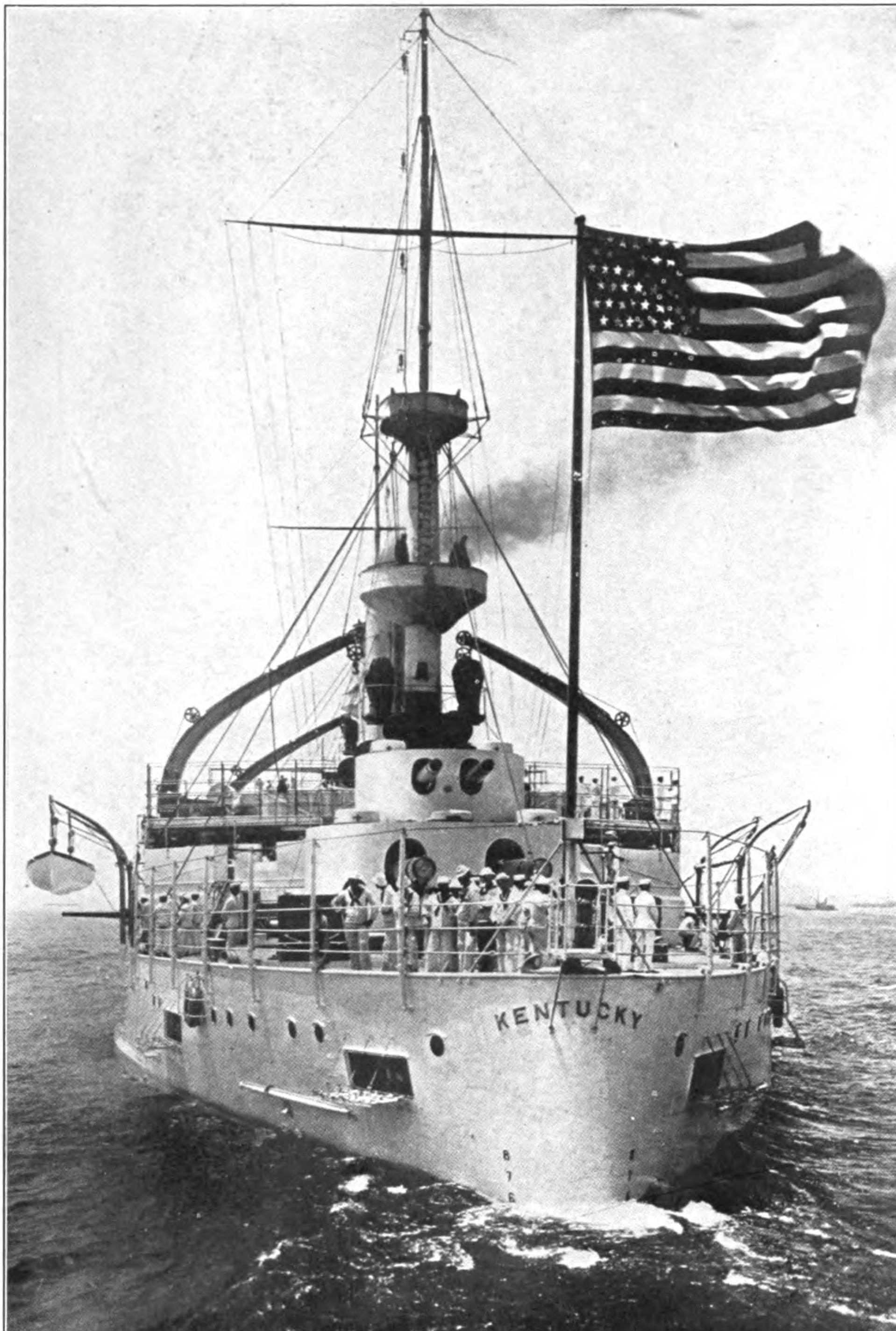

U.S. FIRST-CLASS BATTLESHIP "KENTUCKY", 11,500 TONS; 10,500-I.H.P.; SPEED 16 KNOTS.

ARMOR PROTECTION:—Belt H. N. 16.5 inches amidships, 4 inches at bow, 7.5 feet wide, lower edge 9.5 inches amidships. Upper belt 5.25 inches; battery, 5.5 inches, 2-in. screens in battery. Turrets, 15 inches (for 13-in.), 9 inches (for 8-in.). Armored deck, 2.5 inches flat, 4 inches aft.

ARMAMENT:—Four 13-inch; four 8-inch 40 cal., fourteen 5-inch 40 cal., twenty 6-pdr., eight 1-pdr., four Colts. Four torpedo tubes, above water.

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1906

Corrections

Page 39: Equation (65) should be

$$P' = \frac{1728\ f}{27.68\ a^2}$$

Page 43: Omit the "— 10" in the third term of second member of equations (74) and (75).

Page 44: Equation (21′), *for* 1.54798 *read* 1.54708.

Page 45: Equation (55″), *for* 9.23052 *read* 7.23052.

Page 102: Par. (b) 7th line, *for* pretaining *read* pertaining.

Page 103: The quotation from G. O. No. 15, November 1, 1905, Headquarters Artillery District of New London, should begin with the *third* paragraph, page 103.

Page 132: End of *Problem V.*, should read $\frac{6}{15} = .4 = .4$ ohms.

Page 151: In the first expression for N, change

$$\sqrt{d^2 - c} \text{ to } \sqrt{c^2 - d}$$

Page 165: Line 18, *for* this *read* these.

Page 165: Line 19, *for* 9.53037 *read* 6.53037.

Page 190: 2d par. 1st line, *for* invariable *read* invariably.

Page 262: Table V. The figures at top of table, 0, 1, 2, 3, etc., should be *tenths*, that is, .0, .1, .2, .3, etc,

Page 281: 3rd line above table, *for* was *read* were.

Page 295: Table, $x = 3.0$, *for* 0.27858, *read* 0.26858.

Page 295: Table, $x = 3.6$, *for* 0.33158, *read* 0.33159.

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JOURNAL

OF THE

UNITED STATES ARTILLERY

*"La guerre est un metier pour les ignorans,
et une Science pour les habiles gens."*

VOL. 25 NO. 1 JANUARY–FEBRUARY, 1906 WHOLE NO. 77

THE NEEDS OF THE COAST ARTILLERY

BY "COAST ARTILLERIST"

COLONEL James S. Pettit, Eighth U. S. Infantry, has recently read before the Military Service Institution an able paper on the organization and discipline of our armies as affected by democracy and the question as to how its influence can be most effectually utilized.

It is to be regretted that so excellent an article as this should be marred by an unsympathetic fling at the Coast Artillery, and that so able and forceful a writer and close reasoner as Colonel Pettit should have permitted such a lapse as that evidenced in this reference to the needs of the Coast Artillery made therein.

He says: "I am not impressed by the great demands of the Coast Artillery." He then proceeds to substitute his own views as to the needs of the artillery for those submitted from the office of the Chief of Artillery.

The main contention of Colonel Pettit throughout his article is, [illegible] the military policy of the United States has been erratic and [illegible]ical, chiefly because of the "bungling" interference of Presidents, Secretaries of War, Congressmen and others, who, through ignorance, were incompetent to advise or direct.

By his sweeping assertion, in the passage referred to above, he places himself, it is thought, in the same category with those whom he condemns in a general way. It is not in evidence whereby Colonel Pettit has acquired that special knowledge of the needs of the Coast Artillery that would entitle his views and advice to the weight and consideration he himself argues as proper and necessary in regard to other military affairs. If confronted with a request to qualify as an adviser according to his own standard, he would probably judge himself incompetent, for he is eminently fair-minded where his attention has been duly directed to a point like this.

But this off-hand condemnation of the estimates and propositions that have been presented from time to time by the Coast Artillery for adequate coast protection and for the organization of the personnel assigned to coast defense, is not a new thing. The Coast Artillery has, by long experience, come to look upon such expressions as a matter of course. Opposition has been met officially and privately in every step almost that has been taken or attempted by the artillery in the past, especially since the early 90's. Interference was encountered when first it was attempted to get a Chief of Artillery under the regimental organization. Opposition was again met when it was desired to drop the regimental organization and have a corps organization. Even in the organization of the present artillery corps, the ideas of coast artillery officers were not solicited, and the organization is now defective in consequence thereof. More recently, the views of artillery officers as to the present urgent needs of coast defense have been discarded with perhaps more positiveness than heretofore.

It is such experiences as these that have led many officers of Coast Artillery almost to despair of ever seeing an adequate coast defense and a proper organization therefor established under existing administrative relations. This feeling has come to be almost a general one among coast artillerymen. It is such assertions as this of Colonel Pettit, and the general lack of sympathy of officers of other branches of the service with the aims of the Coast Artillery, lack of interest in, and ignorance of, its work, that called forth a recent contribution to the "Army and Navy Journal" of December 23, 1905, entitled "Coast Artillery and the Navy." That article presented the conclusions forced in upon Coast Artillery officers as follows:

"While the suggestion of so radical a measure as withdrawing control of the Coast Artillery from the War Department and vesting it in the Navy Department may at first cause surprise ; yet, upon consideration, the many valid reasons for the consolidation under one head of the two elements of coast defense cause wonder why it has never been accomplished before. By the very nature of their work the Coast Artillery and the Navy are required to co-operate ; and the line of distinction between the functions of the two when co-operating in the defense of a particular harbor is so faintly drawn that many hindrances to perfect co-operation must surely arise as long as the common head is so far removed as the White House. Whereas, if the Navy Department included both Coast Artillery and Navy, the common head could be effectively represented on the spot by the senior officer. Such a union of the two branches of coast defense would simplify the question of ammunition supply, both at home and at insular naval stations; it would remove the necessity for differentiation between the use of submarine boats in the preparation or maintenance of torpedo defense and in their use in attack; it would facilitate the work of scout-boats and of all other floating adjuncts of harbor defense that are regarded by the Coast Artillery as being within its province.

"In time of peace the incorporation of the Coast Artillery in the Navy Department would afford the immense advantage that comes from a combined study of the problems of attack and defense. The Naval War College, the work of which is much more appropriate for officers of Coast Artillery than is the work of the Army War College, would then be open to a much larger number of officers of Coast Artillery than can ever be the case as long as the Navy Department has no responsibility for their education. And the educational value of the experimental work done at the Naval Proving Ground would be greatly increased through consideration of the Coast Artillery problems, and through general dissemination among artillery officers of the results obtained.

"As affecting the general efficiency of the two services in coast defense, and especially as affecting the development of the Coast Artillery, there should not be forgotten the sympathy and mutual understanding arising from natural dependencies of one upon the other that would be nurtured by the union in one department of the Navy and Coast Artillery. While on the other hand, it appears to many well informed officers that a development of the Coast Artillery is, under present conditions, practically impossible, because of lack of sympathy with, and understanding of, the work of the Coast Artillery on the part of the field forces with whom it is only legally related."

The author of this article is not known to the writer, but he does know that it voices a quite general and growing feeling in the Coast Artillery.

The needs of the Coast Artillery have been set forth in the Annual Reports of the Chiefs of Artillery, particularly in the last report of General Story (1904) and of General Mills (1905). Those who desire to know what these needs are should read with care these two reports, and note the irrefutable facts therein presented.

Having a knowledge of what the interests of the United States in the matter of coast defense demand, and realizing an apparent impossibility of obtaining an adequate defense and proper organization under the administration of the War Department because of the lack of sympathy of the other arms and departments, a sense of duty to the interests of the United States rising above all other considerations suggests a transfer of the administration of the Coast Artillery to the Navy Department.

In such a transfer coast artillerymen see an escape from the lukewarmness that now controls in matters pertaining to coast defense; they see a severance of a union with forces with which they have little or no active connection in time of war, and, at the same time, they note that such a severance would establish closer relations with a body with which they are, of necessity, intimately and co-ordinately associated in war in defending the coast line; they see, particularly, the possibility of an independence of functions and control that would enable the coast defenders to determine matters pertaining to fortification, armament and supplies, in connection with which now they have no adequate voice or power to act, and which now involves often the very great difficulty of getting three separate construction and supply departments into synchronous and harmonious action before material can be installed and made serviceable for the Coast Artillery.

There ought to be no opposition from the army to this transfer. It will reduce the appropriations for the army by several millions, and thereby have a tendency to make Congress consider the annual army estimates in a kindlier spirit. The Ordnance Department could, of course, continue to make the coast defense guns just as well under the proposed as under existing conditions; it is now making guns for the Navy. The Engineer Board could become a mixed board like the Lighthouse Board, and this new Board could attend to construction of and repairs to fortifications. The present Lighthouse Board is such a mixed Board. The electrical work now done by the Signal Corps should, it is thought, be done by experts of the coast defense corps.

The Commanding Generals of the Alantic and Pacific Divisions would lose a large part of their present commands, but, in case of war, these peace relations would be dissolved anyway as soon as the field army should be organized. Would it not be better to have the coast defense troops detached in peace from all relation to the field troops, so that when war with a maritime power begins there would be no change in the administration of the coast defense troops? As elsewhere pointed out, these coast defense forces would include both Coast Artillery and those naval forces manning the auxiliary floating defenses of the Navy which are associated in a mutually supporting way with the shore defenses in harbor defense.

The Coast Artillery looks out to sea toward a naval enemy; it lines up with the home naval forces in action against this naval enemy; its chief professional thought is given to naval questions, of ships, armor, and naval coast attack tactics. It may well be asked, is it not logical and reasonable that there should be a transfer of all such elements of shore defense against naval attack to the Navy Department?

Finally, it should be kept in mind that a transfer of Coast Artillery troops to the Navy Department would not prevent the use of these troops in case of need as infantry with field troops in the interior, or for riot duty, as they receive careful instruction in infantry drill, both close and open order, and castrametation. The marines now under the Navy department have often been used in case of emergency with field troops, and even the bluejackets from the ships are armed and drilled to be so used, and were so used by the British in South Africa.

PRIMERS AND FUZES FOR CANNON*

By Major ORMOND M. LISSAK, Ordnance Department

Instructor of Ordnance and Gunnery, U. S. M. A.

PRIMERS are the means employed to ignite the powder charges in guns.

They may be divided, according to the method by which ignition is produced, into three classes :

Friction primers,
Electric primers,
Percussion primers.

Combination primers are those so constructed that they may be fired by any two of the above methods. Primers that close the vent against the escape of the powder gases are called obturating primers.

All primers should be simple in construction, safe in handling, certain in action and not liable to deterioration in store. Electric primers in addition should be uniform as to the electric current required for firing.

The primer known as to the *common friction primer*, formerly used in all cannon, is shown in figure 1.

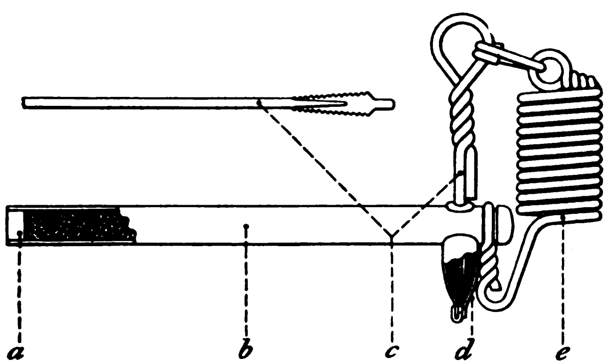

Fig. 1.

The body *b* and the branch *d* are copper tubes. The tube *b* is filled with rifle powder, and is closed at its lower end by a wax stopper *a*. The tube *d* is filled with the friction composi-

* Prepared for the Cadets of the United States Military Academy.

tion, whose ingredients are chlorate of potash, sulphide of antimony, ground glass and sulphur, mixed with a solution of gum arabic. Imbedded in the friction composition is the serrated end of the copper wire *c*, the other end of the wire being formed into a loop for attachment of the hook of the lanyard. The outer end of the tube *d* is closed over the flattened end of of the wire which is bent over into a hook, as shown, and serves to hold the wire securely in place except when a stout pull is given to the lanyard. The pull on the lanyard straightens out the hook, and draws the serrated wire through the friction composition, igniting it. The fire is communicated to the rifle powder in the tube *b*, and thence through the vent to the powder charge in the gun.

For use in axial vents, in order to prevent the primer being blown to the rear among the men of the gun detachment, a coiled copper wire *e* is added to the primer, one end of the wire being made fast to the top of the primer body, the other end to the loop for lanyard hook. The coil is extended by the pull of the lanyard, and the primer when blown to the rear remains attached to the lanyard.

Obturating primers.—The primer above described is blown out of the gun by the explosion of the powder charge, leaving the vent open for the escape of gas. The disadvantage is overcome in modern practice by the use of obturating primers. The breech mechanisms of all guns now made are adapted to obturating primers, and the primer just described is no longer used in service cannon.

Screw friction primer.—This primer, figure 2, has a brass body *i* bored as shown. A pellet of friction composition *d* is

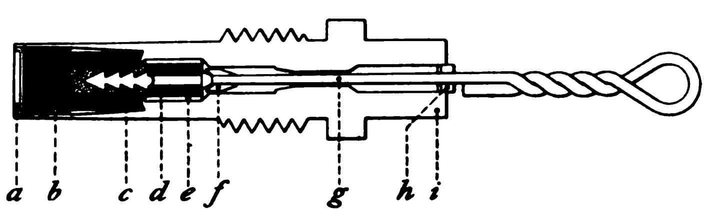

FIG. 2.

moulded around the shank of the serrated wire *g* just above the serrations. A paper cylinder *e* encloses the composition to prevent disintegration. The priming charge is composed of the two cylinders of compressed powder, *b* and *c*, and the loose rifle powder, which facilitates ignition. The safety block *h*, soldered to the wire *g*, prevents any forward movement of the wire through the pellet, which might cause premature firing in transportation or handling. The conical brass gas check *f* is loose on the wire *g*. A brass cup *a*, shellacked in place, closes the mouth of the primer.

The primer is screwed into its seat in the gun. When, by the pull of the lanyard, the serrated wire is pulled quickly through the pellet of friction composition, ignition occurs. The gas check *f* comes to a bearing in the coned seat in rear and prevents the escape of gas through the body of the primer. The primer fits closely in its seat in the gun, and at discharge the thin walls of its mouth are expanded against the walls of the primer seat, preventing the escape of gas around the body of the primer.

This primer was formerly in use in all siege and seacoast cannon. It has been superseded in seacoast cannon by the combination primer described later, but its use will be continued in the 3.6-inch and 7-inch mortars.

To assist in increasing the rapidity of fire of all guns a primer that can be more readily inserted in the gun is required. The desired object has been attained by the addition of firing mechanisms to the breech mechanisms of most guns, the firing mechanisms being so designed as to permit the use of a smooth-sided primer that can be readily pushed into its seat. The head of the primer is firmly held by the firing mechanism, so that the primer cannot be blown out on the discharge of the piece. The firing wire is engaged and pulled by a slotted lever actuated by the pull on the lanyard.

Friction primer, latest pattern.—The primer, figure 3, has a body *h* of brass. The brass firing wire *i* passes loosely

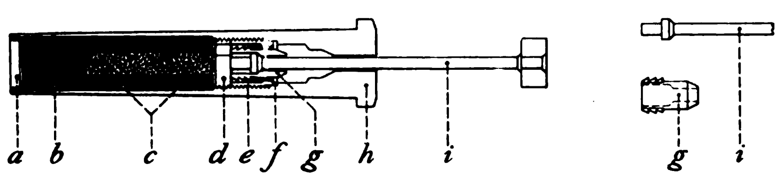

FIG. 3.

through the hole in the serrated cylinder *g*, the end of the wire being flush with the end of the cylinder when the nut on the wire bears against the interior shoulder of the cylinder. The friction composition, pressed into the brass case *e*, surrounds the cylinder *g* above the serrations. The vulcanite washer *f* holds the friction composition in place and prevents it from crumbling when the pull is applied. The nut *d*, screwed to a bearing on the case *e*, holds the assembled parts in place. Three holes through the nut permit the passage of the flame from the friction composition to the priming charge of powder.

When the wire *i* is pulled, ignition of the friction composition is effected. The conical end of the cylinder *g* is pulled to its seat in the body of the primer, and prevents escape of gas to the rear. Should the primer for any reason fail to fire, the wire *i* is now free to move forward without carrying the cylinder *g* and the friction composition with it, and therefore without danger of firing the primer in its reverse movement. In earlier models the teeth were formed on the wire, and it was found that when a primer had failed to fire it might be fired by an accidental reverse movement of the wire forcing the teeth quickly through the composition.

All metal parts of this primer are tinned to prevent corrosion.

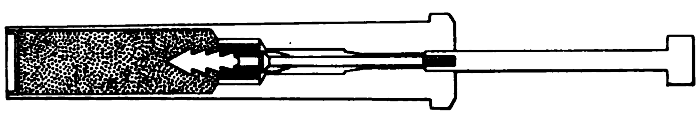

FIG. 4.

Figure 4 shows the more cheaply constructed drill primer of this form.

Electric primers.—The electric screw primer, figure 5, is used in the 3.6-inch and 7-inch mortars, these guns being

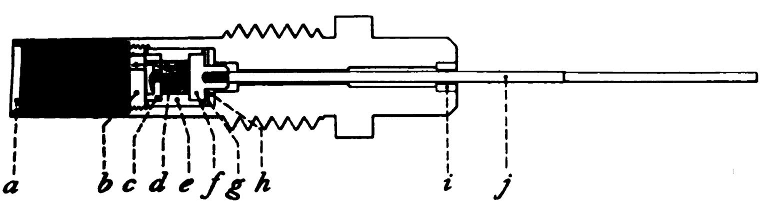

FIG. 5.

adapted for screw primers only. The single copper wire *j*, insulated with silk except at its outer end, passes through the vulcanite bushing *i* and the body of the primer to the brass obturating plug *f* into which it is screwed. The plug is insulated from the primer body by the vulcanite washer *h*, the leather washer *g*, and the vulcanite cylinder *e*. The platinum wire bridge *d*, 0.002 of an inch in diameter, is soldered to the plug *f* and to the brass washer *c*. The latter is put in electrical connection with the walls of the primer by the brass closing screw *b*. A small quantity of guncotton surrounds the platinum wire.

When the primer is inserted in the gun the base end of the wire *j* is grasped by the parts of an electric contact piece through which is passed in firing an electric current insulated from the gun. The current passes through the wire *j*, the platinum bridge and the body of the primer to the walls of the gun, and thence to the ground.

The passage of the electric current heats the platinum wire, igniting the guncotton and the priming charge of powder.

Another electric primer for use in a different breech mechanism is described after the 110-grain percussion primer.

Combination electric and friction primer.—This primer is used in all seacoast cannon except those fitted for percussion firing.

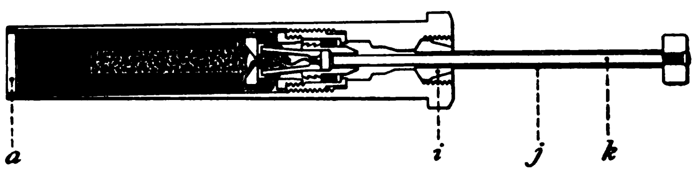

FIG. 6.

The primer is shown complete in figure 6. The igniting elements enlarged are shown in figure 7. The parts of the friction elements of this primer are similar in construction and action to the parts of the friction primer shown in figure 3.

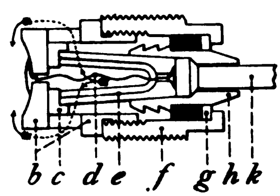

FIG. 7.

For electric firing the wire *k* is covered with an insulating paper cylinder *j* and enters the primer body through a vulcanite plug *i*. The wire is in electric contact with the serrated cylinder *h*, figure 7, but this is insulated from the primer body by the vulcanite washer *g* and the pellet of friction composition, a non-conductor of electricity.

The electrical elements of the primer are assembled in the metal case *f*. The head of the forked metal support *e* is in contact with the headed end of the wire *k*, but not fastened to it. The forked end of the support is held in the vulcanite cup *c*. The brass contact nut *b*, screwed into the end of the case *f*, presses the assembled parts into intimate electrical contact. A platinum wire *d* is soldered to the head of the support *e* and to the contact nut *b*. An igniting charge of guncotton surrounds the wire.

The electric current enters the primer by means of the button on the outer end of the wire *k*, and passes through the primer and gun as described for the previous primer.

