdes.
Frank Thorp.

Captain Elbridge R. Hills.
Henry J. Reilly.

1st Lieut. Thomas R. Adams.
Garland N. Whistler.
David D. Johnson.
William P. Duvall.
William B. Homer.
William W. Galbraith.
Samuel E. Allen.
Warren P. Newcomb.
Charles G. Treat.
Thomas Ridgway.
Willoughby Walke.
Edgar Russel.

2nd Lieut. Charles C. Gallup.
Edmund M. Blake.
Sidney S. Jordan.
Edward F. McGlachlin, jr.
William C. Davis.
George G. Gatley. (28)

NATIONAL GUARD.

Governor Levi K. Fuller, Vermont.

First Regiment Light Artillery, Ohio National Guard.

Colonel E. C. Brush, Commanding 1st Regiment.

Major Joseph C. Ewart, 2nd Batt'l'n.

Captain George T. McConnell, Battery "A."
F. J. Herman, Battery "B."
W. N. P. Darrow, Battery "H."

Lieut. Rollin Moffat, Battery "E."
Geo. M. Wright, Battery "F."

Massachusetts.

Major Richard H. Morgan, 1st Mass. Artillery.
Dexter H. Follett, Battery "A," Boston.

Texas.

Major A. Harrison, 1st Artillery, Texas Volunteer Guard.

Missouri.

Captain Frank M. Rumbold, Battery "A," Mo. National Guard.

Pennsylvania.

Captain Alfred E. Hunt, Commanding Battery "B," Penna.

CIVILIANS.

Mr. W. H. Jaques, Ord. Engr., South Bethlehem, Pa.
Mr. J. R. France, 392 Broadway, N. Y.
Professor M. W. Humphreys, University of Va., Charlottesville.
Mr. A. Victorin, M. E., Watervliet Arsenal, N. Y.
Mr. Laurence V. Benét, Artillery Engineer, Paris, France.
Mr. W. R. Quinan, Pinole, Cal.
Mr. Robert L. Peek, New York, N.Y.
Mr. W. H. Kühl, Berlin, Germany.
Mr. Henry P. Merriam, New York, N. Y.
Mr. Creuzé de Latouche, Paris, France.
Professor A. G. Greenhill, Royal Artillery College, Woolwich, England.

LIBRARIES, ORGANIZATIONS, ETC.

Library of the U. S. Mil. Academy.
The Post Library, Fort Adams, R. I.
The University of Ga., Athens, Ga.
The Hadfield Steel Foundry, Sheffield, England.
The Maxim Nordenfelt Guns and Ammunition Company, Limited, London, England.
The Hotchkiss Ordnance Company, Limited, Paris, France.
The "Presidio Club," San Francisco, California.
The Naval Torpedo Station, Newport, R. I.
German Legation, Washington, D. C.
The Board of Engineers, New York City.
The Naval Proving Ground, Indian Head, Md.

REPORT OF EDITOR TO COMMITTEE.

Fort Monroe, Virginia,
December 31, 1893.

To the Committee of General Direction and Publication,
Journal of the U. S. Artillery.

Gentlemen:

I have the honor to submit the following report upon the development of the *Journal* for the year 1893. As its representative as editor, I further take advantage of this opportunity to introduce a few remarks which seem appropriate to the occasion. The volume published during the past year—Volume II—contains about 730 pages, with the character of which you are individually familiar; comment, therefore, on this subject would be clearly superfluous.

The organization of the *Journal*, and the methods of directing it, have in all respects proved practicable and sufficient to meet the present requirements of publication. They are simple and elastic, yet strong enough to permit the execution of all necessary functions, and admit with facility of such changes as may prove needful in the light of future experience and conditions. The executive machinery essential to publication may in this manner always be kept in suitable relations to its duties.

The *Journal* now enters upon the third year of its existence, and begins its third volume. We have, therefore, the experience and results of the two past years upon which to base judgment of its present position, value and prospects, as an exponent of the new Artillery Science. These considerations in a journal, it may be remarked, must ever be what its supporters make them. There is no evading this fact. *The Journal of the U. S. Artillery* is now just what its advocates have made it, and the same rule will govern in all future years.