It will be observed that the friction elements of the combination primer are independent of the electrical elements, and that when one of these primers fails to fire by electricity it may still be fired by friction.

If, however, the primer fails in an attempt to fire it by friction, it will not generally be possible to fire it electrically since the cylinder *h*, which has been pulled into the head of the primer, is out of contact with the part *e* and the platinum wire bridge. The current will then pass directly from *h* through the primer body and gun to the ground.

The primer should in this case be at once removed from the vent, and not be again used.

The outer button and wire *k* may be turned without danger of breaking the platinum wire bridge *d*.

When an electric or friction primer fails to fire, it should be removed from the vent, and the wire bent down and around the primer to prevent attempts to use it again.

Percussion primers.—The friction and electric primers described are used in guns in which the projectiles and powder charges are loaded separately, the primer being separately inserted in the breech block. Percussion primers, and the electric primer described with them, are, on the other hand, inserted in cartridge cases, in which are usually assembled both the projectile and the powder charge.

The essential parts of a simple percussion primer such as the cap in a small arm cartridge, are the primer cup, the anvil, and the percussion composition.

Formerly the percussion composition of all service primers contained a large percentage of fulminate of mercury. On account of the danger involved in handling mixtures containing the fulminate of mercury, its use as a primer ingredient in service primers manufactured at the Frankford Arsenal has been abandoned, and a mixture known as the H-48 composition is now employed.

This mixture contains the same ingredients as the friction composition, but in different proportions, as follows:

Chlorate of potash, 49.6.	Ground glass, 16.6.
Sulphide of antimony, 25.1.	Sulphur, 8.7.

To insure the practically instantaneous ignition of smokeless powder charges, the addition of a small charge of quick-burning black powder is required. This may be inserted in the base of the smokeless powder charge, or may be contained in the primer. It is desirable, on account of the smoke produced by black powder, and the fouling of the bore, that the quantity of black powder used be limited to the smallest amount that will produce prompt and complete ignition of the smokeless powder. The minimum amounts required for different charges have been determined and, for fixed ammunition, are contained in the percussion and igniting primers. These primers are inserted in the head of the cartridge case, in the position occupied by the primer in the small arm cartridge.

Two sizes of percussion primers, the 110-grain and the 20-grain have been adopted for all guns from the 1-pounder to the 6-inch Armstrong inclusive.

110-grain percussion primer.—The body *f* is of brass, 2.63 inches long. A pocket is formed in the head of the case for the reception of the metal cup *e* containing the percussion composition *d*. Projecting up from the bottom of the pocket is the anvil *c* against which the percussion composition is fired. Two vents are drilled through the bottom of the pocket. The priming charge consists of 110 grains of black powder inserted under high pressure into the primer body around a central wire. The withdrawal of the wire after the compression of the powder leaves a longitudinal hole the full length of the primer. Six radial holes are drilled through the walls of the primer and through the compressed powder. The compression of the powder increases the time of burning of the priming charge and causes the primer to burn with a torch-like rather than an explosive effect, making the ignition of the smokeless powder charge more complete. The holes through the priming charge increase the surface of combustion and the mass of flame, and direct the flames to different parts of the charge of powder, thus facilitating its complete ignition. The paper wad *a*, shellacked in the mouth of the primer, and the tin-foil covering *b*, serve to keep out moisture and to protect

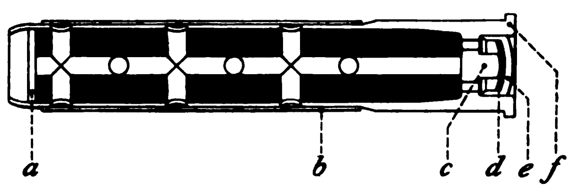

FIG. 8.

the primer from the impact of the powder grains when transported assembled in cartridge cases.

This primer is used in cartridge cases for guns from the 6-pounder to the 6-inch Armstrong gun inclusive.

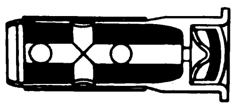

FIG. 9.

The 20-grain percussion primer, shown in figure 9, length 1.1 inches, is used in cartridge cases for 1-pounder subcaliber tubes, 1-pounder machine guns and 1.65-inch Hotchkiss guns.

110-grain electric primer.—This primer, figure 10, is similar in form to the 110-grain percussion primer just described, and has the same priming charge similarly arranged. Ignition is produced electrically through the brass cup *g* to which one end of the platinum wire *e* is soldered. The cup is insulated from the body of the primer by the cylinder *f* and bushing *d*, both of vulcanite. The brass contact bushing *c*, to which the other end of the platinum wire is soldered, completes the electrical connection.

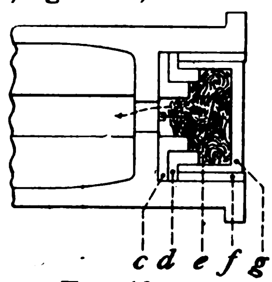

FIG. 10.

20-grain saluting primer.—This primer, figure 11, costing less to manufacture than the 110-grain primer, is to be used in place of the latter with blank charges only. The primer contains a charge of 20 grains of loose rifle powder. As black powder only is used in blank charges, a smaller igniting charge answers.

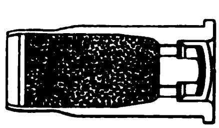

FIG. 11.

The percussion primers and the electrical primer of the same form, are so manufactured as to have a driving fit in their seats in the cartridge cases to which they are adapted, the diameter of the primer being from one-and-a half to two thousandths of an inch greater than the diameter of the seat. Special presses for the insertion of the primers are provided. The primer must not be hammered into the cartridge case. The primer seats in all cartridge cases using these primers are rough bored to a diameter about 20 per cent. less than the finished size, and then mandrelled to finished dimensions with a steel taper plug, to toughen the metal of the cartridge case around the primer seat. The toughening is necessary to prevent expansion of the primer seats under pressure of the powder gases, and consequent loose fitting of the primers in subsequent firings.

Combination electric and percussion primer.—In figure 12 is shown a combination electric and percussion primer used in rapid-fire guns in the U. S. Navy. Its construction can be readily understood from the figure. The insulation is shown by the heavy black lines.

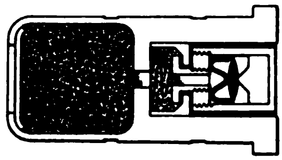

FIG. 12.

When fired by percussion the percussion cap is not directly struck by the firing pin, but by the point of a plunger forced inward by the blow.

Igniting primers.—The igniting primers are for use in cartridge cases for subcaliber tubes for seacoast cannon not provided with percussion firing mechanism. They contain no means of ignition within themselves, but require for their ignition an auxiliary friction or electric primer which is inserted in the vent of the piece in the same manner as for service firing. The flame passes from the service primer through the vent in the breech block to the igniting primer in the head of the cartridge case. The flame from the service primer would not be sufficient to ignite properly the smokeless powder charge in the cartridge case, and, therefore, the igniting primer is added.

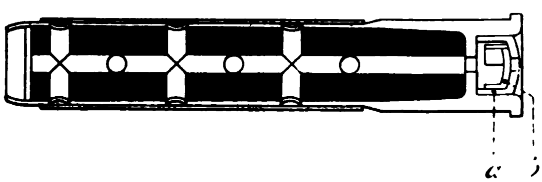

FIG. 13.

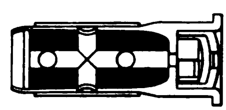

FIG. 14.

The 110-grain and the 20-grain igniting primers, figures 13 and 14, differ from the corresponding percussion primers in the substitution of the obturating cup *a* and obturating valve *b*, both of brass, for the percussion cup and anvil. The obturating cup *a* is provided with a central vent to allow passage for the flame from the auxiliary primer. The obturating valve *b* is cup-shaped, and has three sections of metal cut away from its top and sides to allow passage of the flame. The valve *b* has a sliding fit in the cup *a*, and when the pressure is greater in front of the valve than behind it, the valve is forced to the rear and the solid top of the valve closes the vent in the outer cup.

The valve is shown in section in figure 13, in the position it assumes after firing; and in elevation in figure 14, in its position before firing.

FUZES

Fuzes are the means employed to ignite the bursting charges of projectiles at any point in the flight of the projectile, or on impact.

They are of three general classes:

Time fuzes,
Percussion fuzes,
Combination time and percussion fuzes.

All fuzes should be simple in construction, safe in handling, certain in action, and not liable to deterioration in store. In addition the rate of burning of the time train of the fuze must be uniform.

The time fuze alone, that is, without percussion element, is no longer used in modern ordnance.

Percussion fuzes.—A percussion fuze is one that is prepared for action by the shock of discharge, and that is caused to act by the shock of impact.

When ready to act, as after the shock of discharge, the fuze is said to be armed.

Percussion fuzes are inserted at the point or in the base of the projectile. In some of the projectiles for guns of minor caliber, including the 6-pounder, the fuze is inserted at the point; in others at the base. The percussion fuzes for field, siege and seacoast projectiles are base insertion fuzes.

The percussion fuze consists essentially of the case or body of brass, which contains and protects the inner parts and affords a means of fixing the fuze in the projectile; the plunger, carrying the firing pin and provided with devices to render the fuze safe in handling; the percussion composition, which is fired by the action of the plunger on impact; and the priming charge of black gunpowder.

The percussion composition of all service fuzes manufactured at Frankford Arsenal is the same. The ingredients are chlorate of potash, sulphide of antimony, sulphur, ground glass and shellac. The thoroughly pulverized ingredients are mixed dry, and alcohol is added to dissolve the shellac. The percussion pellets are formed by pressing the mixture while in a plastic state into the percussion-primer recess. Upon the evaporation of the alcohol, the shellac causes the pellet to adhere to the metal of the recess.

A mercuric fulminate percussion composition was formerly used in fuze primers, but on account of the danger incident to handling this compound it has been abandoned as a primer ingredient.

It is still used abroad, and the percussion composition of both the Ehrhardt and Krupp combination time and percussion fuzes contains mercuric fulminate.

Point percussion fuze, for minor caliber shell.—These are adapted to the projectiles for 1-pounder, 2-pounder and 6-pounder guns.

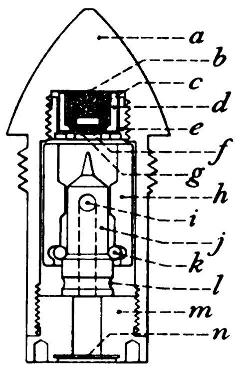

FIG. 1.

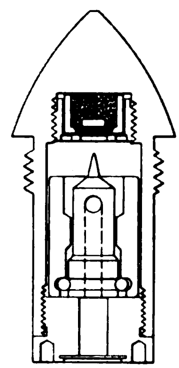
FIG. 2.

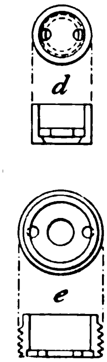

FIG 3.

The body *a*, Fig. 1, is of brass. Into the recess formed in the head is screwed the cup-shaped primer screw *e*, Fig. 3, into which are previously assembled first the brass primer shield *g* and then the primer cup *d*, Fig. 3, containing the percussion composition *f* and the charge of black powder *c*. A tin-foil disk *b* closes the mouth of the primer cup. The primer screw *e* has a central hole through the bottom which permits the firing pin to reach the percussion composition. The primer shield *g* prevents any dislodgment of the composition during transportation, or by shock of discharge, and also restrains the firing pin during flight of the projectile. The primer cup *d* has two chambers separated by a solid partition, through which are bored two circular vents. The lower chamber, 0.03 inch deep, holds the percussion composition, and its wall is undercut to assist in holding the composition in place. The primer cup is 0.03 of an inch longer than the recess in the primer screw *e*, so that when the latter is screwed down hard the primer cup bears against the head of the fuze body.

Contained in the body of the fuze is the plunger, which consists of the firing pin *j*, the firing-pin sleeve *h* and the spli-t ring spring *k*, all of brass. The firing pin has an enlarged rear part joined to the forward part by a conical slope, and provided near the bottom with a groove *l* of diameter slightly larger than the diameter of the forward part of the pin. A radial hole *i* through the pin near its forward end, and an axial hole from this point to the rear end of the pin, provide a passage for the flame from the priming charge. The rear part of the bore through the sleeve, *h*, is of diameter just sufficient to admit the split ring, which rests against the forward shoulder of the counterbored recess, and holds the firing so that its point is wholly within the sleeve. The front part of the sleeve is counterbored to permit ready entrance of the flame from the priming charge into the passage through the firing pin. The plunger thus assembled is placed in the fuze body, which is closed by the brass closing screw *m*, provided with a central vent which is in turn closed by the brass disk *n*. To prevent pressure of the closing screw on the plunger, which might cause expansion of the split ring and the arming of the fuze, the plunger is allowed a longitudinal play in the fuze body of from one to two hundredths of an inch. With the parts of the fuze in this position the point of the firing pin is prevented from coming into contact with the percussion composition, and, therefore, the fuze cannot be fired.

If sufficient force is applied rearwardly to the sleeve, *h*, the split ring, *k*, will be forced over the enlarged portion of the firing pin until it rests in the groove *l*, near the bottom; and the sleeve, moving to the rear, will expose the point of the firing pin. The fuze is then armed, as shown in Fig. 2.

To insure arming of the fuze when fired the resistance of the split ring to expansion is made less than the force necessary to give the sleeve the maximum acceleration of the projectile. Therefore when the piece is fired and while the projectile is attaining its maximum acceleration, the pressure of the sleeve will force the ring over the enlarged part of the firing pin into the groove at the rear.

The diameter of this groove being greater than the diameter of the front part of the firing pin, the ring is now expanded into the counterbored recess in the sleeve and locks the sleeve and firing pin together, with the point of the firing pin projecting beyond the sleeve.

As the plunger of the fuze does not encounter the atmospheric resistance which retards the projectile in its flight, it is probable that during the flight of the projectile the plunger moves slowly forward until the point of the firing pin rests against the brass primer shield.

At impact of the projectile the combined weight of the plunger parts acts to force the point of the firing pin through the primer shield and into the percussion composition, igniting the composition.

The flame from the primer charge passes through the forward vents, through the passages in the plunger, and through the vent in the closing screw, blowing out the closing disk and igniting the bursting charge in the shell.

Base percussion fuze, for minor caliber shell. This fuze, as well as the point percussion fuze, is adapted to the projectiles for 1-pounder, 2-pounder, and 6-pounder guns.

The fuze, Fig. 4, is similar in construction and action to the point percussion fuze. As the primed end of the fuze is toward the interior of the shell the flame from the priming charge passes directly to the bursting charge in the shell. without passing through the body of the fuze. The flame passages through the plunger parts are therefore omitted. The primer cup *b* containing the percussion composition and priming charge is closed at its outer end by the brass disk *a*, which is secured in place by crimping over it a thin wall left on the brass closing cap screw *c*.

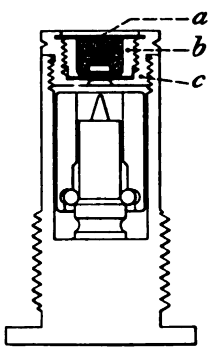

FIG. 4.

There are two classes of ring-resistance fuzes manufactured, the "high resistance" and the "low resistance," so called because the arming resistance of the ring is relatively high or low.

High-resistance fuzes are safe under all ordinary conditions of handling and transportation, and are transported fixed in the projectiles in which used.

Low resistance fuzes cannot, on account of the danger of premature arming, be transported fixed in projectiles.

The low-resistance fuzes are transported packed in hermetically sealed boxes, and, to prevent premature arming of the plunger in handling, the firing-pin sleeve and the firing pin are locked together by means of a safety wire passing through them and the body of the fuze. Just before using this wire must be pulled out, after which the fuze may be screwed into the projectile. The only low-resistance fuze at present issued is the 28-second combination fuze, for 7-inch mortar shrapnel.

The act of arming a ring-resistance percussion fuze shortens the plunger and increases materially its longitudinal play in the fuze body. This fact permits a ready and simple means of inspecting for premature arming without dismantling the fuze. If the fuze be held close to the ear and shaken, the marked difference between the play of the plunger in an armed fuze and in an unarmed one can be readily discerned.

Percussion fuzes for larger projectiles. Centrifugal fuzes.—The centrifugal fuze of service pattern is the result of a long series of experiments made for the purpose of developing a fuze that would fulfil the requirements of absolute safety in handling and transportation, and certainty of action.

In the case of ring-resistance fuzes, or any fuze the action of which depends on the longitudinal stresses developed by the pressure in the gun, the conditions of safety in handling, and certainty of action are opposing ones.

It was impossible to meet successfully both sets of conditions in all cases, the stress developed in the direction of the axis by accidental dropping of a fuze being in many cases higher than that developed in the gun.

As has been shown, two classes of ring-resistance fuzes are required, the "low resistance" and the "high resistance"; the low resistance for use in the 7-inch mortar, in which piece the low powder pressures impart a low maximum acceleration to the projectile, and require greater sensitiveness in the fuze.

The greater liability to accident in handling fuzed projectiles due to the rapidity of fire required from modern guns, has caused the retirement of fuzes that depend for their action upon the acceleration of the projectile in the gun, except in some of the smaller guns where the acceleration is so great that a very high arming resistance can be given. A fuze which is armed by the centrifugal force developed by the rotation of the projectile, and which is safe until the maximum velocity of rotation is nearly attained, has been developed at the Frankford Arsenal, and is now applied to all projectiles above the 6-pounder in caliber.

As already stated, ring-resistance fuzes are used in 1-pounder, 2-pounder, and 6-pounder shell. The limited fuze dimensions render the construction of a satisfactory centrifugal fuze for these shell mechanically very difficult; but, by reason of the high maximum acceleration of these projectiles in the gun, the sensitiveness of the ring-resistance fuzes need not be so great as to interfere with the safe handling of the projectiles.

The centrifugal fuze, before arming, is shown in Fig. 5. Figure 6 is a view of the plunger after arming.

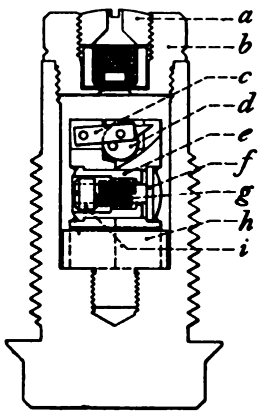

FIG. 5.

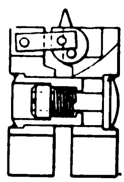

FIG. 6.

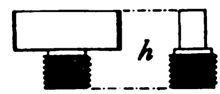

FIG. 7.

The fuze body, or stock, and the primer parts of the centrifugal fuze do not differ materially from the corresponding parts of the ring-resistance fuzes. To protect better the priming charge, the closing cap screw *b* is lengthened and the vented primer-closing screw *a* is added.

The body of the centrifugal plunger is in two parts, nearly semi-cylindrical in shape, which, when the fuze is at rest, are held together by the pressure of a spiral spring *g* contained in the cylindrical bushing *e* which is secured to one of the plunger halves. The spring exerts its pressure on the other half of the plunger through the bolt *f*. Pivoted in a recess in one half of the plunger is the firing pin *d*, which when the fuze is at rest is held with its point below the front surface of the plunger by the lever action of the link *c* which is pivoted in the other half. Under the action of the centrifugal force developed by the rapid rotation of the projectile the two halves of the plunger separate. The separating movement causes the rotation of the firing pin *d*, the point of which is now held in advance of the front surface of the plunger, Fig. 6, ready, on impact of the projectile, to pierce the brass primer shield and ignite the percussion composition. When the fuze is armed the end of the link *c* rests on the axis of the firing pin, thus affording support to the firing pin when it strikes the percussion primer. The separation of the plunger parts is limited by the nut *i* coming to a bearing on a shoulder in the bushing *e*, so as not to permit the diameter of the expanded plunger to equal the interior diameter of fuze stock, see Fig. 8, below.

A rotating piece, *h*, Fig. 7, screwed into head of fuze stock, engages in a corresponding slot cut through the bottom of both plunger-halves and insures rotation of the plunger with the shell.

The strength of the spring *g* is so adjusted that the fuze will not arm until its rapidity of revolution is a certain percentage of that expected in the shell in which it is to be used, and that it will certainly arm when the rapidity of revolution approximates that expected in the shell. Should the parts of the plunger be accidentally separated and the fuze armed by a sudden jolt or jar in transportation or handling, the reaction of the spring will immediately bring the plunger to the unarmed condition.

The fuze just described, called *the "F" fuze*, is used in siege detonating fuzes for 5 and 7-inch shell charged with high explosive.

The fuze shown in Fig. 8, the "*S*" *fuze*, is for use with 3.6 and 7-inch mortar shell, powder-charged, and with the detonating fuzes in 8, 10 and 12-inch armor-piercing projectiles. The additional priming charge in end of fuze gives a greater body of flame than is emitted from the "F" fuze.

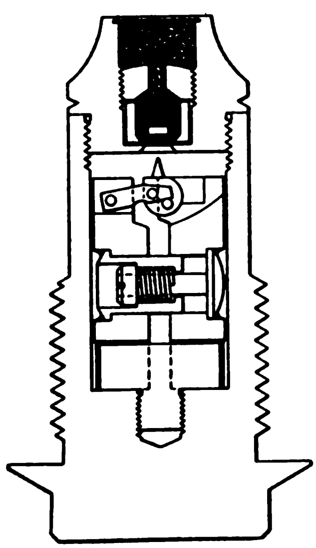

FIG. 8.

A similar fuze of larger size is used in powder-charged shell of 8-inch caliber and over.

A fuze, called the "*12 M*" *fuze*, is provided for use in detonating fuzes for the 12-inch mortar and torpedo shell. This fuze is similar in construction to the other centrifugal fuzes, but on account of the low velocity of rotation of mortar projectiles and their low striking velocity a much heavier plunger is needed to provide the force necessary for arming the fuze, and for puncturing the primer-shield on impact. In addition, the plunger carries on its front surface a swivelled piece which when the fuze is armed falls into the aperture between the plunger-halves, so that when once armed the two parts of the plunger are automatically locked apart in the armed position. This prevents the closing together of the plunger-halves, and the consequent withdrawal of the firing pin, if the shell should strike upon its side, as it does sometimes when fired at low velocities.

Combination fuzes.—All combination fuzes used in the service are point insertion and combine the elements of time and percussion arranged to act independently in one fuze body.

Combination fuzes contain two plungers and two primers, arming and firing by concussion and percussion respectively.

The concussion plunger arms and fires the concussion primer by shock of discharge in the bore of the piece and ignites the time element. The percussion plunger is armed by the shock of discharge and fires its primer on impact.

There are at present two general classes of combination fuzes in service, differing principally in the details of the time-train elements. In the first class this element consists of a wire-drawn lead tube filled with mealed powder, wound in a spiral groove around a lead cone. In the second class the time element consists of two superposed trains of mealed powder compressed under heavy pressure into annular grooves in disks of brass.

The first class is represented by the following Frankford Arsenal combination fuzes: The 15-second, the 28-second high-resistance, and the 28-second low-resistance combination fuzes. No more fuzes of this class are to be manufactured, and the fuze will become obsolete when the supply now on hand is exhausted.

The second class is represented by the Frankford Arsenal 21-second combination fuze. The method of preparing the time train of this fuze insures much greater uniformity of action than was obtained in the fuze with lead-cased time train. This fuze has, therefore, been adopted for use in service shrapnel.

Combination fuze, latest pattern. Fig. 9.—The upper part of the fuze contains the time elements, the lower part the percussion elements. The time elements consist of the concussion or time plunger *b*, the firing pin *c*, and the time train. The firing pin is fixed in the body of the fuze, and the plunger carries the percussion composition and a small igniting charge of black powder. The plunger is held out of contact with the firing pin by the split resistance ring *a*. On the shock of discharge, the inertia of the plunger acting through the conical surface in contact with the split ring expands the ring so that the plunger can pass through it and carry the percussion composition to the firing pin.

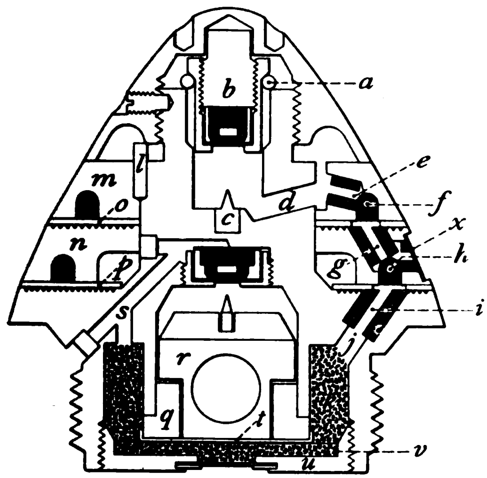

FIG 9.

The time train of the fuze is composed of two rings of powder *f* and *h* contained in grooves cut in the two time-train rings *m* and *n*. The grooves are not cut completely around the rings, but a solid portion is left between the ends of the groove in each ring. Mealed powder is compressed into the grooves under a pressure of 70,000 pounds per square inch, forming a train 7 inches long, the combined length of the two grooves.

The flame from the percussion composition passes through the vent *d* igniting the compressed tubular powder pellet *e* which in turn ignites one end of the upper time train *f*. When the fuze is set at zero the flame passes immediately from the upper time train through the powder pellet *g* to one end of the lower time train *h*; thence through the pellet *i* and vent *j* to the powder *k* in the annular magazine at the base of the fuze.

Under each of the time rings is a felt washer, *o* and *p*, that closes the joint under the ring against the passage of flame, except through the hole in the washer directly over the vent in the part below. The upper washer *o* is glued to the upper corrugated surface of the lower time ring *n* and moves with that ring, the lower washer *p* is glued to the fuze body and is stationary. The upper time ring *m* is fixed in position by two pins *l* halved into the fuze body and the ring, The lower time ring is movable, and any of the graduations on its exterior, see Fig. 10, which correspond to seconds and fifths of seconds of

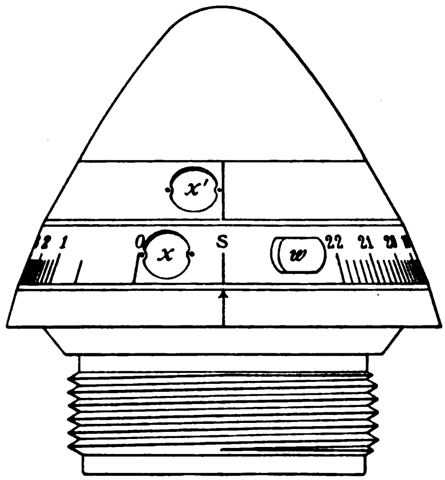

FIG. 10.

burning, may be brought to the datum line marked on body of fuze below the ring. The ring is moved, in setting, by means of a wrench applied to the projecting stud *w*.

To set the fuze for any time of burning, say 20 seconds, move the lower time ring *n* until the mark 20 is over the datum line. On ignition of the primer the flame ignites the upper time train *f*, which burns clock-wise, looking from base to point of fuze, until the hole through the washer over the zero mark of the lower ring *n* is encountered. The flame then passes through the vent *g* to the lower time train *n*, which burns anti-clockwise until the 20 is reached. This mark being over the vent *i* in the body of fuze, the flame now passes to the magazine *k*. The setting of the fuze consists in fixing the position of the passage from the upper to the lower time train, so as to include a greater or less length of each train between the vent *e* and the vent *i*.

In each time ring a vent opens from the initial end of the powder train to the exterior. The vent contains a pellet of powder and is covered by a thin brass cup. The vent in lower time ring is seen at *x* in figure 9. The caps, x, x′, of both vents are shown in figure 10. The blowing out of the cap affords a passage to the open air for the flame from the burning time train, thus preventing the bursting of the fuze by the pressure of the contained gases.

When the fuze is set at safety, indicated by the letter *S* stamped on the lower time ring, the position shown in figure 10, the solid metal between the ends of the upper time train is over the vent *g* to the lower train, and the solid metal between the ends of the lower train is over the vent *i* leading to the magazine. In case of accidental firing by the time plunger, the upper train will be completely consumed without communicating fire to the lower train and to the magazine. The fuze is habitually carried at this setting, which serves also when it is desired to explode the shell by impact only.

For percussion firing the fuze is provided with a centrifugal plunger *r*, as described in the base percussion fuze. To insure rotation of the plunger with the shell the bottom of the plunger is cut away on the sides to fit in a slot in the rotating ring *q*, which is held firmly against the walls of the plunger-recess by the pressure of the closing screw *u*, screwed down hard. A vent *s* leads from the percussion primer to the annular magazine *k*. A thin brass cap *t* separates the lower plunger-recess from the powder in the four radial chambers *v* cut in the bottom closing screw. The central vent in the closing screw is closed by a piece of shellacked linen, held in place by a brass washer.

These fuzes are issued fixed in the loaded projectiles. For protection in transportation the fuze is covered by a spun brass cap, soldered on to the head of the projectile. The soldering strip is torn off and the cover removed before using the projectile.

Combination fuze, old pattern.—The time train *b*, encased in a lead tube, is wound spirally around the lead cone *c*. To set the fuze for any time of burning the time train and lead cone are punctured, by means of a tool provided for the purpose, at the point on the scale marked on the cover of fuze corresponding to the time of burning desired. The puncture passes completely through the time train and the lead cone behind it, forming a channel from the annular space in which the letter *b* appears to the powder in the time train. When the projectile is fired the percussion flame ignites the compressed powder ring *d*, and the flame from this ring ignites the time train at the point at which it has been punctured. The safety pin *a* retains the time pluger in its unarmed position, and must be withdrawn before placing the projectile in the gun. (See Fig. 11.)

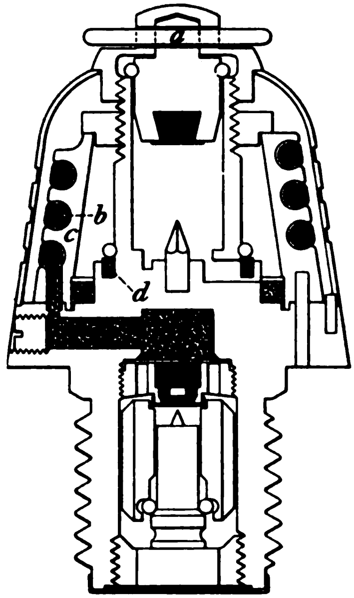

FIG. 11.

Ehrhardt combination fuze.—This fuze is similar in construction to the Frankford Arsenal fuze, latest pattern, described above and differs only in details.

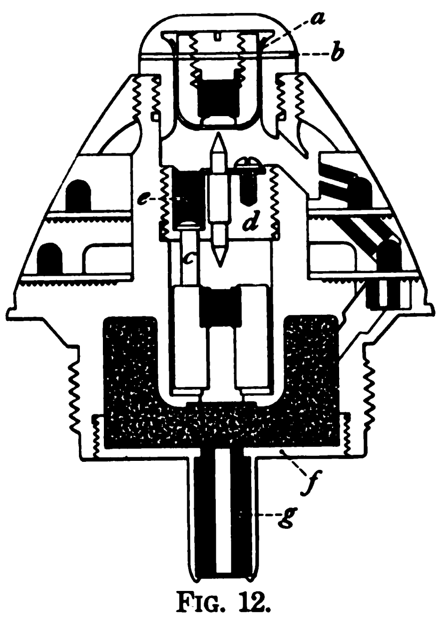

FIG. 12.

The arming of the time plunger of the Ehrhardt fuze, Fig. 12, is resisted by the U-shaped spring *a*, the upper ends of which are sprung out into a counterbored recess in the closing cap, and by the slender brass pin *b*, which passes through the plunger and both sides of the closing cap. At discharge of the piece the inertia of the plunger shears the pin *b* and straightens the U-shaped spring *a*, permitting the plunger to strike the firing pin.

In the percussion mechanism the composition is carried in the plunger and the firing pin is fixed in the diaphragm *d* in body of fuze. The plunger is held away from the firing pin before firing, by the brass restraining pin *c*. The pin is let in to a hole in the diaphragm *d*, the head of the pin abutting against a shoulder near the bottom of the hole. The restraining pellet of powder *e* is pressed in to fill the recess above the pin. A perforated brass disk and a piece of linen close the hole at its upper end and prevent the powder pellet from being jarred out of place. The burning of this pellet on ignition from the time plunger leaves the restraining pin and percussion plunger free to move forward at impact.

A compressed charge of black powder, *g*, is inserted into the extension of the closing screw *f* to re-enforce the magazine charge and effectually to carry the flame to the base charge in the shrapnel.

The Krupp combination fuze does not differ essentially from the Ehrhardt fuze. The shear pin through time plunger is omitted, the U-shaped spring being made strong enough to offer sufficient resistance against accidental arming. The percussion plunger, carrying the percussion composition, is held away from the firing pin, before firing, by a sleeve and an inverted U-shaped resistance spring. A spiral spring between plunger and firing pin prevents the creeping forward of the plunger during the flight of the projectile.

Detonating fuzes.—These fuzes are for use in shell containing high explosives.

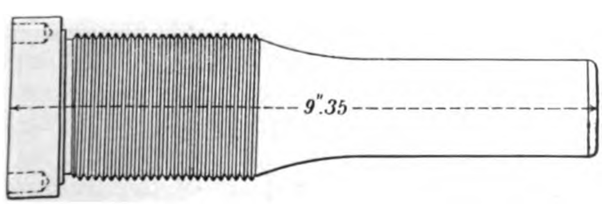

FIG. 13.

Fig. 14 shows the form of detonating fuze for point insertion in field shell. Fig. 13 shows the form of fuze for base insertion in siege and seacoast projectiles.

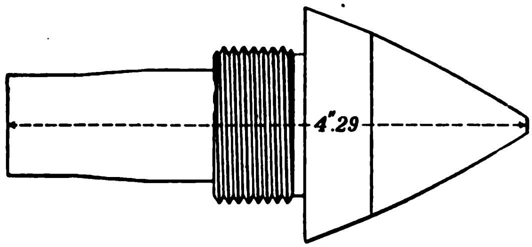

FIG. 14

In order to prevent the unscrewing of the fuze during flight of the projectile, all point insertion fuzes are provided with right-handed screw threads, and base insertion fuzes with left-handed threads.

A CONTRIBUTION TO INTERIOR BALLISTICS

BY COLONEL JAMES M. INGALLS, U. S. A., RETIRED

CHAPTER II.

COMBUSTION OF A CHARGE OF POWDER IN THE BORE OF A GUN

IT has been established by experiment that the velocity of combustion of a grain of powder (black or smokeless) is constant when the surrounding pressure is constant,—as when it burns under atmospheric pressure. Therefore if l_0 is one-half the least dimension of the grain and τ the time of burning of the entire grain under the constant pressure of the atmosphere, we have, since the grain burns on all sides in concentric layers, and is generally consumed when its least dimension disappears,

$$\frac{l_0}{\tau} = \text{velocity of burning} = \text{constant} = V_0 \text{ (say)},$$

In the bore of a gun, however, the pressure surrounding the grain is very far from being constant and greatly exceeds the atmospheric pressure. That the rate of burning has an intimate relation to the surrounding pressure has been recognized from the earliest times. For example, it was long ago observed that time fuzes burned at a slower rate on high mountains; and that in a vacuum grains of black powder could be fuzed without explosion. All writers agree that the velocity of combustion of smokeless powders is, at each instant, proportional to some power of the pressure; but they differ widely among themselves as to what this power is. Sarrau makes it one-half. Saint-Robert, Vieille, Gossot and Liouville give reasons (based, however, upon observations made with a small quantity of powder exploded in an eprouvette of a few cubic inches capacity), for adopting the exponent $\frac{2}{3}$. Centervall makes the exponent $\frac{9}{10}$ for "Nobel NK_4" powder. Lastly Sebert and Hugoniot, from observations of the recoil of a 10-cm gun mounted on a free-recoil carriage, deduced a law of burning directly proportional to the pressure. This law is the most simple of all and allows an easy and complete integration of the equations entering into the problem.* But simple as this law of Sebert and Hugoniot is, we prefer to make use of Sarrau's law of the square root of the pressure, because the resulting formulas are not only simple and easily worked but the results they give agree remarkably well with experiment, as has been repeatedly shown by the writer.† The solution of the problems of interior ballistics requires the adoption of several hypotheses and simplifications that are only approximately true, and the practical value of the formulas deduced can be established only by a comparison of predicted results with experiment. And ballistic formulas (whether exterior or interior) which have not been thus tested are looked upon with little favor by artillerists who are invited to adopt them.

Many of the formulas given in this chapter have been already published; but the works in which they appeared are mostly out of print and difficult to be procured. For this reason, and also because new formulas, which are believed to be of practical value, and have never been published, have since been deduced, they are here submitted for the consideration of our artillery officers.

Sarrau's law of the velocity of combustion of a grain of powder burning under a variable pressure p leads directly to the equation

$$V = \frac{l_0}{\tau}\left(\frac{p}{p_0}\right)^{\frac{1}{2}} \tag{22}$$

in which p_0 is the constant atmospheric pressure.

Substituting for V its general time value, (22) becomes

$$\frac{dl}{dt} = \frac{l_0}{\tau}\left(\frac{p}{p_0}\right)^{\frac{1}{2}}, \tag{23}$$

in which l is the thickness of layer burned in time t.

It will be assumed that the variable pressure p in the bore of a gun is measured by the energy of translation imparted to the projectile, and we shall take for granted that all the other work done by the expansion of the powder gas may be accounted for by suitably increasing the weight of the projectile; or, better still, by diminishing the value of the factor expressing the "force of the powder" so as to satisfy the firing data by means of which the constants are determined. This procedure will be fully illustrated in the next chapter.

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* See JOURNAL U. S. ARTILLERY, Vol. 7, pages 62-82.

† First in the author's "Interior Ballistics," (1894), page 90. Also JOURNAL U. S. ARTILLERY, Vol. 2, pages 85-94; Vol. 6, pages 148-149; and Vol. 20, November-December, 1903, pages 259-286.

If p is the pressure per unit of surface upon the base of the projectile at any instant, ω the area of the base and u the distance travelled by the projectile from its firing seat, we have from the principle of energy and work

$$p = \frac{w}{g\omega} \frac{d^2u}{dt^2}$$

But from mechanics and calculus

$$\frac{d^2u}{dt^2} = \frac{dv}{dt} = \frac{dv}{du} \cdot \frac{du}{dt} = v\frac{dv}{du} = \tfrac{1}{2}\frac{d(v^2)}{du}$$

Therefore

$$p = \frac{w}{2g\omega} \frac{d(v^2)}{du} \qquad (24)$$

In this equation w is the weight of projectile in pounds; and as we shall also adopt the foot as the linear unit, p in (24) will be in pounds per square foot.

Assuming that the "p" in (23) is equal to that in (24), we have

$$\frac{dl}{dt} = \frac{l_0}{\tau}\left(\frac{w}{2g\omega p_0}\right)^{\frac{1}{2}}\left(\frac{d(v^2)}{du}\right)^{\frac{1}{2}} \qquad (25)$$

Since z_0 is the reduced length of the initial air-space and u the distance travelled by the projectile from its firing seat, we may say very approximately, by the principle of the co-volume, that u/z_0 is the number of volumes of expansion of the gas during the travel u. If we make $u/z_0 = x$, and therefore $du/dx = z_0$, (24) and (25) become

$$p = \frac{w}{2g\omega z_0} \frac{d(v^2)}{dx} \qquad (26)$$

and

$$\frac{dl}{dt} = \frac{l_0}{\tau}\left(\frac{w}{2g\omega p_0 z_0}\right)^{\frac{1}{2}}\left(\frac{d(v^2)}{dx}\right)^{\frac{1}{2}} \qquad (27)$$

It will be seen that (27) connects the velocity of burning of the grain with the velocity of travel of the projectile in the bore. It is better to make x the independent variable in the first member as well as the second.

We have from calculus

$$\frac{dl}{dt} = \frac{dl}{dx} \cdot \frac{dx}{du} \cdot \frac{du}{dt} = \frac{v}{z_0} \frac{dl}{dx}$$

Therefore

$$\frac{dl}{dx} = \frac{z_0}{v} \frac{dl}{dt}$$

Substituting in this last equation for dl/dt its value from (27) it becomes

$$\frac{dl}{dx} = \frac{l_0}{\tau}\left(\frac{wz_0}{2g\omega p_0}\right)^{\frac{1}{2}}\left(\frac{d(v^2)}{dx}\right)^{\frac{1}{2}}\frac{1}{v}$$

Integrating between the limits 0 and x we have

$$\frac{l}{l_0} = \frac{1}{\tau}\left(\frac{wz_0}{2g\omega p_0}\right)^{\frac{1}{2}}\int_0^x \left(\frac{d(v^2)}{dx}\right)^{\frac{1}{2}}\frac{1}{v}\,dx \qquad (28)$$

In order to integrate this expression we must know the relation existing between v^2 and x, that is, between the velocity of the projectile in the bore at any instant and the corresponding volumes of expansion of the gas.

From a consideration of the work done by an adiabatic expansion of a weight of gas y at temperature of combustion, (taking the ratio of the specific heats as $1\frac{1}{3}$) we have the well-known equation

$$v^2 = 6gf\frac{y}{w}\left\{1 - \frac{1}{(1+x)^{\frac{1}{3}}}\right\} \qquad (29)$$

in which f is the so called "force of the powder."

Writing for convenience

$$A = 6gf\frac{y}{w},$$

(29) becomes

$$v^2 = A - \frac{A}{(1+x)^{\frac{1}{3}}};$$

whence

$$\left(\frac{d(v^2)}{dx}\right)^{\frac{1}{2}} = \frac{A^{\frac{1}{2}}}{\sqrt{3}\,(1+x)^{\frac{2}{3}}},$$

and

$$\frac{1}{v} = \frac{(1+x)^{\frac{1}{6}}}{A^{\frac{1}{2}}\sqrt{(1+x)^{\frac{1}{3}} - 1}}.$$

Therefore

$$\left(\frac{d(v^2)}{dx}\right)\frac{1}{v} = \frac{1}{\sqrt{3}\,(1+x)^{\frac{1}{2}}\sqrt{(1+x)^{\frac{1}{3}} - 1}}$$

Substituting this in (28) we have

$$\frac{1}{l_0} = \frac{1}{\tau}\left(\frac{wz_0}{2g\omega p_0}\right)^{\frac{1}{2}}\int_0^x \frac{dx}{\sqrt{3}\,(1+x)^{\frac{1}{2}}\sqrt{(1+x)^{\frac{1}{3}}-1}}$$

or

$$\frac{1}{l_0} = \frac{1}{\tau}\left(\frac{wz_0}{6g\omega p_0}\right)^{\frac{1}{2}}\int_0^x \frac{dx}{(1+x)^{\frac{1}{2}}\sqrt{(1+x)^{\frac{1}{3}}-1}}$$

If we put

$$K = \frac{1}{\tau}\left(\frac{wz_0}{6g\omega p_0}\right)^{\frac{1}{2}} \tag{30}$$

and

$$X_0 = \int_0^x \frac{dx}{(1+x)^{\frac{1}{2}}\sqrt{(1+x)^{\frac{1}{3}}-1}} \tag{31}$$

we have the very simple equation

$$\frac{1}{l_0} = K\,X_0 \tag{32}$$

To integrate (31) put

$$1 + x = (1 + y^2)^3$$

from which we readily find

$$X_0 = 6\int_0^y \sqrt{1 + y^2}\,dy$$

Therefore, from calculus,

$$X_0 = 3y\,(1 + y^2)^{\frac{1}{2}} + 3\log_e\left\{y + (1 + y^2)^{\frac{1}{2}}\right\}$$

But

$$y = \sqrt{(1+x)^{\frac{1}{3}}-1} \quad \text{and} \quad 1 + y^2 = (1 + x)^{\frac{1}{3}}$$

Therefore

$$X_0 = 3\,(1 + x)^{\frac{1}{6}}\sqrt{(1+x)^{\frac{1}{3}}-1} + 3\log_e\left\{(1+x)^{\frac{1}{6}} + \sqrt{(1+x^{\frac{1}{3}}-1}\right\} \tag{33}$$

This expression for X_0, and other functions that will be derived from it, can be much simplified by means of circular functions. Thus, if we make

$$\sec\varphi = (1 + x)^{\frac{1}{6}} \tag{34}$$

and, therefore,

$$\sin^2\varphi = 1 - \frac{1}{(1+x)^{\frac{1}{3}}}$$

$$\tan\varphi = \sqrt{(1+x)^{\frac{1}{3}} - 1}$$

and

$$\frac{d\varphi}{dx} = \frac{1}{6\sec^6\varphi\tan\varphi}$$

(31) and (33) become, respectively,

$$X_0 = 6\int_0^\varphi \sec^3\varphi\, d\varphi \qquad (35)$$

and

$$X_0 = 3\sec\varphi\tan\varphi + 3\log_e(\sec\varphi + \tan\varphi) \qquad (36)$$

The definite integral in (35) is a well known function of φ and has been extensively used in Exterior Ballistics. A table of this function computed for every minute of arc up to 87° was first published by Euler, and has recently been re-printed (1904) at the Government Printing Office and issued as Supplement No. 2, to Artillery Circular M. By means of this table it is easy to compute X_0 for any value of x. First compute φ by the equation

$$\sec\varphi = (1 + x)^{\frac{1}{6}}$$

and then take the definite integral, which has been symbolized by (φ) from the table just mentioned. We then have

$$X_0 = 6\,(\varphi) \qquad (37)$$

Expression for powder burned. Return now to equation (32). If we substitute the value of l/l_0 from this equation in (15) we have

$$\frac{y}{\bar{\omega}} = \alpha K X_0 \left\{1 + \lambda K X_0 + \mu (K X_0)^2\right\} \qquad (38)$$

an equation which gives the fraction of charge burned at any instant in terms of the volumes of expansion of the gases generated.

When the powder is all burned in the gun (if it be all burned before the projectile leaves the bore) we have $y = \bar{\omega}$ and $l = l_0$. Therefore if we distinguish X_0 by a dash when $l = l_0$, (32) becomes

$$K \bar{X}_0 = 1$$

and

$$K = \frac{1}{\overline{X}_0} \qquad (39)$$

Also when $y = \bar{\omega}$, (38) reduces to

$$1 = \alpha(1 + \lambda + \mu)$$

a fundamental relation established in Chapter I.

Substituting the value of K from (39) in (38) we have generally

$$\frac{y}{\bar{\omega}} = \frac{\alpha}{\overline{X}_0} X_0 \left\{ 1 + \frac{\lambda}{\overline{X}_0} X_0 + \frac{\mu}{\overline{X}_0^2} X_0^2 \right\} \qquad (40)$$

Expression for velocity of projectile while powder is burning. Substituting the value of y from (40) in (29) and making

$$X_1 = X_0 \left\{ 1 - \frac{1}{(1+x)^{\frac{1}{3}}} \right\} \qquad (41)$$

we have

$$v^2 = 6g \frac{\alpha f \bar{\omega}}{w} \frac{X_1}{\overline{X}_0} \left\{ 1 + \frac{\lambda}{\overline{X}^0} X_0 + \frac{\mu}{\overline{X}_0^2} X_0^2 \right\} \qquad (42)$$

This equation holds only while the powder grains are burning and ceases to be true when $X_0 > \overline{X}_0$.

Velocity of projectile when $y = \bar{\omega}$. When $X_0 = \overline{X}_0$ and therefore $X_1 = \overline{X_1}$, equation (42) reduces to

$$\bar{v}^2 = 6gf \frac{\bar{\omega}}{w} \frac{\overline{X_1}}{\overline{X}_0} \alpha (1 + \lambda + \mu)$$

or, since

$$\alpha (1 + \lambda + \mu) = 1,$$

it becomes

$$\bar{v}^2 = 6gf \frac{\bar{\omega}}{w} \frac{\overline{X_1}}{\overline{X}_0}$$

This equation is of course the same as (29) from which it is derived. This is evident from (41).

For simplicity let

$$\frac{X_1}{\overline{X}_0} = X_2 \qquad (43)$$

Then the expression for $\bar{v}^2$ becomes

$$\bar{v}^2 = 6gf \frac{\bar{\omega}}{w} \overline{X_2} \qquad (44)$$

It should be remembered that all symbols used in this discussion, with a dash, refer to the position of the projectile (either in the bore or in the bore supposed to be prolonged) when the powder has all been burned, and therefore when $y = \bar{\omega}$.