The necessity for a magazine in this country to publish Artillery information and maintain the Artillery view of military problems is not, we believe, by anyone seriously questioned. If there were any doubts entertained on this subject, they were either in regard to the advisability of publishing such a magazine, or in regard to our ability to support it. Fortunately we now have experience on all such points, which never could have been developed by all the doubts and doubters in existence. These mooted points could alone be settled by experiment. The experiment has been made with the result (1) that there is a demand,—a field of usefulness,—for such a paper, and (2) that it can be supported.

The field it is to occupy cannot be better described than by inviting attention to the ground covered by Volumes I and II, as shown by their tables of contents. In these will be found all subjects which come within the domain of Artillery science, either thoroughly discussed or mentioned for future consideration.

The functions of an Artillery journal in this country seem to be clearly defined. The nature of its mission should be outlined by the needs of a progressive and enterprising corps. To keep within its legitimate field, and always in the foreground of Artillery advancement; to inform its readers of what is actually in accomplishment; and, above all, to lead them on to the problems of the future, would seem to be its true policy. To be of the greatest value, it must not only make correct estimates of the present, but must anticipate the future with reasonable accuracy.

Experience has proved so far that, with proper professional and financial support, a valuable magazine can be maintained. The support of the *Journal* by Artillery officers for the past two years,—62% in 1892, and 58% in 1893,—is not quite what one would expect from an arm filled with enthusiasm for its own efficiency and development. At its beginning, officers probably held back on account of not clearly understanding the conditions upon which the enterprise was founded, through fear of lack of money and material for its pages, or injurious effects upon other professional magazines. In answer to these fears, it may be said that it has always appeared on the *Journal's* title page that the Staff of the *United States Artillery School* recognized it officially, thereby becoming sponsors for its character. This action rendered its existence possible by reducing expenses of publication to about one-fifth of the cost under any other circumstances. It was not, therefore, as some may imagine, started as a kind of pastime, to be dropped again when it had ceased to be amusing, but has always rested upon an official basis.

The literary contributions have always proved sufficient for the needs of the *Journal*. The financial statements for the year of 1893 accomyanying this report are conclusive evidence of its condition in this respect.

The prospects of the *Journal* for the coming year are brighter and more encouraging than ever before, and its existence for this year is assured beyond all question. The *Journal*, therefore, commences its third year, not as an experiment, but as an *accomplished fact*. Its continued existence will require only reasonable support and good management.

During the past two years, other magazines have not suffered from the publication of this one, and we here say without fear of contradiction, that those which it was thought would suffer injury have steadily improved during this period. In this particular case, as in many others, where prophecies are made without sufficient foundation, the prophets have been proved to be false, and their predictions have been reversed. Whatever may be the grounds in future, therefore, for indifference towards a magazine which is generally recognized as an Artillery necessity, those just mentioned cannot be urged. Surely in these days of rapid development of new principles and material, when each year carries us far beyond the preceding one, we need some means of communicating with one another, of binding us closer together, and of helping us to form a settled policy. The last few years have shown beyond doubt that Artillery obtains great results only when organized and directed according to scientific principles. It has been truly said in the *Journal* that an Artillery science does exist; it may be added with equal truth that if ever this Artillery science is to exist and assert itself in this country, it must be developed by ourselves and be suited to our own needs and conditions. In the evolution of this Artillery science there is room for all;—in fact, when all are counted, we are few in comparison with the many problems to be solved and duties to be performed. All are therefore solicited to help in this work; for, however great may be our success, it can never be considered complete until all are working together to a common end.

More than one hundred military and scientific periodicals and transactions of technical societies are now received regularly in exchange for our *Journal.** Among these are the best military reviews in the world. The vast fund of information now received and still accumulating needs willing hands to classify, translate, condense, and prepare it for publication. This should be done in a regular, thorough, and systematic manner, so as to form a complete summary of military literature. Such a scheme, once developed and in operation, would render the *Journal* invaluable as a kind of circulating bureau of information. The labor involved in the execution of this plan will be enormous, and it can only be done by many hands working faithfully. It calls for translations from the French, German, Spanish, Italian, and Russian. Foreign armies have among their officers translators in each of these and other languages, who are constantly engaged in extracting and collecting information. By this means only can they keep themselves informed of the advance of military science.