From (44) we have

$$6\,g\,f = \frac{\bar{v}^2}{\bar{X}_2}\,\frac{w}{\bar{\omega}} \tag{45}$$

and this substituted in (42) gives

$$v^2 = \frac{\alpha\,\bar{v}^2}{\bar{X}_1}\,X_1 \left\{ 1 + \frac{\lambda}{\bar{X}_0}\,X_0 + \frac{\mu}{\bar{X}_0^2}\,X_0^2 \right\} \tag{46}$$

For convenience of printing put

$$M = \frac{\alpha\bar{v}^2}{\bar{X}_1}\,; \qquad N = \frac{\lambda}{\bar{X}_0}\,; \qquad N' = \frac{\mu}{\bar{X}_0^2} = \frac{\mu}{\lambda^2}N^2$$

Then, finally,

$$v^2 = MX_1\left\{ 1 + NX_0 + N'X_0^2 \right\} \tag{47}$$

Pressure on base of projectile while powder is burning. Differentiating (47) with respect to the independent variable x, and putting for simplicity

$$X_3 = \frac{dX_1}{dx}\,; \quad X_4 = X_0 + \frac{X_1}{X_3}\,\frac{dX_0}{dx}\,; \quad X_5 = X_0^2 + \frac{2X_0X_1}{X_3}\,\frac{dX_0}{dx},$$

we have

$$\frac{d(v^2)}{dx} = MX_3\left\{ 1+NX_4+N'X_5 \right\} \tag{48}$$

Therefore from (26)

$$p = \frac{w}{2g\omega z_0}\,MX_3\left\{ 1+NX_4+N'X_5 \right\}$$

Combining the constants into one multiplier by making

$$M' = \frac{w}{2g\omega z_0}\,M \tag{49}$$

we have the following expression for the pressure per unit of surface on the base of the projectile,

$$p = M'X_3\left\{ 1 + NX_4 + N'X_5 \right\} \tag{50}$$

Velocity of projectile after powder is all burned. The velocity of the projectile after the powder is all burned is given by (29), substituting $\bar{\omega}$ for y. Reducing by means of (41), (43) and (45), equation (29) becomes, denoting velocity of projectile after powder is all burned by capital V,

$$V^2 = \frac{\overline{v^2}}{X_2} X_2 \qquad (51)$$

The velocity, then, after the powder is all burned varies directly as the square root of X_2. From (41) and (43)

$$X_2 = 1 - \frac{1}{(1+x)^{\frac{1}{3}}} = \sin^2\varphi \qquad (52)$$

and therefore the analytical limit of X_2 as x increases indefinitely is unity. On this supposition (51) becomes

$$V^2 = \frac{\overline{v^2}}{X_2} = V_1^2 \text{ (say)} \qquad (53)$$

We may regard V_1 then as the theoretical velocity of the projectile after an infinite travel. In terms of V_1 (51) becomes

$$V^2 = V_1^2 X_2 \qquad (54)$$

and the expression for M changes to

$$M = \frac{a V_1^2}{X_0} \qquad (54')$$

Pressure after the powder is all burned. Differentiating (54) with reference to x and substituting the result in (26) we have, employing capital P to express pressure in this case,

$$P = \frac{wV_1^2}{2g\omega z_0} \frac{dX_2}{dx}$$

But from (52)

$$\frac{dX_2}{dx} = \frac{1}{3(1+x)^{\frac{4}{3}}}$$

whence

$$P = \frac{wV_1^2}{6g\omega z_0} \frac{1}{(1+x)^{\frac{4}{3}}}$$

or putting

$$\frac{wV_1^2}{6g\omega z_0} = P' \qquad (55)$$

we have finally the very simple equation

$$P = \frac{P'}{(1+x)^{\frac{4}{3}}} \qquad (56)$$

if we make $x = 0$ in (56) we shall have

$$P = P'$$

Therefore P' is the pressure per unit of surface at the origin supposing the powder to be all converted into gas before the projectile moves from its seat.

Formulas for computing the functions X_0, X_1, X_2, X_3, X_4 *and* X_5. We have already deduced

$$X_0 = 6\,(\varphi),$$

and from (41) and (43) we have directly

$$X_1 = X_0 \sin^2 \varphi \qquad (57)$$

and

$$X_2 = \sin^2 \varphi \qquad (58)$$

By definition

$$X_3 = \frac{dX_1}{dx}$$

whence differentiating (57) we have

$$\frac{dX_1}{dx} = \frac{dX_0}{dx} \sin^2 \varphi + 2X_0 \sin \varphi \cos \varphi \, \frac{d\varphi}{dx}$$

But from (31) and (34) we have

$$\frac{dX_0}{dx} \sin^2 \varphi = \sin \varphi \cos^4 \varphi$$

Also

$$2 \sin \varphi \cos \varphi \, \frac{d\varphi}{dx} = \frac{\sin \varphi \cos \varphi}{3 \sec^6 \varphi \tan \varphi} = \frac{1}{3} \cos^8 \varphi .$$

Therefore

$$X_3 = \sin \varphi \cos^4 \varphi + \tfrac{1}{3} X_0 \cos^8 \varphi$$

Let

$$X = \frac{1}{1 + \tfrac{1}{3} X_0 \cos^4 \varphi \operatorname{cosec} \varphi}$$

Then we have

$$X_3 = \frac{\sin \varphi \cos^4 \varphi}{X} \qquad (59)$$

From the foregoing equations we find

$$\frac{X_1}{X_3} \frac{dX_0}{dx} = \tfrac{1}{3} X X_0$$

by means of which are easily deduced from the definitions of X_4 and X_5, the following simple expressions :

$$X_4 = X_0(1 + X) \qquad (60)$$

and

$$X_5 = X_0^2(1 + 2X) \qquad (61)$$

By means of equations (37), (57), (58), (59), (60), and (61) the table of the logarithms of these functions hereto appended was computed.

Expressions for computing τ *and* f. From (30) and (39) we have

$$\tau = \left(\frac{wz_0}{6g\omega p_0}\right)^{\frac{1}{2}}\overline{X}_0$$

And from (45) and (53) we get

$$f = \frac{V_1^2 w}{6g\tilde{\omega}} \qquad (63)$$

Relation between f *and* P′. From (55) and (63) we get

$$P' = \frac{\tilde{\omega}}{z_0\omega} f \qquad (64)$$

Since f (the force of the powder) is the pressure per unit of surface of the gases of one pound of powder at temperature of combustion, occupying unit volume, it follows from (64) that P′ is the pressure per unit of surface of the gases of $\tilde{\omega}$ pounds of powder occupying a volume equal to the initial air-space $z_0\omega$. This has already been deduced in another way, Page 38. Equation (56) is therefore the equation of the pressure curve upon the supposition that the charge is all converted into gas before the projectile has moved from its seat. From equation (21) we have

$$z_0\omega = \frac{27.68}{1728} a^2\tilde{\omega}.$$

Substituting this in (64) we obtain

$$P' = \frac{27.68}{1728}\,\frac{f}{a^2} \qquad (65)$$

From the manner in which equations (44) and (54) were deduced it is evident that they both give same velocity for the travel $\bar{u}$, namely, the velocity $\bar{v}$. And also that (54) is the equation of the velocity curve on the supposition that the powder is all consumed before the projectile has moved from its seat. But we cannot say generally that (50) and (56) give the same *pressures* for the travel $\bar{u}$. This equality depends upon the relative values of α, λ and μ, as may be shown as follows:

If we substitute in (49) for M, $\overline{v^2}$ and $z_0\omega$ their values already deduced it reduces to

$$M' = \frac{3\alpha P'}{X_0} \tag{66}$$

and therefore (50) may be written

$$p = 3\alpha P' \frac{X_3}{X_0}\left\{1 + \frac{X_4}{X_0}\lambda + \frac{X_5}{X_0^2}\mu\right\} \tag{67}$$

If we equate (67) with (56) and reduce, substituting for $(1+\overline{x})^{\frac{4}{8}}$ its value from (34), we have the equation of condition

$$3\alpha\frac{\overline{X_3}}{X_0}\left\{1 + \frac{\overline{X_4}}{X_0}\lambda + \frac{\overline{X_5}}{X_0^2}\mu\right\}\sec^8\varphi = 1$$

which must be satisfied in order that the two pressures p and P may be equal for travel $\overline{u}$.

From (59) we get, omitting the dashes for convenience,

$$\frac{X_3}{X_0}\sec^8\varphi = \frac{\sin\varphi}{X X_0\cos^4\varphi}$$

and therefore, by (60) and (61),

$$\frac{3\sin\varphi}{X X_0\cos^4\varphi}\left\{1 + (1+X)\lambda + (1+2X)\mu\right\}\alpha = 1$$

or, since $\alpha(1+\lambda+\mu) = 1$,

$$\alpha(\lambda + 2\mu)X = \frac{X X_0\cos^4\varphi}{3\sin\varphi} - 1$$

Therefore by (59) and the definition of X,

$$\alpha(\lambda + 2\mu) = \frac{X_0\cos^4\varphi}{3\sin\varphi} - \frac{1}{X} = -1 \tag{68}$$

By referring to Chapter I., page 187 it will be seen that the relation between α, λ and μ expressed in (68) can exist only when $s' = 0$. That is, only for those grains which reduce to a point or to a line — straight or curved — when about to disappear.

We can show this in another way. Equation (67) expresses the value of p while the powder is burning; and the distance the projectile travels before the powder is all burned depends upon the thickness of web. Now imagine the thickness of web of the grains, of which a charge is composed, to diminish indefinitely and finally to become infinitesimal, so that the charge is burned instantly, before the projectile begins to move. On this supposition X_0, X_3, X_4, and X_5 all become zero. But their ratios in (67) are finite and can easily be determined. If i is an infinitely small angle we see at a glance from (36) that $X_0 = 6i$. Then from (57) and (58) we find at the limit, $X_1 = 6i^3$ and $X_2 = i^2$. Also $X = \frac{1}{3}$, and then (59), (60) and (61) become $X_3 = 3i$, $X_4 = 8i$ and $X_5 = 60i^2$. Therefore the ratios in (67) are

$$\frac{X_3}{X_0} = \frac{1}{2}, \quad \frac{X_4}{X_0} = \frac{4}{3} \text{ and } \frac{X_5}{X_0^2} = \frac{5}{3}.$$

Therefore (67) becomes at the limit, dividing out P′,

$$\frac{3}{2}\alpha\left\{1 + \frac{4}{3}\lambda + \frac{5}{3}\mu\right\} = 1$$

This may be written

$$\alpha(1 + (1 + \tfrac{1}{3})\lambda + (1 + \tfrac{2}{3})\mu) = \tfrac{2}{3}$$

$$\therefore \quad \alpha(1 + \lambda + \mu) + \alpha(\tfrac{1}{3}\lambda + \tfrac{2}{3}\mu) = \tfrac{2}{3}$$

$$\therefore \quad \alpha(\tfrac{1}{3}\lambda + \tfrac{2}{3}\mu) = -\tfrac{1}{3}$$

$$\therefore \quad \alpha(\lambda + 2\mu) = -1$$

This is the same relation that was found before. We can therefore say that for spherical, cubical, cylindrical and certain pierced cylindrical grains, the pressure curves (50) and (56) run into each other at the travel u and from there on they become one and the same curve. This is not true for grains for which $s' > 0$. For these the pressure at travel $\bar{u}$ given by (50) is greater than that given by (56), and this difference increases with s′.

Some special formulas. If we make

$$k = \frac{y}{\omega},$$

we have by dividing (46) by (40) and reducing by (53),

$$v^2 = kV^2 = kV_1^2 X_2 \tag{69}$$

That is, the velocity of the projectile at any travel before the charge is all burned is equal to what the velocity would have been at the same travel had all the charge been converted into gas before the projectile moved, multiplied by the square root of the fraction of charge burned.

For spherical, spheroidal, cubical and certain other forms of grain we have $\alpha = 3$, $\lambda = -1$ and $\mu = \frac{1}{3}$. Substituting these in (40) we have by obvious reductions

$$k = 1 - \left(1 - \frac{X_0}{\overline{X}_0}\right)^3 \tag{70}$$

and therefore

$$X_0 = \overline{X}_0 \left\{ 1 - (1 - k)^{\frac{1}{3}} \right\} \tag{71}$$

For a cylinder with axial perforation, whose length is equal to the thickness of web, and also approximately for a long slender cylinder, or prism of square section, we have $\alpha = 2$, $\lambda = -\frac{1}{2}$ and $\mu = 0$. Substituting these in (40) gives

$$k = 1 - \left(1 - \frac{X_0}{\overline{X}_0}\right)^{\frac{1}{2}} \tag{72}$$

and

$$X_0 = \overline{X}_0 \left\{ 1 - (1 - k)^{\frac{1}{2}} \right\} \tag{73}$$

Equations (70) and (72) give the fraction of the charge consumed for any given travel of projectile, and conversely, (71) and (73) enable us to determine the travel of projectile for any given fraction of charge burned. For any other forms of grain the solution of a complete cubic equation is necessary to determine X_0 when k is given. See equation (40).

Expressions for maximum pressure. It is well known that the maximum pressure in a gun occurs when the projectile has moved but a short distance from its seat, or when u and x are relatively small. The position of maximum pressure is not fixed but varies with the resistance encountered. As a rule it will be found that the less the resistance to be overcome by the expanding gases the sooner will they exert their maximum pressure; and, also, the less will this maximum pressure be. The differentiation of (50) gives an analytical expression for the maximum value of p, but it is too complicated to be of any practical value. A reference to the table of the X functions shows that the factor X_3 is a maximum when $x = 0.65$ nearly, while X_4 and X_5 increase indefinitely. When λ is negative it is evident that p will be a maximum when x is less than 0.65, and when λ is positive when x is greater than 0.65. There will therefore be two cases depending upon whether the powder grains burn with a decreasing or an increasing surface. These must be considered separately.

(a) *When the grains burn with a decreasing surface; or what is the same thing, when λ is negative.* A function at or near its maximum changes its value slowly. Therefore a moderate variation of the position of maximum pressure will have no practical effect upon the computed value of the pressure. It has been found by trial in numerous cases that if we take $x = 0.45$ for the position of maximum pressure when λ is negative no material error results. For this value of x the table gives

$$\log X_3 = 9.85640-10$$
$$\log X_4 = 0.48444$$
$$\log X_5 = 0.93587$$

Substituting these in (50) and designating the maximum pressure by p_m, we have approximately, when λ is negative,

$$p_m = [9.85640-10]M'\left\{1-[0.48444]N + [0.93587-10]N'\right\} \quad (74)$$

(b) *When the grains burn with an increasing surface.* When the grains burn with an increasing surface λ is generally positive, and it will not be far wrong to assume that the maximum pressure occurs when $x = 0.8$. For this value of X we have from the table,

$$\log X_3 = 9.86027-10$$
$$\log X_4 = 0.60479$$
$$\log X_5 = 1.17352$$

Substituting these in (50) it becomes

$$p_m = [9.86027-10]M'\left\{1 + [0.60479]N-[1.17352-10]N'\right\} \quad (75)$$

A reference to the table shows that the maximum value of $\log X_3$ is 9.86486—10. Therefore if we suppose N and N′ to be each zero, equation (74) and (75) become

$$p_m = [9.86386-10] \ M'$$

or, in terms of the characteristics and elements of loading,

$$p_m = [0.68642] \frac{\alpha f}{\tau} \sqrt{\frac{w\bar{\omega}}{a\,c^2}} \quad (76)$$

This last equation is in form the same as Sarrau's monomial formula for maximum pressure.

Working formulas. It is customary in our service to express the volume of the powder chamber (C) in cubic inches; the various pressures in pounds per square inch; the caliber (c), the reduced length of the initial air space (z_0) and the travel of the projectile (u) in inches, while the velocity of the projectile is expressed in foot-seconds and its weight in pounds and ounces. These most unfortunate units, which American and English artillerists alone of all the world have to contend with, are apt to cause confusion and error in the applications of ballistic formulas to gunnery problems. To avoid this as far as possible, we will reproduce the most important of the formulas deduced in the proceeding pages with all the reductions made and the mathematical and physical constants introduced and combined into one (or more) numerical coefficient represented by its logarithm, for convenience. The physical constants adopted are the following :—

$$g = 32.16 \text{ f.s.}$$
$$p_0 = 10333 \text{ kgs. per square metre.}$$
$$= 2116.3 \text{ lbs. `` `` foot}$$
$$= 14.6967 \text{ lbs. `` `` inch}$$

The number of cubic inches occupied by one pound of water is found by dividing 61.0254 (number of cubic inches in a litre) by 2.20462 (number of pounds in a kilogramme). The result is 27.68 cubic inches very nearly. We will not give the work of reduction, as the reader who wishes to verify the results will have no very great trouble in doing so. The working formulas are as follows for foot-pound units:—

$$\Delta = [1.44217] \frac{\tilde{\omega}}{C} \qquad (19')$$

$$z_0 = [1.54798] \frac{a^2\tilde{\omega}}{c^2} \quad \text{(in inches)} \qquad (21')$$

$$z_0 = [0.46789] \frac{a^2\tilde{\omega}}{c^2} \quad \text{(in feet)} \qquad (21'')$$

$$V_1^2 = [4.44383] f \frac{\tilde{\omega}}{w} \qquad (44')$$

$$M' = [7.82867-10]\, M \frac{w}{a^2\tilde{\omega}} \qquad (49')$$

$$P' = [7.35155-10]\, V_1^2 \frac{w}{a^2\tilde{\omega}} \qquad (55')$$

$$\tau = [8.56006-10] \frac{a\sqrt{w\tilde{\omega}}}{c^2}\, \overline{X_0} \qquad (62')$$

$$M = \frac{\alpha V_1^2}{\overline{X_0}}$$

$$f = [5.55617-10]\ V_1^2 \frac{w}{\tilde{\omega}} \qquad (63')$$

$$P' = [1.79538] \frac{f}{a^2} \qquad (65')$$

METRIC UNITS

In metric units we shall take C in cubic decimetres, p in kilogrammes per square centimetre, c in centimetres, z_0, u and v in metres. With these units our formulas become,

$$\Delta = \frac{\tilde{\omega}}{C} \qquad (19'')$$

$$z_0 = [1.10491] \frac{a^2\tilde{\omega}}{c^2} \qquad (21'')$$

$$V_1^2 = [2.76948]\ f \frac{\tilde{\omega}}{w} \qquad (44'')$$

$$M' = [7.70764-10]\ M \frac{w}{a^2\tilde{\omega}} \qquad (49'')$$

$$P' = [9.23052-10] V_1^2 \frac{w}{a^2\tilde{\omega}} \qquad (55'')$$

$$f = [7.23052-10]\ V_1^2 \frac{w}{\tilde{\omega}} \qquad (63'')$$

$$\tau = [9.36872-10] \frac{a\sqrt{w\tilde{\omega}}}{c^2} \overline{X_0} \qquad (62'')$$

Characteristics of a powder. The quantities f, τ, α, λ and μ were called by Sarrau the characteristics of the powder because they determine the physical qualities of the powder. Of these factors f depends principally upon the composition of the powder, and in the same gun is practically constant for all powders having the same temperature of combustion. It increases with the caliber of the gun, and for this reason its value determined for one caliber cannot be depended on for any other caliber. The factor τ, the time of combustion of a grain of powder in free air, depends generally upon the least dimension of the grain, and upon its density. The factors α, λ and μ depend exclusively upon the form of the grain, and for the carefully prepared powders now employed their values can be determined with great precision. They are constant so long as the grain in burning retains its original form.

Expressions for velocity and pressure in terms of the characteristics of the powder. When f and τ have been determined by suitable firings, as will be illustrated in the next chapter, we can compute V_1^2 and $\overline{X_0}$ for the same gun and varying charges and weights of projectile, by means of equations (62′) and (63′). From these we readily obtain the following expressions for the factors M, M′, N and N′ in terms of the characteristics f, τ, α, λ and μ :—

$$M = [3.00389]\ \frac{\alpha f}{\tau}\ \frac{a\,\bar{\omega}^{\frac{3}{2}}}{c^2 w^{\frac{1}{2}}} \qquad (77)$$

$$M' = [0.83256]\ \frac{\alpha f}{\tau}\ \frac{\sqrt{w\,\bar{\omega}}}{a\,c^2} \qquad (78)$$

$$N = [8.56006-10]\ \frac{\lambda}{\tau}\ a\frac{\sqrt{w\,\bar{\omega}}}{c^2} \qquad (79)$$

$$N' = [7.12012-10]\ \frac{\mu}{\tau^2}\ \frac{a^2 w\,\bar{\omega}}{c^4} = \frac{\mu}{\lambda^2} N^2 \qquad (80)$$

If we substitute the value of M′ from (78) in (74) and (75) and reject the terms within the braces, we have in effect, Sarrau's monomial formula for maximum pressure.

Applications will be given in the next chapter.

METHOD OF INSTRUCTING COAST ARTILLERY MEN PREPARATORY TO GUNNERS' EXAMINATIONS

BY CAPTAIN MANUS McCLOSKEY, ARTILLERY CORPS

INSTRUCTION, no matter what the subject is, should be progressive and systematic. The best system used in modern educational methods is the one that produces the best results. The first consideration, therefore, in the education of the coast artilleryman will be the method or system employed. The purpose of all instruction is to make men quick, accurate, and intelligent in the duties to which they may be assigned. While the act of qualifying gunners is not the goal that the instructor seeks, yet at the same time, a fair outward index of a company's degree of instruction is the proportion of its gunners.

The following method of instruction is the outgrowth of a system begun by the author at Fort Canby in 1901 and modified by the various orders, etc., issued relative to requirements for gunners' examinations. It is used, firstly, to prepare men for the gunners' examination, and, secondly, to teach men some of the essentials to a proper conception of their daily work. It is altogether separate and distinct from the instruction given to the company as a unit in manning the armament to which it is assigned.

For indoor instruction the company is divided into three parts after the first sergeant has reported to the company commander and the range detachment has proceeded to the improvised plotting room in the barracks.

Part I. is composed of first-class gunners.

Part II. is composed of second-class gunners and those men, not gunners, who, after trials, give promise of becoming first-class gunners.

Part III. is composed of men who are expected to become second-class gunners and also, of the "hopeless," that is, men who are not expected to qualify.

The members of Part I. are utilized as instructors of the various detachments hereinafter mentioned, Those not so required receive advanced instruction under a competent non-commissioned officer or are instructed with Detachment No. 5 of Part II. Each instructor is given a card containing the subject assigned him, its scope or extent, and questions pertaining to it.

For instruction, the members of Part II. are divided into five detachments and subjects assigned to detachments as follows:

Detachment No. 1, Azimuth Instrument.—Angles; definition of, azimuth angles, how measured, horizontal and vertical angles, angles measured by the azimuth instrument. Graduation of the instrument; reading; leveling and orientation of; focussing; setting up over a point and orienting from given data; taking successive observations and readings at intervals of 20 seconds.

Detachment No, 2, Plotting Board, etc.—Scales of and their meaning. Features appearing upon boards. To lay off a distance on the board and to measure the distance between two points. To locate a point given its azimuth and range from position finder station, then give its azimuth and range from the directing point. To show how lateral and longitudinal deviations of the fall of shot with reference to the target are taken. To make use of the plotting board as used by the company and to show how the course of a target is plotted.

Detachment No. 3, Correction Devices.—To use these and to show how the range and deflection corrections are determined according to the system in use in the company. To know also what data are sent to the emplacement and how these are obtained.

Detachment No. 4, Difference Chart and Gun Commander's Range Scale.—To use the difference chart. To use the gun commander's range scale as used in the company.

Detachment No. 5, Elementary Gunnery and General Features of Warships.—To define axis of the bore; line of fire; line of sight; drift; muzzle velocity; quadrant elevation; sight elevation; angle of departure; angle of fall; jump; trajectory; time of flight. To know the general features of battleships, cruisers, protected cruisers, torpedo-boat destroyers, torpedo boats.

Detachment Number 5 is instructed by an officer—all other detachments are instructed by first-class gunners who posssess aptitude therefor.

In like manner, for instruction, the members of Part III. are divided into nine detachments and subjects assigned as follows:

Detachment No. 1, Powders.—Kinds used; in what zones used; highest and lowest weight of charge and corresponding muzzle velocity.

Detachment No. 2, Projectiles.—Name the projectiles used and give their weights. State what the painting indicates. Name the principal features of a projectile. Why capped? Which contain bursting charges and fuzes?

Detachment No. 3, Fuzes.—Name each kind of fuze used in the battery; how inserted to make a tight joint and how each kind operates.

Detachment No. 4, Primers.—Identify the different kinds of primers used in the battery and explain how each kind operates. Reload a drill primer.

Detachment No. 5, Cordage.—Define yarn, strands, jaws of rope, short-jawed rope; long-jawed rope, guys, spun yarn, marlin, standing rigging, running rigging. Explain the difference between hawser-laid rope and cable-laid rope. How are these two kinds of rope coiled? How is the size of rope denoted? Worm a rope, parcel it, serve it, whip it. Give reasons for thus treating rope.

Detachment No. 6, Knots and Hitches.—Make a square knot; a bowline; a single sheet bend or a weaver's knot; rolling hitch; blackwall; round turn and two half hitches; clove hitch, cat's paw; sheep-shank; marlin-spike hitch. Explain the use of the foregoing. What is a strap or sling and what is its use?

Detachment No. 7, Splices and Lashing.—Make an eye-splice; a short splice; a long splice. Make a shear lashing; a square lashing. What do shears consist of? How are they rigged and raised, and what they are used for for? How and when is the tackle made fast; How are shears held in position afrer being raised? How can a change of direction of the fall of the tackle be made to lead it to a capstan, or so that a large number of men can apply themselves to it.

Detachment No. 8, Rigging Tackles and Gins.—Name the different parts of blocks (shell, sheave, pin, strap) and describe the different kinds (single, double, treble, snatch and tail blocks). What is a tackle? Point out the running part; the standing part; the fall. Rig the following: Whip, whip upon whip, gun tackle, gun tackle on gun tackle, luff on luff, single burton. Power gained in the foregoing. Mouse a hook and explain its purpose. Name the different parts of a garrison gin. How much can be safely lifted with it? Explain how it is assembled and raised. How can the upper block be placed in position after the gin has been raised? At what distance should the foot of the pry-pole be placed from the foot of each leg.

Detachment No. 9, Hydraulic Jacks.—For what is the hydraulic jack used. What liquids are used in the jack? How is the jack cared for when not in use? Show how to use a jack in raising a heavy weight; in lowering a heavy weight; use of a claw in connection with the jack.

The above method is used only as a beginning. As soon as an instructor considers a member of his detachment proficient, he reports to the company commander and, if satisfied that the candidate knows the subject, the company commander places him in another detachment. When men have passed satisfactorily through all the instruction laid out for members of Part III., that is, when they appear likely candidates for first-class gunners, they are transferred to Part II. and receive instruction accordingly. The method above outlined is purely for indoor work and is independent of the daily practice of the range detachment (or section) in the improvised plotting room.

OUTDOOR INSTRUCTION

For outdoor instruction, the company is divided into three parts as before enumerated, that is,

Part I. is composed of first-class gunners.
Part II. of candidates for first-class gunner.
Part III. of candidates for second-class gunner.

The members of Part II. are divided into three detachments:

Detachment No 1 is given practical work in the plotting room, including all of its details.

Detachment No. 2 is given practical work with the azimuth instrument.

Detachment No. 3 is given instruction in laying the mortar; the use of the quadrant, setting and reading it, placing it on the mortar. Laying the mortar with the data received from the plotting room, Case III.

The members of Part III. are divided into five detachments and subjects assigned as follows:

Detachment No. 1.—Manual of the piece, duties of the cannoneer as laid down in Drill Regulations for Coast Artillery.

Detachment No. 2.—Nomenclature as in Drill Regulations and Ordnance Department pamphlets, describing the piece to which the company is assigned.

Detachment No. 3.—Breechblocks, dismantling, assembling, and adjusting for firing.

Detachment No. 4.—Recoil cylinders, stuffing boxes. Removing old packing, repacking. Throttling device, object, care, and use of. Care and preservation of carriage, what and how to oil. Grease cups.

Detachment No. 5.—Projectiles as seen in the magazine; kinds, uses, features of, capping, painting, etc. Inserting fuzes.

Occasionally the whole company is given practical instruction in the gin and shears.

The method of instruction above outlined is followed in the 126th Company, Coast Artillery, which is a mortar company. By a few obvious changes the system can be used in a gun company. The Syllabus of Examinations for Gunners, published in General Orders No. 93, War Department, 1905, is closely followed. The system of instruction has been very successful in this company, and has proved its practical efficiency. At the conclusion of the last gunners' examination there were 52 first-class and 42 second-class gunners in the company out of 103 men present for examination,—a result that I ascribe the application of the method given above.

A PROPOSED SYSTEM OF RANGE FINDING

By 1st Lieutenant F. WHARTON GRIFFIN, Artillery Corps

THE range finders in use by the U. S. army to-day are unsatisfactory with the exception of those used by the coast artillery. In recent years numerous experiments have been made with the range finders of foreign make, such as the Zeiss stereoscopic binocular range finder and the Forbes telemeter, but these also have proved unsatisfactory.

The essentials of a good range finder are that it should be accurate, easily carried in the field, should require a short time and few men to obtain the range, and of course the less complicated the parts of the range finder and the method of obtaining the range the better. With all range finders it is easier to find short ranges with accuracy than long ones. For this reason this system is proposed for use by the infantry, and if it should be tried and any one of the methods proves to be satisfactory a similar method will be presented for trial by the field artillery.

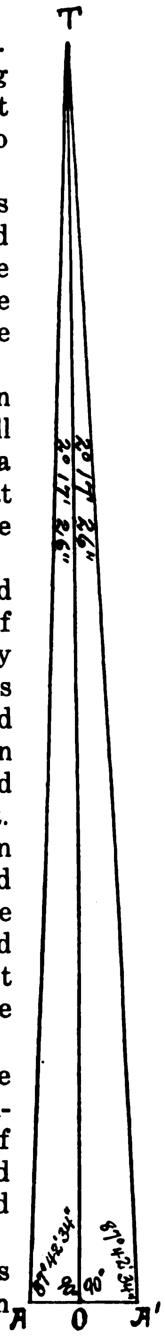
The best range finder now in use for troops in the field is the Weldon. This range finder is used by the field artillery and in theory it is sufficiently accurate, but unless it is in the hands of a well trained man it is very inaccurate and even in the hands of such men errors sometimes occur.

The principle by means of which the range is obtained in this proposed system is similar to the method employed in the Weldon but the instruments (there are two of them used in conjunction) are entirely different.

Before describing the proposed instruments a discussion of the principle will be given. An attempt has been made to eliminate all the errors that are liable to occur when using the Weldon and to make the instruments almost as accurate when used by untrained men (but men who understand the principle) as it is when used by trained men.

FIRST METHOD

This method depends upon the solution of one side of a right plane triangle; the angles of the triangle always being constant and hence the two adjacent sides of the 90° angle are in proportion.



The natural tangent of 87° 42′ 34″ is 25. Therefore in all right plane triangles containing an angle measuring 87° 42′ 34″ the sides adjacent to the 90° angle are in proportion of one (1) to twenty-five (25).

It will be seen in the figure, if O represents the point from which the range is to be obtained and T represents the target, that if a 90° angle be measured at O and the point A be found where the angle between AT and AO equals 87° 42′ 34″, the side TO is 25 times as long as the side OA.

The proposed instruments to be used to obtain the range consist of two instruments that will measure the 90° and the 87° 42′ 34″ angles and a tape line from which the range can be read at once, i.e. without having to multiply the distance AO by 25.

The instruments to be used to consist of rigid cross sights mounted on pointed staffs. One of these instruments to have the sights permanently fixed at right angles and similar to the surveyor's cross. The sights of the surveyor's cross would not be the best sights for range finding and in their place I would suggest two metal wedge-shaped sights. The front sight the same as the rear sight.

The other instrument to have one sight at an angle of 87° 42′ 34″ to the other and the same kind of sights described for the first instrument. These instruments to be detachable from their staffs and provided with the ball and socket movement similar to the Jacob's-staff. The sights to be carried in leather cases swung over the shoulder.

If the staff of the 90° instrument be made several feet shorter than the staff of the instrument containing the 87° 42′ 34″ angle and one of the sights of the 90° instrument be telescopic and provided with stadia wires, ranges can be read directly.

If the stadia method be used the cross arms of the 90° instrument should be provided with level tubes.

A time saving device for the 87° 42′ 34″ instrument would be a movable center similar to that in the transit but having more play.

The dimensions of the instrument and the metal or combination of metals out of which they should be made will be determined later if this system is approved. The instruments in their leather cases will not be much larger than the cavalry sketching case.

The tape need not be over 80 yards long, for this length of tape will measure a range of 2000 yards, $80 \times 25 = 2000$. This tape might be self-winding on a reel in a box and the box provided with some arrangement to hold it in place, as a pin to be stuck in the ground.

It will be seen from the figure that the range can be found by laying off the right plane triangle either to the right or to the left of the line TO.

Two men are required to find the range and for convenience I will call them No. 1 and No. 2.

No. 1 sets up the instrument, which has the sights permanently fixed at right angles, on the target. He then directs No. 2 on the line OA until he has found the point A with the other instrument, and the distance OA measured by the tape gives the range. If the stadia be used the range is read as soon as the point A has been found, but unless O and A are on very nearly the same level the tape line would have to be used. If the right plane triangle is laid off to the right of the line TO, No. 1 directs No. 2 along the line OA′ until he has found the point A′, and the range is found as before explained.

In order to prevent confusion on the part of No. 2 the sight which he is to point towards the target should be marked. It will be seen in the figure that this sight when used on the right of the point O is revolved 87° 42′ 34″ from the position that it is when used on the left of the point O. The sight to be used on the right should be marked R and the sight to be used on the left should be marked L. Then no confusion is possible.

Three men could find the range more quickly than two. No. 3 goes with No. 2 and uses the target sight while No. 2 uses the other.

When three men are used, without the use of the stadia, no staff is necessary for the 87° 42′ 34″ instrument for the sights can then be used as a hand instrument.

SECOND METHOD

This consists in using a permanent base and measuring the angle at the point A or A′. The instrument to be used at the point O to be the same as the one used in the previous method without telescopic sight or level tubes. The tape to be 40 yards long. At the end of this tape the second instrument is to be set up. This instrument is similar to a small azimuth instrument but mounted on a Jacob's-staff and provided with the ball and socket movement and level tubes. It should also have a movable center. The sight need not be telescopic, but like the sights described in the first method. It should also be provided with a vernier, vernier clamp and vernier tangent screws. The instrument should be set up reading 0° and pointing at O and the angle TAO should be read.

This gives the range immediately if a range table has been prepared beforehand. The natural tangent of the angle multiplied by forty is the range. Thus if the angle be 87° 42′ 34″ its natural tangent is 25 and $25 \times 40 = 1000$ yards. The sights on this instrument should be very little above the vernier plate in order to make the instrument as flat as possible.

THIRD METHOD

The instruments used are the same as those used in the second method except that the 90° instrument should be provided with a telescope, and stadia graduations should be marked on the staff of the other instrument.

The range is found by means of a plotting board. A base is measured any convenient length and the angle read at the end of it. This base is measured on the plotting board and the angle plotted and the range read off from the board.

PROFESSIONAL NOTES

WAR MATERIAL, 1905

Although few changes or improvements of a startling character have been effected during the past year in the manufacture of guns, projectiles or armor plates, still a steady progress has been made in the development of designs and processes already in hand at the commencement of the year; the study of metallurgy, for example, having given considerable impetus to the perfecting of steel and other metals for the construction of guns, armor plates, and armor-piercing shell, as well as of gun mountings, carriages, and fuzes, &c.

New field guns.—A good deal of energy has been displayed by the Royal Gun Factories towards the completion of the armament of our horse and field batteries of Royal Artillery with the new quick-firing gun. As very meagre descriptions of these guns have hitherto appeared in the Press, it may not be out of place to give a few particulars. The horse artillery gun is a 13-pounder of 6 cwt.; the field artillery gun is an 18-pounder of 9 cwt. When we compare these weights with those required for horse and field artillery weapons twenty years ago, the great improvement in the design and in the material of the modern guns is very apparent. Had it not been for the improvement of the steel employed, the weight could never have been reduced so considerably. And yet lightness is of infinite importance to the efficiency of field guns. The mechanism of both guns is precisely similar; they only differ in size. The parts of the breech gear are few and and strong, and can be put together in five minutes. Very few of the features of the German 15-pounder are observable in this gear. The "rebound spring" in the striker is one, and the "retaining catch" on the lever another. A portion of the breech opening of the gun is cut away on the right side, where the hinge of the breech block is placed, so as at once to admit the breech screw—which is cylindrical instead of ogival, as in the German weapon—into the breech end of the gun. This gives a vast increment of strength to the grip of the screw. The "safety catch" is also of quite a different character from the cylindrical button of the 15-pounder, and when closed precludes the possibilities of firing altogether. The gun has high projecting "feathers" at the sides along its whole length, which slide in "feather ways" on the mounting. The recoil cylinder is above the gun, with a combination of two large sets of very powerful springs, and a hydraulic buffer in the center, by means of which the recoil is entirely absorbed. A large ring upon the summit of the breech supports the rear of the cylinder. Both guns have the exterior of the breech curiously rounded, so that it resembles a ram's head, in order to remove all superfluous angles of metal. The gun-carriage has a cylindrical trail with spade at the end, and a hinged lever for training, like the 15-pounder, but the wheels are of wood, with gun-metal naves. It was the steel wheels and axles of the 15-pounder which gave so much trouble upon their introduction into the Service in 1900. A training arc, worked by a hand wheel, is provided with a new gun-carriage, which admits of 4 deg. of training on either side, or through an arc of 8 deg., ample for ordinary field purposes. Two seats are provided on the trail behind the gun, one for the layer and the other for the man firing, and the gun-carriage practically remains stationary after taking up its position. The elevating gear and a powerful brake clipping both wheels are also worked by hand wheels, controlled by the two gunners on the trail seats. The new field guns, so far as at present issued, have given the utmost satisfaction. The shrapnel shell, which are being made at the Royal Laboratory, for the field and horse artillery guns, are solid walled, the heads not being detachable from the sides. The openings are very large, so as to admit of their being easily packed with bullets. A large gun-metal socket is screwed in at the top, into which the fuze is screwed. This last is made of aluminium, with a very broad base to fit the socket.

Heavy guns.—A series of heavy siege guns is now under construction, some of them being already completed and in the service. This weapon, which is of 5.4-in. caliber, and throws a 60 lb. shell, is to take the place of the 4.7-in. siege gun. It is 12 ft. long and capable of being fired at an elevation of 21 deg., having at that angle a range of 14,000 yards. Although so powerful a gun, it is mounted upon a travelling carriage of moderate weight, having a trail with ordinary double brackets, the construction being very strong. There is no spade at the point of the trail. Large cast steel shoes are slipped beneath the wheels and secured whilst the gun is in position, so that the wheels cannot revolve. An arc for lateral training is contrived beneath the breech and upon the brackets, and thus the necessity for shifting the trail is obviated. The recoil of the gun is absorbed by two heavy recoil springs placed high up on the flanks of the gun, and a recoil buffer on the summit of the breech. The breech and breech screw are of the Welin type. This gun will be largely used in India to replace the 4.7-in. gun.

The 10-pounder jointed screw gun, for mountain service in India, has given good results. It was used in the recent expedition to Thibet, and found invaluable. A series of heavy coast howitzers, from 9.2-in. in caliber downwards, is also under construction in the shops and mounting grounds. Of heavy land service guns, the largest to be seen at present in any numbers are those of 9.2-in. The 12-in. gun has only been mounted at a very few places around our coasts or at the coaling stations abroad. But the 9.2-in. is universally asked for. At the present moment a battery of these powerful weapons is nearly completed in a position of magnificently high command in the Isle of Wight. The mountings for these 9.2-in. coast guns are now being enclosed within a face-hardened steel shield of 8-in. and 6-in. armor, and all the heavy work of training, elevation, and shot-lifting at the elevating derricks is performed automatically, a great saving of labor for the gun detachments, which can consequently be reduced. The shock of recoil is taken up by a powerful hydro-pneumatic cylinder, which stores the "power" for the purposes indicated, and this power is sufficient to train and elevate the gun, and to raise the projectile into position. As fast as is possible, existing positions are being completed with these automatic mountings, though the operation is a tedious one.

New naval guns.—By the courtesy of Vickers, Sons, and Maxim, Limited, we have been furnished with descriptions of their latest designs of guns, mountings and ammunition, with a statement as to ballistic powers. Many of these are quite new, and form the most powerful types of weapons which have been mounted in any vessels afloat. The 12-in., 9.2-in., and 6-in. types are assumed to be firing capped projectiles, and the results are based on "actual penetrations obtained with lower velocities." With a capped projectile of 850 lbs., and a muzzle velocity of 2850 foot-seconds, the 12-in. gun has a penetrative power of 24.3 in. into K.C. plate. This figure is much modified, of course, at ordinary ranges in action—say, at 4000 yards—but still the powers are gigantic. With a capped projectile of 380 lbs., and a muzzle velocity of 3048 foot-seconds, the 9.2-in. gun has a penetrative power of 20 in. into K. C. plate. With a capped projectile of 100 lbs., and a muzzle velocity of 3060 foot-seconds, the 6-in. gun has a penetrative power of 12.25 in., into K.C. plate. The calculated perforation of the uncapped 31-pounder armor-piercing projectile, fired from their 4-in. gun is equally remarkable, being no less than 11.5 in. of mild steel plate; nearly three times the caliber of the projectile! We observe that the calculated perforation of the 12-in. gun with the same projectile, capped, at a striking velocity of 2700 foot-seconds, based on Tresidder's formula, is given in his paper in Brassey's *Annual* for 1905, as 24.9 in. K.C. steel. The figure given for penetration by Vickers, Sons, and Maxim as the result of calculations made by actual experiments is, therefore, eminently satisfactory. Tresidder's formula gives 19 in. as the penetration into K.C. steel, with a capped 9.2 armor-piercing projectile at a velocity of 2700 foot-seconds. The results formulated by Vickers, Sons, and Maxim give 20 in., but with a velocity of 3048 foot-seconds. This may be regarded as equally good. Tresidder's estimated penetration into K. C. steel for 6-in. gun with capped projectile at 2700 foot-seconds is 12.1 in. The results obtained by Vickers, Sons, and Maxim with 3060 foot-seconds were 12.25 in. The close approximation of the estimates based upon Tresidder's formula with the results obtained from actual experiments by the great gun firm is very reassuring. The caps for the armor-piercing shells supplied by this firm are screwed to the point of the projectile without the cutting of cannelures around it. This is an element which should give additional strength to the shell in its passage through armor.

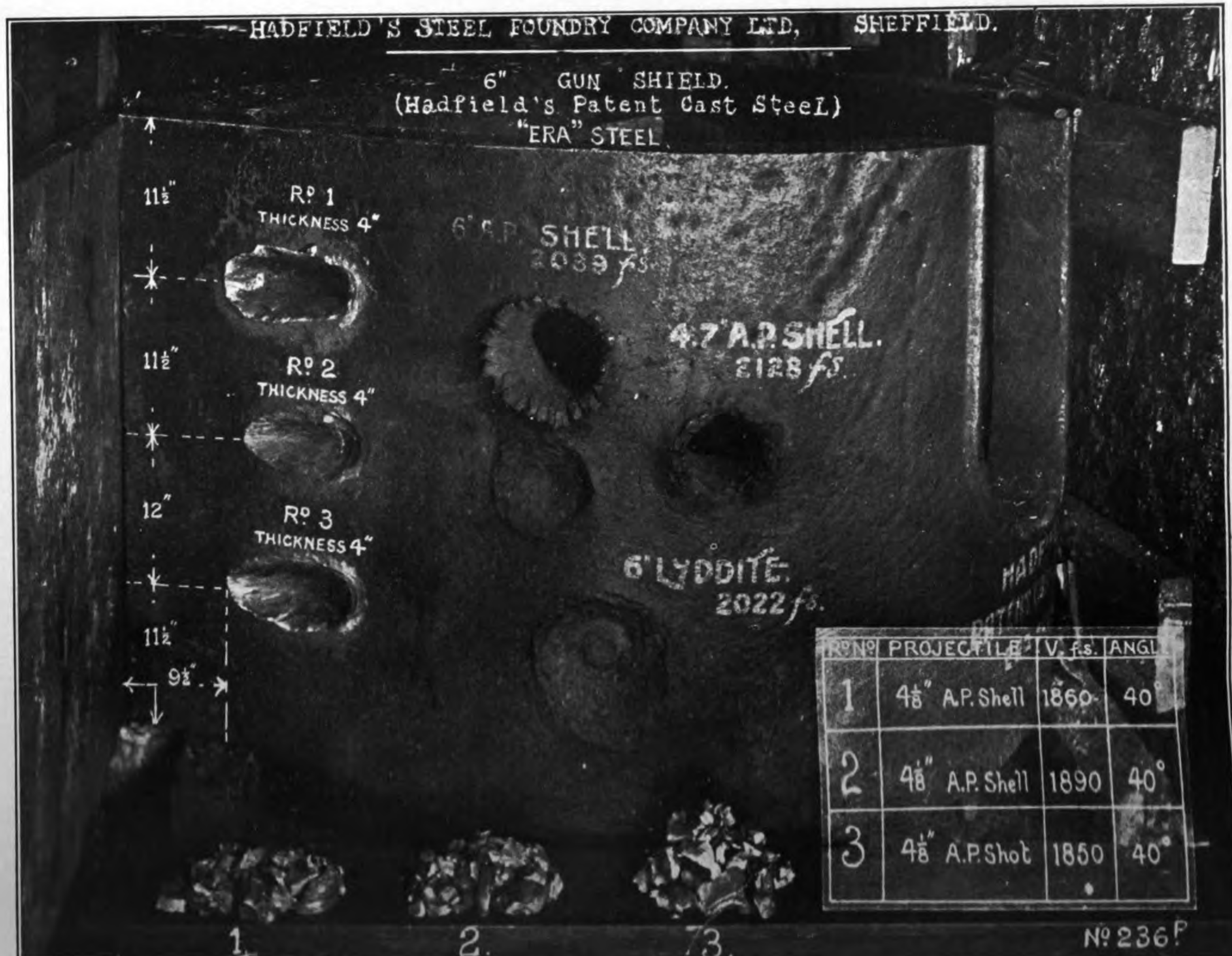
Before leaving the subject of guns we deem it necessary to allude briefly to the agitation which took place during this year in regard to the large numbers of 12-in. naval guns of the Mark VIII. pattern, which were found to be unduly defective in their A tubes on examination, and to several serious misadventures which occurred with some of these guns, the forward part of whose tubes was blown away upon the guns being fired. This was notably the case on the Majestic, one of the 12-in. guns having several feet of the tube at the muzzle blown clean out, and another 12-in. gun being seriously injured. This was at ordinary gun practice. The official report of the Ordnance Committee upon the failure of these guns generally ascribed their reduction in caliber—which was, of course, the primary reason for the dangerous choke at the muzzle—to longitudinal extension of the service A tube, due apparently to the design of that particular "mark." The report said that the whole of the sixty Mark VIII. guns would have to be "lapped out" sooner or later, but that the deeper step and thicker A tube of the later marks—Mark IX.—would probably prevent the same thing happening again.

Projectiles.—It is satisfactory to note that the "capped" projectile has at last "come to stay" at the Arsenal. A considerable number of Hadfield's "Heclon" capped armor-piercing shells of 6-in.. 7.5-in., and 9.2-in. calibers is in evidence in the Royal Laboratory, with the "thumb marks," which are characteristic of them, to be seen at the base of the caps, these being the impress upon the soft metal cap where it is hammered into the milled recesses on the nose of the projectile. Firth's "capped" armor-piercing shells of many calibers are also to been seen in large numbers, being recognized by the annular groove or grooves in the nose of the shell, and other corresponding grooves inside the cap, which are fitted in some cases with an iron rod run round, or tinned and sweated together with low fuzing-point solder. These are the Firth and Firth-Sterling caps. The Royal Laboratory authorities have a pattern of "cap" of their own, though it is not yet in evidence, being under consideration ; but we believe it to be a modification of the annular groove principle of attachment to the point of the shell. Judging from the large number of capped shell which are in course of treatment at the Arsenal at this moment, it would seem apparent that the system has received approval from H. M. Government.