The amount of excellent literature published in the German language is enormous. The influence of the German nation upon military problems renders it particularly desirable that we should be more familiar with their methods and teachings. But few of us read this language, and German literature generally remains unnoticed, or comes to us, after considerable delay, at second or third hand. Improvement in this line will be a problem for the future.

The plan of presenting in each number of the *Journal* a classified summary of military progress will, we believe, commend itself to all. To carry it out will require at least one officer of experience and judgment in each class of subjects to keep it up to date. Captain James M. Ingalls, 1st Artillery, Instructor in the Department of Ballistics in the U. S. Artillery School, has volunteered to do this for his own department. Lieut. Willoughby Walke, 5th Artillery, Instructor in the Department of Chemistry and Explosives, has for some time been preparing current literature on powders and explosives for the same purpose.

With others to take up, in a similar manner other important branches of our profession, the full scope and value of the *Journal* should be realized.

Finally, it will be noted that the publication of the information as contemplated in this outline, will probably necessitate an increase in the size of the

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* List follows this Report.

Journal or its more frequent issue. In fact, with good loyal support from our own arm and the outside interest now rapidly growing, a bi-monthly publication should be possible in the near future.

In closing these remarks, I wish to return thanks to the members of your committee for counsel and other aid given in reference to the policy to be followed. I wish, further, to acknowledge my obligations to all who have helped in the work of preparation and publication. I make special acknowledgements to Lieut. Cornélis DeW. Willcox, 2nd Artillery, for numerous services in the way of correspondence and other aid,—particularly for preparing the index to Volume I and the announcement and index to Volume II.

FINANCIAL STATEMENT, 1893.

Comprising a record of the receipts and expenditures for the period from December 16, 1892, to December 31, 1893.

RECEIPTS.

	$ c.	$ c.
DECEMBER 16-31, 1892—Subscriptions	2 50	
Sales	75	3 25
JANUARY, 1893—Subscriptions	76 75	76 75
FEBRUARY—Subscriptions	134 35	
Sales of No. 6	75	135 10
MARCH—Subscriptions	185 75	
Sales of No. 6	1 50	
Receipts from London Agent	3 28	190 53
APRIL—Subscriptions	45 50	45 50
MAY—Subscriptions	5 00	5 00
JUNE—Subscriptions	9 85	
Sales of No. 7	100 00	109 85
JULY—Subscriptions	19 50	19 50
AUGUST—Subscriptions	22 00	
Receipts from London Agent	6 56	28 56
SEPTEMBER—Subscriptions	7 00	
Sales of No. 8	75	7 75
OCTOBER—Subscriptions	22 50	
Sales of reprints of Vertical Fire	25 00	47 50
NOVEMBER—Subscriptions	17 50	17 50
DECEMBER—Subscriptions	40 50	40 50
Total Receipts	727 29	727 29

Total Receipts	727 29	727 29
Cash on hand December 15, 1892, last settlement	147 57	
On Deposit with London Agent	30 31	177 88
Total	905 17	905 17

EXPENDITURES.

	$ c.	$ c.
DECEMBER 16-31, 1892—Duties, expressage and fees on foreign package	5 97	5 97
JANUARY, 1893—For coated-book paper	11 00	
“ stamps	15 00	
“ lithographic plates, No. 6	46 98	
“ reproducing drawings	6 50	
“ clasp envelopes	24 00	
“ algebraic signs	1 40	
“ bristol board	3 25	
“ incidentals	4 65	
“ salary regular compositor	12 25	125 03
FEBRUARY—For copyright, *Journal* for 1893	2 00	
“ extra composition	5 00	
“ folding and binding No. 6	7 40	
“ salary regular compositor	12 00	
“ stamps and postal cards	10 00	36 40
MARCH—For printing paper	63 75	
“ coated-book paper	19 80	
“ incidentals	5 00	
“ type symbols	4 51	
“ valuable foreign periodicals	34 00	
“ salary regular compositor	12 75	139 81
APRIL—For lithographic plates for No. 7	7 38	
“ type symbols	2 23	
“ duties, fees and expressage on foreign package	2 44	12 05
MAY—For type symbols	7 64	
“ salary regular compositor	12 25	
“ printing paper	26 65	
“ extra composition	10 00	
“ incidentals	5 00	
“ stamps	6 00	
“ binding No. 7	6 85	74 39
JUNE—For salary regular compositor	25 00	
“ lithographic plates for No. 8	11 52	36 52