To turn to the question of projectiles generally, it is interesting to observe that all the best results of experimental trials made with armor-piercing shells during the year have been with capped projectiles. Information of a remarkable character is to hand. We have already attended to the capped "Heclon" shell from Hadfield's Steel Foundry Company, which have been delivered into the Service, and which have successfully passed the severe ordeal of penetrating—whole—a one-caliber thickness of Krupp cemented plate. In Spain Messrs. Hadfield have been correspondingly successful, having completed the unit of large caliber capped shell for the Spanish Navy. One of the "Heclon" projectiles has recently been fired at an important foreign Government proving-ground, and gave remarkable results. The plate attacked was 12 in. in thickness, of the K.C. type, backed with 12 in. of oak backing, and 3 ½-in. skin plates. Such a plate is usually attacked by a one-caliber projectile—that is, 12-in.,—but in this case a "Heclon" projectile of 10-in. caliber was fired at it, with the low velocity of 1877 foot-seconds. The shell perforated the plate and backing, and was found with only the point and two pieces of the shoulder broken off no less than 2600 ft. beyond the target. When we compare this result with that obtained by each of four 9.2-in. projectiles, fired against a sample 9-in. K.C. plate, for the Japanese battleship Kashima, and manufactured by Thos. Firth and Sons in December, 1904, the advantage of the cap is very pronounced. The striking velocities of the four rounds were from 1814 foot-seconds to 1985, the mean velocity being far superior to that of the "Heclon" shell. The four Firth shells were all broken up, and the greatest penetration was 3.1 in. After such a result from a capped projectile, far surpassing any hitherto recorded, the superior advantage of the "cap" appears proved to the hilt. No 10-in. uncapped shot could have pierced the 12-in. K.C. plate under any circumstances, but we believe that the "Heclon" steel shell would have broken the record by getting through even a 10-in. plate at so moderate a velocity. As it is, the result must be regarded as unique. The "Helcon" 7.5-in. capped projectiles have also repeatedly perforated 9-in. plates at 1975 foot-seconds velocity, the shell passing through this severe test and being found practically undamaged far beyond.

Armor Plates.—As usual, we have not much to record upon the important question of armor plates. The various makers in this country being pledged to secrecy, very few results are made public, and official trials are usually made with low velocity and a one-caliber plate, or such a trifling difference exists as would be between a 9-in. plate and a 9.2-in. shell. In America the velocities are usually very low indeed, so that penetration could hardly be expected. Indeed, the main idea seems to be the obtaining of a plate which will not break under fire, from a shell of equivalent dimensions, caliber to thickness, at such a striking velocity as might be expected at fighting range. Proof to destruction is seldom applied to heavy side or barbette armor. The effect of crushing fire at high velocities is left to be divulged by the circumstances of war. Hence the photographs of plates for the Commonwealth and Asahi, and their appearance after very mild attack from 9.2-in. guns merely show that they can be penetrated to the extent of 3 in. or 4 in. without serious cracks being set up, or the backs being destroyed. Some valuable particulars in regard to foreign armor plate trials are recorded by Captain Tresidder in his excellent article in Brassey's *Annual.* The photograph of a sample cemented steel plate made for the Patrie by the special Marcell process of thickness tapering from 10.9 in. to 9.3 in. was fired at with 5-in. Chamond forged steel armor-piercing projectiles of 9.45-in. caliber, 317 lb. in weight, at striking velocities of 2054, 2201, and 2208 foot-seconds. The first shot broke up partly, but the second and third lodged in the plate unbroken. All bases projected to the rear about 7 in., showing the excellent material of which they were made, though failing to penetrate. The plate was not cracked, and its behavior was considered so good that the highest classification for premium was accorded to it—"No. 6." Capital results have been obtained with plates made by Monsieur Charpy, of the St. Jacques Steel Works at Montlucon. Captain Tresidder says that the steel is expensive, being high in nickel, but the results obtained with it are highly commended by the Essen authorities. For thicknesses below 4 in., where the Krupp process should cease, the Charpy plates constitute a decided advance on anything previously tested against an attack of a perforating as distinguished from a racking nature. They can be made as thin as 1.18 in. Thus they would be of infinite service for the protection of our torpedo boat destroyers against 6-pounder quick-firing guns, even when only of this slight substance.

Mr R. A. Hadfield has made good progress with his "Era" steel plates during the past year, and is getting good results for shields and other similar purposes. The "Era" steel plates, which are cast and not forged, contain a considerable quantity of manganese amongst other alloys. A 6-in. gun mounting, made of this alloy, was found to possess extraordinary gun-fire-resisting properties. A. P.-shell of 4.7-in. caliber, also common and lyddite shell of 6-in. caliber, were fired against it at velocities up to 2128 foot-seconds, but failed to penetrate. Finally a 6-in. armor-piercing shell was fired with a velocity of 2039 foot-seconds, but, although almost half of this shell got through, it is believed to have burst on the outside. At lower velocities the shells merely made an indention. The plate was quite uncracked. We learn that at Shoeburyness, with a 6-in. "Era" steel armored plate, still more remarkable results were obtained. Projectiles from 6-in.,


HADFIELD'S STEEL FOUNDRY COMPANY LTD, SHEFFIELD.
6" GUN SHIELD.
(Hadfield's Patent Cast Steel)
"ERA" STEEL
11½"
Rº 1
THICKNESS 4"
11½"
Rº 2
THICKNESS 4"
12"
Rº 3
THICKNESS 4"
11½"
9½"
SHELL
4.7" A.P. SHELL.
2128 f.s.
6" LYDDITE.
2022 f.s.
Rº Nº | PROJECTILE | V. f.s. | ANGL
1 | 4⅛" A.P. Shell | 1860 | 40°
2 | 4⅛" A.P. Shell | 1890 | 40°
3 | 4⅛" A.P. Shot | 1850 | 40°
1.
2.
3.
Nº 236 P


HADFIELD'S STEEL FOUNDRY COMPANY LTD, SHEFFIELD.
6" GUN SHIELD
(Hadfield's Patent Cast Steel)
"ERA" STEEL.
4.7" A.P. SHELL 1968 f.s.
4.7" A.P. SHELL 1702 f.s.
4.7" A.P. SHELL 1704 f.s.
Rº 4. THICKNESS 4"
Rº 5. THICKNESS 3¾"
Rº 6. THICKNESS 4"
13"
11¼"
13½"
7¼"
9½"
10¾"
10½"
Rº Nº | PROJECTILE | V.f.s. | ANGLE
4 | 4⅛" A.P. Shell | 1850 | 30°
5 | 4⅛" Capped "Heclon" A.P. Shell | 1840 | 40°
6 | 4⅛" Capped "Heclon" A.P. Shell | 1830 | 40°
237.P

7.5-in., 9.2-in., and other guns, were fired at it at an angle of 30 deg. from the perpendicular to the plate's face. Some were capped, the others were not. The capped shot generally got through, except we believe, the 6-in., which was deflected. The uncapped shot did not penetrate except in one instance of the smaller size. Singularly enough, the cap appeared to cause the smaller projectile to fail in penetration. A 7.5-in. "Era" steel gun shield has now been prepared by the Hadfield Company, which is, we understand, being experimented with by the artillery authorities at Shoeburyness.*

Range indicator.—We cannot conclude this summary without a reference to an invention of great value, which has been perfected for the Navy during the past year, and is called the Vyvyan-Newitt range finder. It is the invention of Lieutenant Arthur Vyvyan, the details of mechanism having been designed by Mr. Newitt, R. N., an electrical engineer. The main idea is that of transmitting the range observations, taken by a range officer stationed in the "fire control top" upon the mast of a war vessel, automatically, to the various gun positions on board. A series of electric motors, running at a uniform speed, is provided, one in the top, the others at the gun positions. Any movement in the motor at the "top" is transmitted automatically to the gun positions. Thus, when the range officer in the top sees an object or vessel to be brought under fire, he estimates distance, and informs the officer at the instrument in the top, who fires a gun for trial shot, say 400 yards short of estimate, and sets his instrument running with the pointer on a dial to indicate same to gun positions, all the instruments of which record similarly. The speed of ship and deflection of the range are provided for automatically. If the observing officer reports distance under-estimated, a second trial shot is fired, say at half the under-estimate. This will probably bring the instrument's pointer to a close approximation the range; if not, a third can be fired. All this will not occupy more than a few minutes, and the instant that the recording officer in the top hits the right range, all the gun positions have it too. The installation for working this range transmitter is running at Whale Island with remarkable smoothness and accuracy, and a duplicate has already been placed on a war vessel.—*The Engineer, London.*

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POWDERS IN USE IN THE ITALIAN SERVICE

Charcoal powders.—(a) Fine-grain powder employed up to the present time in cartridges for small arms and now used for the bursting charges of certain projectiles. (b) Large-grain powders for cartridges for field guns and also for reduced charges for guns of medium caliber. (c) Progressive powders, the grains of which, highly compressed, are formed of numerous small grains of great density held together by very fine powder. This powder is used in making up the charges of large caliber guns and also for the service charges of guns of medium caliber. (d) Prismatic powder, black and brown, for cartridges of the 400 mm. gun.

Powders with explosive gelatine base.—(a) Balistite for small arm ammunition, both rifle and revolver. Balistite consists of an intimate

*Through the courtesy of Mr. R. A. Hadfield, we are enabled to reproduce the accompanying interesting photographs showing results of tests of 6-in. "Era" cast steel shields.—*Ed.*

mixture of equal parts of soluble nitrocellulose and nitroglycerine: it contains also a little aniline to increase its stability. It is very insensitive to shock and friction, and is not affected by moisture, in fact so slightly that it can be left in water for several days without losing its qualities appreciably, if the precaution is taken to dry it on the outside after immersion. It is in the form of small cubes (6,000 to the gram for the infantry cartridge), of a color passing from a deep yellow to a reddish brown. (b) Solenite, the composition of which differs but little from that of balistite, is in the form of hollow cylinders; up to the present time it has been used only in small arms, model 1891. (c) Filite, which is in fact only balistite, in sheets, in fine cords, or disks; it is used in the rapid-fire guns, caliber, 42 and 57 mm., in the 75 mm. mountain guns and the 87 mm. field guns.

Explosives with nitrocellulose base.—Wet guncotton in the form of parallelpipedon-shaped grains is used for the bursting charge of the 321 mm. shell, the torpedo shells (from 3 to 4 calibers) of the 240 mm. howitzer, and the common shell of coast howitzers (long and short) caliber 280 mm. In the form of disks it is also used for the bursting charge of torpedo shells (from 4 to 6 calibers). In this case in order that the percentage of water may not diminish, the explosive is enclosed in zinc boxes hermetically sealed (by soldering), which can be placed in the projectiles. Dry guncotton is used as a detonator for the wet guncotton.

Explosives with picric acid base.—Pertite, used for charging projectiles. (But the use of this explosive does not seem to be fixed in orders up to the present time).—*Revue de l'Armee Belge.*

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COMPARATIVE EFFECT OF VARIOUS DETONATORS

The French Commission on explosive substances checked the weight and composition of various types of detonators before subjecting them to two series of comparative tests called "theoretical" and "practical," the former consisting of two distinct classes, viz., *a*, free exposure to air, and *b*, partial confinement. The "practical" tests, based upon transmitting detonation of the fulminate to explosives having a high ammonium nitrate content or to this substance pure, gave comparative results, either by the number of complete detonations of the ammonium nitrate explosives or by the length to which the explosion was transmitted in pure ammonium nitrate. These results were compared with the theoretical effects of the first-named series of tests, and the following conclusions were arrived at:—

(1) To obtain serious guarantees as to the detonating of explosives, the regularity of detonators should be checked rather than a selection made of given fulminating compositions.

(2) Testing detonators in small lead blocks with gauges of the recesses formed and calculation of the mean difference of volume appears to afford a practical determination of regularity.

Before the Commission's report was published M. H. Schmerber, Ingénieur des Arts et Manufactures, Paris, had nearly completed some investigations in the same direction which he also divided into two classes, theoretical and practical, while his tests bore upon three types of detonator, viz.: (1) pure fulminate of mercury, (2) mixed picric acid and fulminate, and (3) mixed chlorate of potash and fulminate. His object was not only to study the comparative effect of various detonators, but also to find simple and rapid means of testing them.

Among the theoretical tests, that which consists in producing an indentation in a lead plate by a detonator placed vertically upon it gave comparable indications for detonators of identical charges, but not for those of different charges. Satisfactory results were obtained by firing a detonator placed horizontally on the lead plate and gauging the cavity produced. When the effects of fulminate detonators were known it became easy to compare them with those obtained with detonators of different compositions. As regards useful effect, detonators of picric acid base appeared decidedly better than those of the other types, the pure fulminate and fulminate-chlorate giving practically equal results, while as regards regularity pure fulminate detonators occupy the first place.

The fact must not be lost sight of that what is required in practice is not so much power in a detonator as instantaneity of detonation, a rapid transmission of the explosive wave. It also appears of interest to acertain whether the results obtained with new and dry detonators could be depended upon in those kept for some time and that might have absorbed humidity. It was found that a short exposure to a damp atmosphere but slightly increased the weight of detonators of all three types, but that with long exposure, while the increase in weight of fulminate detonators was almost negligible, that of the picrated and chlorated types became considerable. The two latter, subjected to the tests in which they had shown good results when new and dry, now gave miss-fires or imperfect detonations, but the pure fulminate detonators appeared to be scarcely impaired.

A fact which appeared to recur in nearly all the tests is that the higher the detonator charge the less difference was appreciable in the various types. A curious circumstance is the facility with which detonation was transmitted to a second cartridge, while that of the first might have been very slight. Most of the practical tests were made in the open air, where detonation is transmitted less readily than in a closed chamber, so that comparison is easier, but they were completed by a series carried out under the latter conditions, more nearly resembling actual practice. An iron pipe 40 cm. (16 in.) long representing the shot hole was let (tight) into a cast-iron block representing the explosion chamber, and the cartridge with its detonator was well tamped with sand.

The same tests as before were repeated under these conditions, with the result that complete detonations with non-sensitive powders were more easily obtained than in the open air, while at the same time being perfectly concordant with the former tests so far as the less characteristic effects permitted of ascertaining. Picrated detonators, again, showed their superiority over those of pure fulminate, while the chlorated appeared to take an intermediate place, but when damp detonators were tested in a close chamber those of pure fulminate came once more to the fore by reason of their great regularity.

Summarising the results of his investigations, M. Schmerber arrives at the following conclusions, which fully corroborate those of the Explosives Commission :—

(1) Detonators of fulminate composition produce effects equal if not superior to those of pure fulminate, provided they can be of careful and recent manufacture.

(2) Detonators of pure fulminate afford greater guarantee than do those of fulminate composition, because the regularity of their manufacture is more certain and their inalterability greater.—*Arms and Explosives.*

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REARMAMENT OF THE BELGIAN FIELD ARTILLERY

The Belgian Minister of War has made known his decision on the subject of the trials of quick-firing guns for the Belgian army. The decision have gone in favor of the Krupp firm, and the Krupp 12-pdr. will, therefore, be introduced for the Belgian Field Artillery. All those who know the very remarkable success which has attended the trials will applaud the decision. The gun is said to present incontestable superiority, and embodies all the features which can be required in a quick-firing gun intended to be used in the countries where the Belgian armies may be called upon to fight. Two batteries have been under trial, and there have been great delays, the last part of the competition having lasted more than a year. The competing guns arrived in Belgium in the beginning of 1905, and were subjected at Brasschaet to preliminary inspection and practice on the trial ground. The two batteries were then employed in maneuvers at Beverloo, and then effective trials followed at Brasschaet. Finally, the guns have been transported along the roads for a distance of 5,400 km., in order to test their robustness and suitability for service. These trials went on until October, and various reports were addressed to the Minister of War towards the end of November. It required all the high competence of the Director-General of Artillery to examine, discuss, and collate in less than a month the numerous documents relative to these trials. This was necessary in order that formal conclusions might be reached, and that the chief of the department might be permitted to arrive at a decision at the beginning of this present year. Thus, if our artillery finally possesses field artillery material of a modern degree of excellence, it is to Lieut.-General Hellebaut to whom the credit must be given. It is hoped there will be no delay in giving effect to this new policy. Money should be available because the legislators have at various times expressed their readiness to vote the necessary expenditure. The action of the Minister of War is therefore awaited in regard to the acceptance of the contracts.—*Belgique Militaire.*

The adopted type is known as the "7.5 cm. field gun, L/30," with the usual sighting arrangement, and also the panorama sight. Its future construction will include, however, certain modifications of detail, that the extensive tests, lasting nearly a year, have shown to be indispensable; but these changes in no way affect the principles of the system and it will not be at all necessary to test them be new trials of any duration.

The limbers of each piece and each caisson of the Krupp battery that was selected for the tests contained only 28 and 32 rounds, respectively. It has been decided to increase the size of these limbers a little so as to have a single type carrying a uniform number of 40 rounds. The body of the caisson is of the "non-upturning" type and contains 61 rounds.

It is thought these conditions of ammunition transport can be fulfilled without sensibly diminishing the mobility of the piece and caissons.

Netherlands	Switzerland	United [8] States of America	Portugal	Belgium [9]
1903	1903	1902	1904	1905
7.5	7.5	7.62	7.5	7.5
30	30	29	31.4	30
horizontal wedge guide shaft	horizontal wedge guide shaft	interrupted screw	eccentric screw	horizontal wedge guide shaft
350	330	377	340	330
950	1000	970	1080	1030
1750	1750	1724	1830	1715
1800	1820	1835	1852	1785
40	40	36 + 4 on carriage	38	32
104	96	106	110	101
6.0	6.35	6.8	6.5	6.5
....	6.35	...	....	....
136.4	143	149	....	148
....	143	....	....	....
270	210	295	294	360
11	12.5	11	10	9
....	0.515	....	....	0.465
....	....	8.7	8.198	8.14
500	485	518	....	500
76.5	76.1	93	....	83
5600	5900	....	....	....
long recoil carriage	long recoil carriage	long recoil carriage	long recoil carriage	long recoil carriage fixed trail spade
	1.35	1.22	....	....
3 to 4 mm. nickel-steel shield	steel shield 1.55 mm. high 4.25mm thick	folding shield in two parts 5 mm.	shield	shield 5mm.
	armored	one lower shield	armored up-turning	armored 5 mm.
		independent line of sight	independent line of sight	ordinary sight and panoramic sight
16.5	16	15	16	
7	8	5	5	
4	4	8	9	
6	6	6	....	
20	20	20	15-20	16-25
	4	4	....	
	10	12	....	
0.983	0.99	....	0.955	
Krupp	Krupp	Ord. Dept.	Creusot	Krupp

course of construction. [8] A model 1902 with shield has been adopted and put in
pected during course of construction,

The experimental material, which will be modified, as indicated above, at the Belgian Royal Gun Foundry with the co-operation of the Krupp works, will be used during the winter course at the Firing School at the Brasschaet polygon. This will enable the designated personnel to learn all the details of the service and care of the new material.

After the tests by single piece, it was evident that among all the powders used the smokeless powder of the firm of Cooppal and Co., (which had been used with the Cockerill-Nordenfelt material on rigid carriage) was the most satisfactory. Consequently it was prescribed that this powder should be used in the tests of the two batteries of trial guns (Krupp and Saint-Chamond). This explosive, like the L^3 powder adopted for the Mauser carbine and rifle, is of a pure nitrocellulose base. It has the form of translucent strips, very elastic, of a straw-color yellow, about 210 mm. long, 17 mm. wide, and 0.9 mm. thick.

The Royal Powder Works at Wetteren, after long and minute research, has succeeded in making new improvements in its products. In fact, ballistic tests recently made at Brasschaet with this new powder demonstrate that it fulfils to-day, in a yet more perfect manner, all the conditions its use in a rapid fire field gun demands.—*Revue de l'Armee Belge.*

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FRENCH HORSE ARTILLERY

The *France Militaire* announces that the batteries of the 2nd Cavalry Division at Lunéville, hitherto armed with the 80 mm. gun, model, 1897, will be provided with the new 75 mm. guns with which the field batteries are armed. The journal adds that the arrival of this material will certainly cause a change in the cadres of the brigade divisions of horse artillery, which were originally constituted for batteries of 6 guns, whilst the 74 mm. batteries have only 4.

The French have just assigned to each horse battery four 75 mm. rapid-fire guns of the same model as that which has been in use in the field batteries since 1897, but slightly modified to increase its mobility. The 80 mm. gun has been put out of commission.

According to competent French authority, it said that the 4-gun organization of horse batteries is provisional and that the cavalry divisions will preserve their 6-gun batteries. The 80 mm. piece weighs 1650 kg. while the new piece weighs 1850 kg. It is thought that this diminution of mobility is ample compensated for by the very considerable increase in the efficiency of the piece and its projectile.

We learn further from other sources that the French shops are working on the construction of a 75 mm. light gun, the weight of which is not to exceed 1500 kg. This would constitute an ideal solution of the problem, for horse artillery and field artillery in general, since unity of caliber would be realized and it would greatly facilitate the employment of horse batteries by not obliging them to carry along a great number of caissons and by ensuring their resupply from the usual ammunition trains of the army.

—*Belgique Militaire.*

LOCALIZATION OF THE R. G. A.

A special Army Order, has been issued dealing with the localization and reliefs of the Royal Garrison Artillery :—

The following memorandum explanatory of the scheme will take effect from April 1, 1906:—

The existing system of reliefs by complete companies, by which the whole of the artillery garrisons are often changed at the same time, impairs the efficiency of our defended ports. A considerable time must elapse before the incoming units can acquire a through knowledge of the armament, local conditions, and general surroundings, such as tides, channels, zones of fire, area of illuminated water, and the various conditions of the atmosphere both by day and night. A further disadvantage of interchanging companies is that, as the strength of the artillery in a garrison varies with the armament to be manned, the establishment of companies on change of station has to be either increased or reduced, so as to fit in with the armament of the new station. To obviate these disadvantages it has been decided that, both at home and abroad, the companies of R.G.A. (which will retain their present designations) are to be localized. The establishment of each station is to be maintained by drafts from the depots, or from the home companies, or by the individual relief of officers and men, as is now the practice in the case of the fortress companies of the Royal Engineers.

Organization of Royal Garrison Artillery.—The establishment of R.G.A. in a fortress is the number of officers and men required to man the armament of the fortress, after taking into account a due proportion of such local and auxiliary forces as may be available. Army Headquarters will only deal with this fortress establishment as a whole. The distribution of the personnel among the companies of R.G.A. comprising this establishment will be effected, in the first instance, by the officer commanding the troops at the station concerned. Thus each company will be of such establishment as will best conduce to unity of command in the several fire commands and battery commands of the fortress; this establishment as soon as fixed should be reported to the War Office, and once fixed, is not to be altered except under authority from the Army Council. At stations where district establishment as well as companies exist, the former will be absorbed into coast defense companies, the establishment of which will be increased proportionately, and considered as part of the establishment of the fortress. At stations where there is no R.G.A. unit, existing arrangements will hold good. The siege companies are not to be allotted to fixed armaments, but may be utilized to man the movable armaments.

District staff.—The district staff will remain as at present. The following will be transferred from the district establishment to the district staff ;—Warrant officers, n. c. o.'s above the rank of sergeant, artificers and bands.

Depots.—The existing six R.G.A. depots will be retained, and recruits will be enlisted for the R.G.A. generally.

Specialists.—Provision is made for the proportion of these in general, and at stations where there are no companies of artillery. At stations where there are now companies and district establishment, the number of depression range-takers, now found by the district establishment, will be added to the company percentage.

Training of auxiliary forces allotted to fortresses.—These should be trained in peace in the works and with the armament to which they are allotted on mobilization.

Foreign service.—The period of service abroad entitling officers and men to register their names for transfer home is six years.

—*Army and Navy Gazette.*

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SOME NOTES ON THE MODERN COAST FORTRESS

These notes make no pretense to teach the whole duty of the military engineer with reference to the defense of a modern coast fortress. They are notes and nothing more.

My only excuse for writing them lies in the fact that, at the present time, much thought is being given to this special type of defense, owing to the lessons of the Russo-Japanese War; and that I, as Chief Engineer of the Portmouth and Portland defenses, have had opportunities of discussing and considering the various changes and modifications that the lessons of that war are forcing upon us.

I propose to omit, as far as possible, the general descriptions to be found in the text-books and elsewhere, and to dwell rather on novel views. These views, as expressed, must be taken as my own, and may not be concurred in by everybody, Their consideration can do no harm and may do good.

RESPONSIBILITY FOR THE DEFENSE

On the declaration of war the primary duty of a navy so powerful as ours would be the seeking out of the enemy's fleet, with a view to its destruction. To do this satisfactorily the navy should have its own hands free, and it should not be hampered by having to look after the defense of its "bases"—strong fortified ports, where its ships could be repaired or replenished with coal, ammunition, provisions, and men. On this account it is usual in the British Service to provide "fixed" defenses at these ports, and to intrust the land forces with their design in time of peace and their manning in times of war. The relative advantages and disadvantages of this system have been much discussed. On the one side it has been argued that as naval bases are solely for the use of the navy, who are especially acquainted with the methods of attack that are likely to be used by ships, it were better that the navy should also take charge of the fixed defenses; whilst on the other side it is argued that the navy in time of war will have quite enough to do in "blue water" without frittering away their time and opportunities in operations on land, and further that the defense of a coast fortress may be from the land as well as from the seaside, as was exemplified in the recent attack on Port Arthur.

Under present arrangements, as stated, our army is primarily responsible for the defense of the coast fortresses, but still both services must co-operate in carrying out the details of any scheme. As instances of questions which require mutual consideration we may mention—(i.). The regulations for the examination service and the passing in and out of the port of friendly vessels. (ii.) The transmission to the Fortress Commander, as soon as possible, of intelligence from naval sources as to the whereabouts of the enemy's fleets or ships. (iii.) Arrangements with the naval officer in charge of the local submarine and torpedo craft, whose sphere of operations would, as a rule, be immediately in front of the fixed defenses.

Many other mutual arrangements, which will be necessary, will no doubt suggest themselves to one's mind; and this necessity is provided for in most modern coast fortresses by the formation of a permanent joint Naval and Military Committee, which the Commander of the fortress, as President, can assemble, from time to time, as he considers necessary, whether for the purpose of preparing for war in times of peace, or for carrying on a successful defense during war.

TYPE OF DEFENSES

The type of defense to be adopted in a coast fortress will depend on:—(A) the nature of attack that may be expected; (B) the local conditions of the port; and (C) the strength and nature of the garrison that is likely to be available.

I do not propose to deal with the question of defense against attack from the land side, nor do I propose to take into account the amount of assistance that may be obtained from the defenders own naval forces, as this latter may, at any time, cease to exist either permanently or tenporarily.

(A) NATURE OF ATTACK THAT MAY BE EXPECTED

Any modern scheme of defense for a coast fortress in Great Britain will have to consider the following forms of attack, and each form may be combined with one or more of the others, the one form being often employed as a blind or feint with the object of giving a better chance of success to one or more of the others:—

(*a*). The attack by torpedo craft at night.

(*b*). The attack by submarine or submersible vessels by day.

(*c*). Bombardment by large war vessels.

(*d*). Blocking operations, by sinking vessels in the fairway where harbors have narrow mouths or artifical entrances.

(*e*). The laying of mines to prevent ingress or egress from the port.

To explain these attacks more in detail:—

(*a*). All our harbors, and especially those on the Southern or Eastern coasts, are liable to attack by torpedo craft by night, which may be expected immediately on, or even prior to, the declaration of hostilities. This latter fact is fully recognized in our modern defense schemes, and steps are taken to meet such attacks accordingly. It is the most likely form of attack nowadays, offering as it does a chance of producing far-reaching advantages for the attacker with very little commensurate risk.

(*b*). The landsman cannot assist to any great extent in beating off an attack by submarines or submersibles, and it would not therefore be likely to affect any of his schemes of defense.

(*c*). As regards bombardment by large warships I cannot do better than quote from *Garrison Artillery Training*, Vol. I., 1905:—"The attainment of sea command being the vital issue, an enemy will rarely be prepared, before that issue has been determined, to risk the loss or the crippling of a portion of his battleships or cruisers by exposing them at effective ranges to the fire of shore batteries. The recent development of torpedo craft and submarine boats have, moreover, much enhanced the risk incurred by battleships and cruisers in delivering an attack on a port in which such craft may be stationed."

Still the unlikely may happen, and has happened before now, and the object of coast defense is to prevent such possibilities. Fog has to be specially considered in our English climate in connection with this and many other forms of attack; and there are many positions which war vessels could take up in the vicinity of our modern coast fortresses, in which they could not well be fired upon in thick weather, and from which, nevertheless, they could in a short time produce a very telling effect on a dockyard or on ships crowded together in a harbor.

In these days of wireless telegraphy the movements of all warships will be pretty accurately known to both sides, and the fact that our ships may have been called away for a time to concentrate at a certain point may tempt a few armored cruisers of the enemy to appear before a port, to which our fleet cannot return for say 24 hours, and, after delivering a rapid and telling bombardment, to get away again before they can themselves be punished.

(*d*). Some of our harbors are specially open to blocking operations, on account of the narrownass of the natural ships' channel at their entrances, and some on account of the narrow passages through artificial breakwaters. The Japanese in the late war, as is known, made many unsuccessful attempts to block the entrance to Port Arthur; but they would probably have met with more success if they had had at their disposal some of those old battleships and cruisers which we are now throwing away. Such vessels would stand a lot of knocking about from shore batteries at night (especially as the heavy guns of those batteries would have no auxiliary lights) and would, if sunk in the fairway of the harbor's entrance, possibly prevent ingress or egress of warships for many weeks.

(*e*). Attack by mine-laying (if attack it can be called) evidently bears but little on the question of "fixed" defenses.

(B) THE LOCAL CONDITIONS OF THE PORT

The siting and nature of the fixed defenses of a port must, of course, be much influenced by its local conditions; and hence a good sea chart and contoured map of the surrounding country is an absolute necessity to the designer of coast defenses, who must also have an accurate knowledge of other details such as the rise and fall of the tide, the strength and nature of currents, etc.

(C) THE GARRISON THAT IS LIKELY TO BE AVAILABLE

It is not necessary to dilate much upon this self-evident fact that the design of the defenses must be much influenced by the numerical strength and value of the troops that can be allotted to them. Where skilled troops are plentiful a type of defense may be entertained which would be quite out of place where many such troops could not be supplied.

DEFENSIVE MEASURES AGAINST THE DIFFERENT FORMS OF ATTACK

Let us now consider how the different forms of attack can be met with the greatest probability of defeating them.

ATTACK (*a*)

Attack (*a*) by torpedo craft will be delivered at night; and therefore it is imperative for the defender to have a considerable portion of water area well illuminated to allow of the anti-torpedo-boat guns stopping all hostile vessels that attempt to pass them. Remember that these guns are at all times practically useless unless there are ample lights to assist them.

The usual arrangement, where local conditions so permit, is to have an outpost line and inner defenses so arranged that the gun resistance and lighting become stronger as we gradually approach the the entrance of the port in which the friendly ships can lie behind a strong boom.

To warn the guns many look-outs are employed, and these, on detecting the presence of a hostile boat, can ring alarm gongs at all the Q. F. gun groups, and can communicate by telephone with the different Fire Commanders. Remember that the control of fire of the Q.F. anti-torpedo-boat guns in the hands of the gun group commander and is not controlled by anyone else.

I think that more attention, than is usual, might be given in the modern fortress to the question of protecting the lights both from raiding parties and from the hostile fire of boats, and that the lights should have more spare projectors and engines than at present. Our present system of lighting is run on such an economical scale that if one light is out of action for even a short period a very awkward unilluminated area is formed at many vital points.

The old question of the control of the electric lights crops up again from time to time. I noted the following remark in the "Highly Commended" Duncan Essay for 1905, by Major H. B. Wood, R. G. A. :—"In home waters the control of the electric lights is at present vested in the hands of the R.E." Now this is scarcely correct. The control of the electric lights is, by official instructions, in the hands of the Section Commander and he can delegate that power to whomsoever he likes, provided he bears in mind the general instructions to the effect that artillery fire at night will be assisted by "fixed" beams only, and that although "search" lights may sometimes be employed for the purpose of discovering the movements of the enemy's ships, they will only *under exceptional circumstances* be used for following or fighting them by artillery fire. Peace maneuvers have shown that nothing aids the passage of hostile boats more than putting the control of gunfire and lights into the same hands. The R.E. with their lights assist the R.G.A. with their guns in the defense of a coast fortress in somewhat the same way as the R. F. A. assist the infantry in the attack of a position, but no one would advocate the control of field guns being put into the hands of the brigadiers of infantry. Major Wood adds in his essay "All appear to agree with the principle that electric lights and guns should be under one head." Quite so, but that head should not, primarily, be the R.E. or the R.G.A., but the Section Commander, who is responsible for the defense of the whole section.

The inner lights should not as a rule be exposed continuously; they should be "damped" until the alarm circuit gives warning of the approach of a hostile vessel; and it would appear that the look-outs on that circuit should have the power of warning the lights as well as the guns, which is not the present arrangement.

Owing to the necessity of constant peace practice with the lights their positions are probably well known to all foreign powers, and it would appear advisable to arrange in peace time for certain extra lights to be erected on mobilization so as to act as false guides to an enemy's vessels, and so possibly run them ashore. Naval men, who have had experience of the difficulties of handling torpedo craft in the glare of electric lights, specially advocate the use of such false lights.

The effective range of electric lights *as regards the laying of guns* is generally much overstated in the text-books. In considering defenses those distances may well be lessened by 30 to 50 per cent. Attack (*a*) is not likely to be delivered in England on a night that would allow of the maximum effective range of the lights.

The present anti-torpedo-boat guns are for the most part of the 12-pdr. Q. F. type. It is doubtful if these guns are sufficiently heavy to stop a modern destroyer, and it is probable that many of them will have to be replaced before long by others of a heavier type. 6-pdrs. give no commensurate return for the manning numbers required to work them.

ATTACK (*c*)

Attack (*c*), or bombardment by war vessels, will probably never take place as long as vessels cannot carry it out without the risk of receiving considerable punishment themselves; but this fact points at once to the necessity of having guns of sufficient caliber placed well to the front to prevent hostile vessels from getting into positions from which they could bombard satisfactorily. It is stated that Admiral Togo, after some experience before Port Arthur, issued a general order that none of his vessels were to approach within 12,000 yards of the guns of the defense. He would not have been compelled to exercise this precaution unless the Russians had mounted powerful guns to oppose him.

In modern designs therefore we aim at pushing our heaviest guns (9″.2) to the front to fire on all waters there in which big war vessels can maneuver, and at removing them from interior waters into which, in the present day, such vessels could not penetrate.

There seems to be but little likelihood of a heavier gun than the 9″.2 being used for coast defenses. The projectiles of the 9″.2 gun are about the heaviest that can, on an emergency, be man-handled; and the expense and complications af a 12″ barbette mounting would be so great as to render the employment of so heavy a gun improbable, in the immediate future at any rate.

It has been advocated by some that the medium guns (6″) should be done away with altogether; as being useless against modern armored vessels. I do not concur in this view, because :—(i.) there are many parts of a modern war vessel of the 1st class that are unarmored, and, if we are to believe newspaper reports, Admiral Rozhdestvensky has stated that at the battle of the Sea of Japan his vessels suffered more from the fire of medium guns amongst the *personnel*, etc., than from that of the heavy guns; (ii.) it is important to have some medium guns in the front line to act as auxiliaries to the 9″.2 guns by drawing off the enemy's fire from them whilst they are going through the comparatively slow process of loading which is inherent in them.

The use of high-angle-fire guns has to a great extent gone out of fashion. They complicated the defense and required considerable manning parties; but they would be very useful against attack (*c*) and I, for one, am not convinced as to the advisability of doing away with guns which can be worked by comparatively unskilled men, and which cannot be themselves silenced.

ATTACK (*d*)

Attack (*d*), or the channel-blocking attack, is a difficult one to meet satisfactorily. Such an attack would certainly be made at night and probably in conjunction with attack (*a*). There is considerable difficulty in sinking an old armored vessel by gunfire before she can get to her goal, and this is specially difficult at night when, as at present, the heavy guns have no lights to assist them.

The best arrangement probably is, as far as possible, to deny all passages except one to approaching vessels and to have considerable gun power on that one.

It is probable that extra lights will have to be added to our present establishment in some cases with a view to giving the heavy guns of the fortress this power of stopping blocking vessels at night.

—*Col. T. R. Main in the Royal Engineers Journal.*

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LESSONS OF THE WAR: ARTILLERY ACTION

The long range, the rapidity of fire of the modern gun, its capacity for operating in hidden positions, and the small effect produced on earthworks and invisible objectives are the *data* which at the present time regulate the employment of artillery. All troops showing themselves in the zone of shrapnel action may suffer terrible losses in a few minutes, and artillery can nowadays operate at a range of over 5 kilometers. On the other hand, on account of its small explosive force, it causes no damage whatever to material objects. As regards common percussion shell, its sphere of action is extremely limited on account of the difficulty of obtaining sufficient precision. Thus the essential task of artillery is the destruction of living objects. The habitual method of firing is by *rafale* fire. There is no longer any artillery duel in the sense understood by this expression. A battery on which fire is directed is compelled to cease firing; when the enemy has fired some *rafales* on it, he stops to avoid waste of ammunition, and either ceases fire altogether or changes to deliberate fire. It is therefore impossible to annihilate artillery whose gunners are under shelter in trenches or behind shields. The object of the artillery fight is to hold the hostile artillery under the constant threat of *rafale* fire to prevent it from firing on the infantry or on any other moving objects. Well concealed positions, a good preparation for opening of fire, and a judicious organization of observation make it permissible to retain several batteries available to act against the hostile infantry, or to concentrate their fire on a selected point of attack. Long range very greatly assists the concentration of fire, whilst at the same time making it unnecessary to mass the artillery in long continuous lines, which the enemy would quickly discover. There is all the advantage of distributing the batteries under shelter in the terrain and of spoiling the enemy's aim; in addition, this reasoned breaking up of batteries allows all portions of the ground in front and on the flanks better to be swept by fire.

Artillery can do nothing without a throughly well-organized observation service, conducted by officers and gunners personally scouting along the whole front and gleaning information gathered by other branches of the service; the telephone has, consequently, become indispensable to artillery for the transmission of information. Staffs should remember to forward all the information which comes to them on to the artillery. The Japanese organized their observation service to a most remarkable degree of efficiency, yet they nevertheless frequently fired on unoccupied zones. Commanders of batteries should see as much of the ground as possible so as to be able to show initiative, and even batteries themselves should see the country round. "The shields protecting them against shrapnel would in such cases render immense service." But artillery should be able to fire masked, and that often causes commanders of batteries or brigade divisions to be at a distance from their commands, when they can only communicate with them by telephone. In any case, all the terrain in front of the batteries must be seen by the battery observers.

To emerge from a zone known to the enemy and under his hot fire, recourse must be frequently had to small battery changes of position; these movements should be entirely carried out by hand and without being seen, otherwise they are useless. Changes of position in order to approach the objective are only permissible when one is over 3,500 meters from it It is better for artillery to prepare the attack remaining on positions already occupied, so that the firing may not be interrupted. It would be better that the batteries advancing should be taken from the reserve, in order that they might, if possible, attempt to take the enemy in flank. When it is possible, naturally the position on which the attack must be prepared should be approached as close as possible, as this will create a great impression; but this is not indispensable, nor is it always possible. When the enemy gives way, the artillery must be brought as quickly as possible on to the conquered position.

Firing over infantry is inevitable and frequent. It alone permits the artillery to avoid assembling in vulnerable masses; to utilize the whole range of the gun in concentrating the fire of the various batteries on the same objective, and to cause the artillery to be a constant menace to the adversary's movements. The commander of the troops distributes his artillery, points out to it the positions to occupy, and the general objectives; he keeps the artillery commander informed of the fortunes of the fight, gives him new duties, etc. The artillery commander distributes the various duties amongst his batteries, organizes a system of observation along the whole front and flanks of his radius of action, so that he may be informed without delay of the appearance of favorable objectives. He superintends the supply of ammunition.

On visible objectives the most efficacious method of firing is that of the *rafale* of shrapnel. When the Japanese wished to reach masked objectives they directed a slow fire on the ground behind the positions, preferably on points where they supposed the reserves, limbers, etc., to be, and fired a *rafale* as soon as they detected the slightest movement. The Russians, when firing against material obstacles, such as villages, trenches, etc, simultaneously employed percussion and time-fuze shrapnel. When they were able to do so they combined the shrapnel fire from field guns with common fire from howitzers. The Japanese fired common and shrapnel shell simultaneously or alternately; the common shell to cause movement behind shelter and the shrapnel then to inflict losses.

The report is of the opinion that batteries of 8 guns should be given up, and that 6 or even 4 guns per battery are sufficient. "If it is properly provided with ammunition, a battery of 4 guns can carry out all the duties usually confided to an 8-gun battery, for it was hardly ever necessary to resort to the maximum rapidity of fire. The 4-gun battery is less cumbersome and more mobile, and can adapt itself better to the ground." Range finders, good battery telescopes, and good field glasses are indispensable.

—*Journal Royal United Service Institution.*

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THE DREADNOUGHT

Few, if any, warships built in this or any country have excited the same keen and universal interest as the Dreadnought, launched at Portsmouth Dockyard on February 10th. This is due to the fact that the vessel is beyond doubt the most powerfully armed, the best protected, and the fastest battleship ever laid down. It embodies, not only in the general elements of design, but also in the details of equipment, the great experience and knowledge of strategy and tactics of Sir John Fisher, the First Sea Lord of the Admiralty, universally regarded as the leading exponent of our naval policy. His ideas have found expression in concrete form through the co-operation of Sir Philip Watts, K.C.B., the Director of Naval Construction, who has ever shown skill and initiatory courage, and these qualities have attained their fullest scope in the design of this new ship.

The armament calls for first attention. All of the ten guns of the primary armament are of the 12-inch caliber; indeed, in all the large armored ships which have recently been laid down in the British Navy, this is the only gun adopted. There are many advantages to be derived from unification of caliber: the supply of ammunition at the naval bases is enormously simplified, while on board ship there is less likelihood of confusion, and a greater certainty of being able to use the best guns effectively up to the last moment of an engagement, because the remaining store of ammnnition may be conveyed from one magazine to another in order to serve the gun most conveniently placed. This unification is being universally accepted, partly as a consequence of British advocacy, but mostly because of the reports by attachés present at the Battle of the Sea of Japan. There is not, however, the same general agreement as to the caliber of gun which should be adopted, owing solely to the amount of attention that must be devoted to the question of cost. Most of the Powers, however, accept the 12-inch gun, although in France there is a strong advocacy of a new 11-inch weapon, while in the new Russian cruisers the 10-inch gun is being adopted. The deficiency in caliber in the latter instances is partly compensated for by higher velocities.

Recent war experience has shown that the gunner should be able to strike any target that can be properly aimed at, or is within view; the perfection of sighting apparatus is such that these are almost synonymous terms. But it is not sufficient merely to strike the target—it must be destroyed; and to attain this object many naval officers contend that more than mere striking velocity is required. The mass of the shot counts, and therefore more destruction will be attained with a projectile of 850 pounds weight fired from a 12-inch gun than with a 500-pound shot from a 10-inch gun, or a 380-pound shot from a 9.2-inch gun, even although these latter, by reason of their greater velocity, develop nominally the same striking energy. This was obvious by examination of the Russian ships sunk at Port Arthur, because the smaller shots from the 6-inch guns, and even many from the 12-inch guns, failed in what, a century ago, was termed "smashing" effect, when the old carronades were introduced. Volume in shells is also of importance for the same reason, although the destructive effect of the contents is directly relative to size. There is therefore little chance of the 12-inch gun being discarded for a lighter weapon of high velocity, even although the direct saving in weight on board ship for a pair of guns and their mountings within a barbette is between 170 and 200 tons, while the indirect saving, consequent upon a possible reduction in the dimensions of the ship and the power of machinery, is nearly threefold. The probabilities are rather in favor of even greater calibers.

There is, however, no obvious reason why the velocity of the 12-inch gun should not be increased in a way corresponding with that of the new French 11-inch or the new Russian 10-inch guns. It is said that in the large Russian cruiser, which the Vickers Company are building, there will be fitted 10-inch guns to attain a velocity in service of 3000 feet per second with a normal pressure in the chamber and bore. Such a velocity has only been exceeded on purely experimental trials, and has thus far not been regarded by any means as a normal condition, so that great interest will be taken in this new weapon. Looking, however, to the success hitherto of the Vickers ordnance, and to the great influence that such success has had on warship power generally, there seems no reason to expect other than a satisfactory issue from this further advance. The effect will be a development of energy in the 10-inch gun corresponding almost to that of the 40-caliber 12-inch gun; but were the same velocity applied to the 45-caliber 12-inch gun, its power would be proportionately increased. In the Dreadnought, however, the guns of 45 calibers are to have a velocity restricted to 2850 feet per second, and will give a muzzle energy of 48,000 foot-tons. These guns are being manufactured, with their mountings, by Sir W. G. Armstrong, Whitworth, and Company, Limited, and Messrs. Vickers Sons and Maxim, Limited.

Up till quite recently the 12-inch gun adopted on British ships has been of only 40 calibers in length, and the velocity has been more usually 2500 feet or 2600 feet per second. Each gun of the Dreadnought will therefore be something like 30 per cent. more powerful than those fitted in ships of two years ago, double the power of the 9.2-inch gun, nearly five times the power of the 7.5-inch gun, and eight times that of the 6-inch gun. It will thus be readily understood that in offensive power the new ship is an enormous step forward. In the case of the Royal Sovereign, built in 1892, and with four 12-inch guns of moderate power, the collective energy at the muzzle of one round from all the guns was only 159,619 foot-tons. The vessels of ten years later had a collective energy of 194,400 foot-tons, and in these vessels there were only four 12-inch guns, the remainder of the armament being 6-inch weapons. In the King Edward VII. class, four 9.2-inch guns took the place of some of the 6-inch quick-firers, and, as a consequence, the energy was increased to 270,000 foot-tons. In the Lord Nelson all of the 6-inch guns were discarded, and the armament became four 12-inch guns with ten 9.2-inch guns; and now in the case of the Dreadnought, with ten 12-inch guns, the collective muzzle energy of one round has gone up to 480,000 foot-tons. Thus in ten years, from 1892 to 1902, there was an increase of 22 per cent., while in the past five years the advance has been made 147 per cent. More important still, every shot from the Dreadnought will be effective at six miles range; whereas in the case of the ships of three years ago the maximum range was not more than five miles, and even then the number of shots fired within a given time was only 30 or 40 per cent. of that of the Dreadnought.

It is contended, however, that there is a tendency to make warships merely floating gun carriages, and that calculations as to the collective energy of one round, and also of the weight of shot fired in a given time, are illusory. As regards the former, it may be accepted, so far, at least, as the Dreadnought is concerned, that the increase in gun power which we have notified has not been attained at the expense of any other quality which goes to make up fighting efficiency. The new ships will meet British Admiralty conditions; but there will be more common-sense interpretation of this phrase, and less of needless duplication. This has too often been justified as an effort to ensure reliability, which, after all, is only a comparative condition. The personal equation has been frequently undervalued. As to the measurement of gun power by the standard of weight of shot and collective energy per unit of time, there is no other basis embracing caliber, length, velocity, and energy of gun, and the efficiency of the breech mechanism and mountings. It is true that the maximum rapidity of fire attainable may not be utilised in any engagement. A large measure of success of the Japanese Fleet was consequent upon their power of restraint, and of making sure that every shot represented value in progress towards the destruction of the Russian ships. But it is necessary that the guns should be there, and that the mechanism and mountings should give a great rapidity of fire for any emergency requiring concentration; and the measure, under some common denominator, of each element constituting their power is as important, in estimating the design, as the horse-power of the machinery, which is not developed at all stages of the engagement.