JULY—For steel wire	3 53	
“ stamps	10 00	
“ extra composition	5 00	
“ binding No. 8	2 85	
“ incidentals.	5 00	
“ lithographic plates for No. 9	23 00	
“ salary regular compositor	12 25	61 63
AUGUST—For incidentals	5 00	
“ type symbols	3 36	
“ copying manuscript.	3 00	
“ lithographic plates for No. 9	3 00	
“ salary regular compositor	12 75	27 11
SEPTEMBER—For lithographic plates for No. 9	19 76	
“ red paper	5 50	
“ coated-book paper	6 60	
“ copying drawings	3 50	
“ salary regular compositor	12 25	
“ type symbols	3 40	51 01
OCTOBER—For extra composition	5 00	
“ binding No. 9	4 20	
“ stamps and postage	20 00	
“ salary regular compositor.	12 25	41 45
NOVEMBER—For salary regular compositor	12 50	12 50
DECEMBER—For stamps	10 00	
“ lithographic plates for No. 10	1 00	
“ coated-book paper	6 60	
“ red paper.	5 50	
“ salary regular compositor	12 25	35 35
Total expenditures	659 22	659 22
Cash in Bank of Hampton, Va.		215 64
Cash on deposit with London Agent		30 32
		905 18

Available Resources, $245.96.
Liabilities, none.

ARTICLES OF EXPENSE.

	$ c.	$ c.
Copyright, *Journal* for 1893		2 00
Illustrations—Lithographic plates No. 6	46 98	
" " No. 7	7 38	
" " No. 8	11 52	
" " No. 9	45 76	
" " No. 10	1 00	112 64
Printing—Salary of regular compositor	148 50	
Extra composition	25 00	173 50
Paper—Printing	90 40	
Red (for covers)	11 00	
Coated-book (for illustrations)	44 00	145 40
Reproduction of drawings		10 00
Clasp envelopes		24 00
Duties, expressage, etc., on foreign parcels		8 41
Special type symbols and binding wire		26 07
Stamps, postal cards and postage		71 00
Bristol board		3 25
Binding *Journal*		21 30
Incidentals		24 65
Copying manuscript		3 00
Foreign journals		34 00
Total		659 22

I certify that the above statement of accounts is a correct record of receipts and expenditures for the period mentioned above.

(Signed) John W. Ruckman,
1st Lieutenant U. S. Artillery, Editor.

Audited and found correct.
(Signed) Jas. M. Ingalls,*
Captain 1st Artillery.

Fort Monroe, Va.,
Feb. 19, 1894.

The above report having been submitted to the members of the Committee individually, is approved and signed by the committee.

(Signed) Henry W. Closson, Colonel 4th Artillery.
" James M. Ingalls, Captain 1st Artillery.
" E. L. Zalinski, Captain 5th Artillery.
" E. M. Weaver, 1st Lieutenant 2nd Artillery.
" G. O. Squier, 1st Lieutenant 3rd Artillery.

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* Designated by the Committee to audit the accounts.

LIST OF EXCHANGES.

1 Aldershot Military Society.
2 Allgemeine militär-zeitung.
3 Allgemeine schweizerische militär-zeitung.
4 American Engineer and R. R. Journal.
5 American Journal of Mathematics.
6 Annual of the Office of Naval Intelligence.
7 Annual Report Smithsonian Institute.
8 Annual Report of the American Iron and Steel Institute.
9 Archiv für die Artillerie-und ingenieur Offiziere.
10 Arms and Explosives.
11 Army and Navy Gazette.
12 Army and Navy Journal.
13 Army and Navy Register.
14 Artilleri-Tidskrift.
15 Artilleriiskii Journal.
16 Beiheft zum militär-Wochenblatt.
17 Belgique militaire.
18 Boletin del Centro naval.
19 Broad Arrow and Naval and Military Gazette.
20 Cassier's Magazine.
21 Circulo naval—Revista de Marina.
22 Electrical Engineer.
23 Electrical Engineering.
24 Electrical Review.
25 Electricité.
26 Engineer.
27 Engineer (N. Y.).
28 Engineering.
29 Engineering Magazine.
30 Engineering and Mining Journal.
31 Engineering Review.
32 Expériences de Tir (Krupp's).
33 Génie civil.
34 Internationale Revue, über die gesammten Armeen und Flotten.
35 Iron Age.
36 Jährbücher für die deutsche Armee und Marine.
37 Journal de la Marine, Le Yacht.
38 Journal of the American Chemical Society-
39 Journal of the American Society Naval Engineers.
40 Journal of the Franklin Institute.
41 Journal of the Military Service Institution.

42 Journal of the U. S. Cavalry Association.
43 Journal of the Royal United Service Institution.
44 Journal of the Photographic Society of Great Britain.
45 Journal of the United Service Institution of India.
46 Kriegswaffen.
47 Marine de France.
48 Marine Review.
49 Marine Rundschau.
50 Mémoires et Comptes rendus des Travaux de la Société des Ingénieurs civils.
51 Memorial de Artilleria.
52 Mémorial des Poudres et Salpêtres.
53 Militaer-Wochenblatt.
54 Militaert Tidsskrift.
55 Militaire Gids.
56 Military Society of Ireland.
57 Mittheilungen aus dem Gebiete des Seewesens.
58 Mittheilungen über Gegenstände der Artillerie-und Genie-Wesens.
59 Norsk militaert Tidsskrift.
60 Orgân der militär-wissenschaftlichen Vereine.
61 Popular Science Monthly.
62 Porvenir militar.
63 Proceedings of the American Philosophical Society.
64 Proceedings of the Institution of Mechanical Engineers.
65 Proceedings of the Royal Society of New South Wales.
66 Proceedings of the U. S. Naval Institute.
67 Razviedchik.
68 Reichswehr.
69 Reports Bureau of Ethnology.
70 Revista cientifico-militar (Buenos Ayres).
71 Revista cientifico-militar y Biblioteca militar.
72 Revista da Commissao technica militar consultiva.
73 Revista do Exercito e da Armada.
74 Revista general de Marina.
75 Revista de la Asociacion de Navieros y Consignatorios.
76 Revista maritima brazileira.
77 Revista militar.
78 Revue d'Artillerie.
79 Revue de l'Armée belge.
80 Revue d'Infanterie.
81 Revue du Cercle militaire.
82 Revue du Génie militaire.
83 Revue maritime et coloniale.
84 Revue militaire de l'Etranger.
85 Revue militaire suisse.

86 Revue universelle.
87 Rivista di Artiglieria é Genio.
88 Russkii Invalid.
89 Schweizerische Monatschrift für offiziere aller waffen.
90 Schweizerische Zeitschrift für Artillerie ünd Genie.
91 Scientific American.
92 Technology Quarterly.
93 Transactions of the American Institute of Electrical Engineers.
94 Transactions of the American Institute of Mining Engineers.
95 Transactions of the American Society of Civil Engineers.
96 Transactions of the American Society of Mechanical Engineers.
97 Transactions of the Canadian Institute.
98 Transactions of the Canadian Society of Civil Engineers.
99 Transactions of the East of Scotland Tactical Society.
100 Transactions of the Institution of Naval Architects.
101 United Service (Hamersly's).
102 United Service Gazette.
103 Western Electrician.

CONTENTS BY NUMBERS.

NO. 1.

NO. 2.

NO. 3.

NO. 4.

INDEX TO VOLUME II.