The distribution of the armament on board the ship is equally important. The offensive power being concentrated in fewer guns, it becomes necessary that each gun should be capable of use through a wide angle; in other words, that more of the guns than hitherto should be capable of firing on either broadside. The obstruction offered by deck erections can always be minimised, but there is great difficulty in arranging magazines at the base of the gun-mountings, so as to ensure an easy and continuous flow of ammunition to the guns. In a modern high-speed battleship, however, 160 feet to 200 feet of the length of the ship is required for the machinery and coal-bunkers; and it is doubtful if the expedient of placing the magazines between the boiler-rooms is prudent, in view of temperature and possible explosions. There is consequently a strong presumption in favor of placing the guns, whose mountings are of great depth, and whose magazines require a considerable area, forward and abaft the machinery. The Italians are said to favor the fitting of six pairs of 12-inch guns in the center line of the ship, and of placing the magazines alternately with boiler and machinery compartments. The American proposal is to fit pairs of 12-inch guns, in two barbettes at the bow and in two at the stern all eight guns being in the center line of the ship, the inner barbettes in each case being at a higher level than those in front, so that all four guns in the forward part of the ship may fire ahead as well as on either beam, and that all four guns aft may fire astern as well as abeam. It should be stated that these guns will not be superposed, as in the case of some of the earlier American ships, but will be entirely separate. The arrangement is open to the objection that the blast from the guns in the rear pair may considerably disturb the men working the guns in front, and especially the captain at the more or less exposed firing station, while the unignited gases entering through the ventilating-holes on the top of the hood may have a stupefying effect on the whole gun crew.

In the Dreadnought both these objections have been overcome, the arrangement devised affording the maximum of efficiency. On the forecastle there will be mounted two 12-inch guns in a barbettte, the center line being considerably above the water-level. On each side, a short distance to the rear, there will be two other pairs of 12-inch guns on the upper-deck level, and in order to enable these guns to fire ahead an embrasure is formed at each side of the forecastle, so that all six 12-inch guns may take part in a running fight. At the same time four of them can be used on each broadside. Aft there are two pairs of guns, both in the center line of the ship, one pair to the rear of the other; but with this difference, as compared with the American design, that both pairs are on the same level and are a considerable distance apart. The four guns, therefore, cannot be fired astern, although they have a very considerable arc of training abaft and forward of the beam. Instead of placing the guns in the fore-and-aft line they might have been mounted in echelon, but the objection to this is the same as that made to the American plan. Presuming the four guns mounted in echelon to be fired on the beam, the blast and unignited gases from one pair of guns might seriously hinder the work done by the other pair. As it is, with the gun-muzzles in line, and a considerable distance apart, there is less likelihood of interference the one with the other, especially as the admiral would make it a point in his tactics to secure the weather berth. The Dreadnought arrangement, it is true, reduces the astern fire to two guns, which is less than in any preceding ship where there are either 9.2-inch guns or 6-inch quick-firers on each quarter. Both the pair of 12-inch guns should be adequate, in view of the other qualities of the Dreadnought, in comparison with probable combatants. It is not probable—at all events, for several years—that any of our possible enemies will build a ship with greater offensive power, or with more admirably distributed and effective armor protection. That being so, one is justified in assuming that the Dreadnought will not require to run before a superior ship. Moreover, her speed of 21 knots would probably enable her to outclass any more powerfully-armed vessel, as in most foreign Powers the question of cost must militate against high speed with such gun-power. The tactics would be rather to swing the ship, so as to bring to bear upon a following enemy the whole broadside. This was undoubtedly Admiral Togo's procedure, and, as events showed, it was the correct one.

The Dreadnought, therefore, besides having ten 12-inch guns, will have the enormous broadside fire of eight 12-inch guns, which far excels anything in previous ships. Since the range in battleship engagements of the future is likely to be not less than five miles, and as it is essential that each shot must have a smashing effect, apart altogether from the power of penetrating armor, if may be taken that nothing less than a 10-inch gun is of any avail; so the 12-inch gun confers undoubted and necessary superiority. The Dreadnought, even in a broadside action, is therefore equal to any two ships afloat. None of the guns are at a less height than the upper-deck level, and the two forward barbette guns are on the forecastle. This very desirable improvement adds materially to the fighting efficiency, because, in a heavy sea, with the ship rolling through 20 degrees or 25 degrees, the guns formerly placed on the main deck could only be fired intermittently, owing to the disappearance of the target from the sighting position. In the new ships, with weapons on a higher plane, the captain of the gun need never lose the enemy on his sights.

Another important point in reference to the armament of the modern ship is the protection against torpedo and submarine boats. Hitherto in the British service the 12-pounder gun has been regarded as sufficient, but the surprising success of the Japanese destroyers in their recent engagements, even taking into account the preparatory work of destruction and and demoralization by the battleship and armored cruiser of the previous day, has reawakened the feeling that this type of craft has great potentialities, and that a rapid-firing weapon of great power is needed to check small craft maneuvered with such daring and courage as was shown in the Sea of Japan. The 12-pounder gun has not what have already termed a sufficient "smashing" effect. The Japanese in their new battleships have decided to fit a numerous battery of 4.7-inch guns firing 45-pound shots, and curiously enough the Russians in their new cruisers are adopting the same weapon, and are fitting over twenty of them. In the Dreadnought the intention is to adopt an entirely new weapon, using an 18-pound shot, and many may have doubts as to the adequacy of this new weapon, in view of the immense superiority of the vessel in every other respect.

The placing of the guns on the upper deck has materially simplified the arrangement of the armor, and here it may be interjected that the adoption of turbines has assisted towards this higher gun-platform, because the weights with turbine machinery are lower in the ship, and thus the center of gravity is considerably lower; at the same time the top hamper in the ship has been reduced. The main belt in the way of the machinery has been increased in thickness to 10 inches, and the upper deck is armored. The gun mechanism is protected by thick heavy hoods, as in the case of the earlier barbette guns; and the gun-mountings, while largely protected by the main broadside armor, are further shielded by armor barbettes or cylindrical casings.

The adoption of the steam-turbine has not only increased the speed, but has resulted in the improvement of the maneuvering quality of the ship. Four shafts are adopted, and this has greatly facilitated the fitting of a double stern with two rudders—a form of stern advocated for some time for heavy battleships. The cutting away of the deadwood in combination with a balanced rudder has improved the turning moment of later single-stern battleships by 30 per cent.; and as the double rudder enables a larger area to be utilized effectively, without increasing the torsion on the threaded shaft of the steering gear, there will be still better facility in maneuvering. While there is no change so far as the upper works are concerned, the stern of the ship is doubled under water, with two rudders quite twenty feet apart. The deadwood is cut away in each case to provide an aperture for the propeller on each of the inner shafts, while the two outer shafts project in the usual way beyond the shell of the ship some distance forward. This duplication of rudder also reduces the stress on the steering gear. It has been found in some ships, where the one rudder is operated from the rudder-head cross-head by rods connected through nuts to a shaft with right and left-handed screw-thread, that the torsion on the shaft is very severe when the rudder is put hard over, especially when the ship is going astern at high speed. The duplication of steering-gear with two shafts will greatly reduce the stress.

The contract for the turbine machinery was placed with Messrs. Vickers Sons and Maxim, Limited, and it is anticipated that with the four propellers running at over 300 revolutions, the power developed will be equal to 23,000 indicated horse-power. There will be two high-pressure turbines and two low-pressure turbines, each on separate shafts, and each shaft will also carry an astern turbine, two of which will take high-pressure and two low-pressure steam. The high-pressure main and astern turbines are to be on the wing shaft, and the two inside shafts, in addition to carrying the low-pressure ahead and astern machines, will also have turbines of small diameter for cruising purposes. Steam for the low powers will pass from the boiler into the cruising turbines, thence to the high-pressure wing turbines, and back to the low-pressure turbine before entering the condenser. This will enable a full range of expansion to be economically attained, even with a small volume of steam.

The steam pressure is to be higher than any previous turbine ship, as the eighteen Babcock and Wilcox boilers are to be worked at 250 pounds pressure, which will be slightly reduced at the high-pressure turbines. The boilers, consistent with the latest practice, will be fitted for working not only with coal, but with oil fuel.

In order to reduce the power necessary to attain a speed of 21 knots, and to reduce the draught for a given displacement—the Dreadnought when ready for sea will be about 18,000 tons on 26 feet draught—it was decided to increase the length of the ship from the 410 feet of the Lord Nelson to close upon 500 feet, with a beam 82 of feet. This increase in length had the further advantage that it afforded greater room forward and aft for magazines under the 12-inch guns without interfering with the under-water torpedo-tube gear in connection with the five submerged tubes. The larger magazine will, of course, be forward, where there are six 12-inch guns.

All the executive officers will have their quarters forward. It is somewhat surprising that hitherto the Admiralty have continued the location of the officers in the stern of the ship—a survival of the old sailing-ship and paddle-steamer days—while in the merchant service the change was made thirty years ago. The conservatism which has hitherto been maintained in the service called for the isolation of the admiral in a flagship, and the commanding officer in other vessels, and this has been the excuse for placing the principal rooms at the stern, far removed from the venue of work. In most ships, even in ordinary service, the day cabin of the captain, which is under the bridge, is most frequently used, and in action the ordinary rooms of the officers would seldom be utilised.

In determining, therefore, entirely to re-arrange the habitable quarters of officers and crew the Admiralty have taken a wise step. There is no reason whatever why the forecastle of the ship should not be made as attractive and as exclusive as the stern, and under ordinary steaming conditions there will be more comfort, as, even with reciprocating engines, vibration is least felt forward.

It will thus be seen that from first to last the Admiralty have brought to bear upon the design of the Dreadnought not only a well directed experience, but a common-sense determination to retain only those traditions of Admiralty practice which improve the fighting efficiency of the ship, and not those influences and traditions which have accumulated in the hands of successive Boards, who, not having the courage to prefer the modern to the old, compromised matters by adopting both. One other feature which deserves reference is the rapidity with which the ship has been constructed. Nominally the keel was laid at the beginning of October, but a large quantity of preparatory work had been done before this.

Even so, however, it may be said that from the time when instructions were given—about seven months ago—there has been built into the ship 5,500 tons of material, and it is anticipated that the progress of the machinery, guns, gun-mountings and armor will enable the vessel to be completed and be on her trials in the early weeks of 1907.—*Engineering.*

On February 10th, the Dreadnought, the most powerful warship in the world, was launched at Portsmouth. She has been frequently spoken of as if she marked an entirely new departure in naval architecture. This is not strictly true. She is evolved from types which have preceded her, and the apparent jump is due, not a little, to the fact that her immediate predecessors are still far from completion. It is principally in displacement and main armament that she makes a larger step in advance than is usual, but she is as truly evolved from the Nelson class as that class is from the King Edward. This ship, with her seven sisters, carries four 12-in. guns and four 9.2 guns, and displaces 16,500 tons; immediately following her come the Nelson and Agamemnon, weighing 16,600 tons, armed with four 12-in. pieces, and no less than ten 9.2's—an armament which not a few critics are inclined to consider superior to the ten 12-in. guns which it is reported the Dreadnought will carry. From these two vessels to the Dreadnought of over 18,000 tons displacement, the principal change is in the extra length that is entailed by her high speed, but she is, nevertheless, their direct decendant.

Few vessels within recent years have attracted so much attention as the Dreadnought, for the interest of the public has been excited by her great size, turbine engines, and tremendous fighting power, no less than by the speed at which she has been brought to the launching stage, and by the secrecy with the Admirialty has been careful to surround her. The object of this secrecy is clear to all who follow intelligently the development of the navies of the world, and who are able to appreciate at its true value the high diplomacy which underlies naval construction. We are prone to forget that the peace of Europe reposes in the maintenance of a certain balance of power, which might be easily upset by changes in one navy or another, but we must not be blind to the significance of the speed with which the Dreadnought is being built. Our Admiralty, we may rest assured, is not inspired by any idle desire to create a record. More, far more, lies behind. The Dreadnought, both in her enormous power and the rapidity with she will rise into commission, is meant as an object lesson which those who are intended to learn cannot fail to appreciate. But much of the advantage which we expect to retain by the possession of this great vessel would be endangered were the details of her construction known before she was near completion. We know that she is closely observed, and that other nations will at the earliest moment seek to produce a "reply" to her, and it is clearly wise policy to retain the lead which we possess by concealing as long as possible details of her design and strength. Some time ago the Admiralty issued a special appeal to the whole Press that nothing would be made public without their direct sanction, and it would be a matter for deep regret that several papers have so far forgotten their loyalty as to give descriptions of the vessel without this sanction were it not for the fact —and we have the highest authority for the statement—that, without exception, every account that has yet appeared is far from accurate, The secret has been kept with admirable closeness, and it is safe to assert that at the present moment not only is the nature of the armament of the Dreadnought unknown outside a very limited circle, but that even the statement so confidently made that she will carry ten 12-in. guns has no solid foundation, and it is as likely to be wrong as right.

By degrees the actual facts about the Dreadnought must leak out; but, in the meantime, it should be the object of all who can do so to assist the Admiralty in its policy of concealment. If the secret can be kept for another twelve months we shall have secured an advantage in time that will be of inestimable value in maintaining the superiority of the British Navy, which is universally regarded as essential to the peace of the world.

—*The Engineer*, (*London*).

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WAR VESSELS BUILDING IN JAPAN

From one of the newspapers just to hand from Japan, we learn that the following is the list of war vessels building, or about to be laid down, in the dockyards of that country :—

At Kure, the battleship Aki (18,000 tons), about to be laid down.

At Yokosuka, the battleship Satsuma (18,000 tons), about to be laid down.

At Kure, the armored cruiser Tsukuba (14,000 tons), laid down in February, 1905, and expected to be launched in February, 1906.

At Kure, the armored cruiser Ikoma (14,000 tons), laid down in December, 1904, and expected to be launched in December 1905.

At Yokosuka, the armored cruiser Kurama (14,000 tons), laid down, but dates are not given.

At Kure, the armored cruiser Ibuki (14,000 tons), about to be laid down.

The *Jiji Shimpo*, referring to this subject, says that the Japanese Admiralty has already elaborated a scheme of naval expansion which awaits the approval of the Diet. Although Japan has now a fairly large and efficient navy, it is recognized that some of her best ships are beginning to be out of date, and everything goes to indicate the necessity of building larger ships, with much heavier armaments and higher speed. The *Jiji* says :— "England is now building the Lord Nelson, a battleship with a displacement of 18,000 tons, and an armament of of four 12-in. guns; but

English architects contemplate something much more formidable. Russia's new navy well certainly be on modern models, and Japan must live up to the time." We are informed that the new submarines, five in number, when performing evolutions before the Emperor at the naval review, proved a great success, and the authorities are about to increase the squadron. The Japanese believe that the submarine is especially suitable for their navy, as its management demands precisely the qualities in which the Japanese officer and sailor excel, courage which never shrinks from self-sacrifice and absolute coolness in action. The destroyer Asakaze was launched at the Kawasaki yard, in Kobe, at the end of October, in the presence of a large company, and Captain Ommaney, of the H.M.S. Andromeda, cut the rope freeing the vessel. The Asakaze is one of the five destroyers ordered by the Admiralty from this same firm. We learn further that a new factory for large guns is nearly completed in the neighborhood of Tokio, midway between Oji and Itabashi, covering an area of 10,000 tsubo (83 acres). It is said to be very complete in every department and fitted with the most improved appliances. Much energy has been shown in pushing on the work. Four thousand men are said to have been employed originally, but the number is now reduced to seventeen or eighteen hundred. The cost is put at two million yen, and the shops are now about ready to begin operations. It is quite evident that the Japanese are determined to maintain all the advantages that they have gained. It is, however, to be regretted that political conditions should have forced them into the course of militarism instead of the peaceful development of the resources of their country.

—*Engineering.*

Short Notes

Nearly all fuzes are provided with a delayed-action element, which, with armor-piercing projectiles, permits them to pass through the armor before bursting takes place, and for shells fired in the open it permits the shell to rise after impact to a sufficient height to make the fragments effective over a larger area than would result from the shell bursting on the ground. This is accomplished by placing a small pellet of dense powder in the path of the flame, from the priming pellet in the fuze to the igniting or detonating element, depending upon which is used. Detonating fuzes, which are used with high explosives, have, in place of the igniting charge of the ordinary fuze, a detonating charge of mercuric fulminate, the amount depending upon the projectile in which the fuze is to be used.

—*The Engineer, London.*

Naval guns for coast defenses.—The decision has been arrived at to re-arm all the modern forts on the coast of the English Channel with six-inch naval guns, in order to bring about more complete fighting unity between the sister services. If we exclude Portsmouth, Plymouth, and Dover, the majority of the coast defense batteries have nothing heavier than the 4.7-inch gun, and although it is a very efficient weapon of its type (throwing a projectile of 45 lbs, in weight, and having a penetrating power equal to perforating 6.6 inches of wrought iron at a range of 2,000 yards), yet manifestly such a gun is of very little value against even light armored battleships. The intention of the naval authorities is, by strengthening our coast-line forts, to establish points of advantage for "mosquito" operations. Torpedo craft will be enabled to lie under cover of these defenses, dashing out, as opportunity offers, to deliver an attack, and then retiring to shelter. The new 6-inch gun, with which the forts are to be re-armed, is the Vicker's pattern wire-wound, weighing seven tons unmounted. It will be capable of throwing a projectile of 100 lbs. in weight, with a fire delivery of twelve rounds per minute, but even greater rapidity could be gathered if mechanical means of recovering the recoil were devised; its penetrating power is equal to perforating fifteen inches of wrought iron at a range of one mile. The cost of this new gun is £1,673, without mountings, or nearly three times that of the 4.7-inch piece. The work of rearmament is to be carried out as early as possible.—*United Service Gazette.*

The Spanish Minister of War introduced in the Cortes, last December, a bill authorizing the purchase from the Creuzot factories of 200 quick-firing guns with the necessary material. A vote of £840,000, spread over four financial years, will be appropriated to defraying the cost of the new armament.—*Page's Weekly.*

New explosives.—Three new explosives for use in mines, etc., have been added to the Home Office schedule. Their names and composition are as follows:—

Ammonal B, consisting of 93 to 96 parts by weight of nitrate of ammonium, 2.5 to 3.5 parts of metallic aluminum, 2 to 3 parts of charcoal, and 0 to 1 part of moisture.

Ripping Ammonal, consisting of 84 to 87 parts by weight of nitrate of ammonium, 7 to 9 parts of metallic aluminum, 2 to 3 parts of charcoal, 3 to 5 parts of bichromate of potassium, and 0 to 1 part of moisture.

Rippite, consisting of 59.5 to 62.5 parts by weight of nitroglycerine, 3.5 to 4.5 parts of nitrocotton, 18 to 20 parts of nitrate of potassium, 9 to 11 parts of oxalate of ammonium, 0.5 to 1.5 parts of castor oil, 3.5 to 5.5 parts of wood-meal (dried to 100° C.), and 0 to 1 part of moisture.

Special conditions as to use, detonating, marking, thawing, etc., are attached to each case.—*Iron & Coal Trades Review.*

Resupply of batteries in position by mechanical means.—The resupply of ammunition to batteries in position by the means now in use is often very difficult. In Russia experiments have just been made with a small wagon weighing only 30 kg., with wheels 0.3 meters in diameter, the dimensions of which are such that it can be readily attached under a limber or caisson; it contains the same number of rounds as one limber. Near the pieces which are to be supplied is arranged by means of stakes driven in the ground a pulley through which is run a cable 600 meters long. The small wagon fastened to the cable is drawn from the sheltered position up to the battery either by horses or by men not exposed to fire. After having pulled it in one direction, they pull back the wagon to the place where it is loaded again. This arrangement appears to be of value in the organization of defensive positions.—*Revue de l'Armee Belge.*

A report on the tests of seven types of submarines submitted to the Russian Admiralty says that in the deciding run of 560 miles, from Cronstadt to Libau, in which four boats took part, the verdict favored the Lake boat.

At Yokosuka the Japanese have under construction a battleship with a displacement of 19,250 tons, which is a greater displacement than has been attempted by any other navy heretofore, and as soon as this ship is launched a sister ship is to be laid down.—*The Engineer, London.*

The following is the Japanese naval program for completion this year:

Battleship Satsuma, 19,250 tons, in October, at Yokosuka.

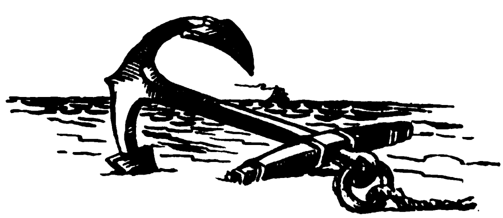
Armored cruiser Kurama, over 14,000 tons, in August at Yokosuka.

Armored cruiser Ikoma, in March, at Kure.

Despatch boats—Magazi, 2,300 tons, in July, at Nagasaki; and Yodo, 2,500 tons, in July, at Kobe.—*Daily Telegraph, (London).*

The Dreadnought took the water on Saturday without a hitch. Her immense length was apparent as she glided into Portsmouth Harbor—it is over 500 ft. This and her fine lines forward made her look like a cruiser rather than a battleship as she swung to her anchors. The disposition that will be given to her armor was, of course, clearly visible—a complete belt up to the main deck for about two-thirds of her length, and a slightly narrower belt aft. There is no indication of armor above that.

—*The Engineer, London.*



BOOK REVIEWS

Festungskrieg. Eine applikatorische Studie uber den modernen Festungskampf. Heft 2. Der Kampf um ein vorgeschobenes Einzelfort. Von Schwarte, Major m. d. U. des Generalstabes. 12+120 p. maps. 9¼×6¼. Berlin. E. S. Mittler und Sohn. 1906. M. 3.80.

This book constitutes Part II. of this important study on the attack and defense of fortifications, the first part of which, published last year, awoke much interest and met with a most favorable reception. As already mentioned,* this part discusses the struggle for an outlaying separate fort, the capture of which is essential in order that the attacking forces may reach the desired point of attack on the main fortress, and also that they may not be hampered in establishing their communications, etc., with their rear. The same treatment of the subject is followed as in Part I.; the theatre of operations is the same, and Fort Gollmer-Berg of the fortifications of Wittenberg is selected as ths work to be captured. Part II., however, goes more deeply than the first into the tactical and technical details of fortress warfare; the field of operations is limited, and the conditions become more specialized. These details are based on standard technical works, regulations, etc., bearing on the employment of the various units, and are here co-ordinated and brought into harmonious working in the solution of the problem.

The concrete examples set forth the measures taken by the attack and the defense, and the series of problems on the course of operations from day to day, that naturally arise for solution, give an excellent practical idea of the manner in which the attack and defense of a modern fort will be conducted. In this way they enable both commanding and subordinate officers to acquire an intimate knowledge—within the limits of the problem—of the correct application of the principles of this mode of warfare. These lessons have to be learned in time of peace, and failing actual fortress maneuvers—which are not always possible, due to lack of the necessary zone of operations, the amount of preparation involved, the vast quantity of material and other details required in a modern siege, not to mention cost—this applicatory method appears to be the next best means of teaching the subject to the soldiers and officers of all arms.

The Salamanca Campaign. By Captain A. H. Marindin, The Black Watch. 59 p. maps and plans. 11 x 10. London. Hugh Rees, Ltd., 119, Pall Mall, S.W. 1906. 7s. 6d.

The officer who takes up this book with the expectation of reading it in the usual sense of the word will be disappointed. The author has intentionally produced rather a skeleton, an analysis, than a body of current narrative.

* JOURNAL, September-October, 1905.

Accordingly, after a brief introduction on the events leading up to the campaign in question, he presents the situation as it unfolded itself from day to day, and adds, by way of conclusion, a brief commentary. If the expression be permissible, Captain Marindin's book is not an independent treatment of the subject; this does not mean, however, that he has not treated his subject in an independent way. On the contrary, he has put it in the power of the unbiased reader to get at the truth; and that truly is, or should be, the main purpose of all studies of military history.

Readers of this study are to be congratulated on its make-up; it is a luxury always to have a necessary map opposite the page one is working on. To this end, the book is mostly printed on one side of the page only; and the maps, barring a total lack of orographic features in those directly accompanying the text, a defect for which the author is not responsible, are clear and easily followed.

Captain Marindin has produced a valuable study upon a most interesting campaign.

Taschenbuch der Kriegsflotten. VII. Jahrgang, 1906. By B. Weyer, Kapitanleutnant a. D. 410 il. & plans of ships. 6¾ x 4¾. Munchen. J. F. Lehmann's Verlag. 1906. M. 4.

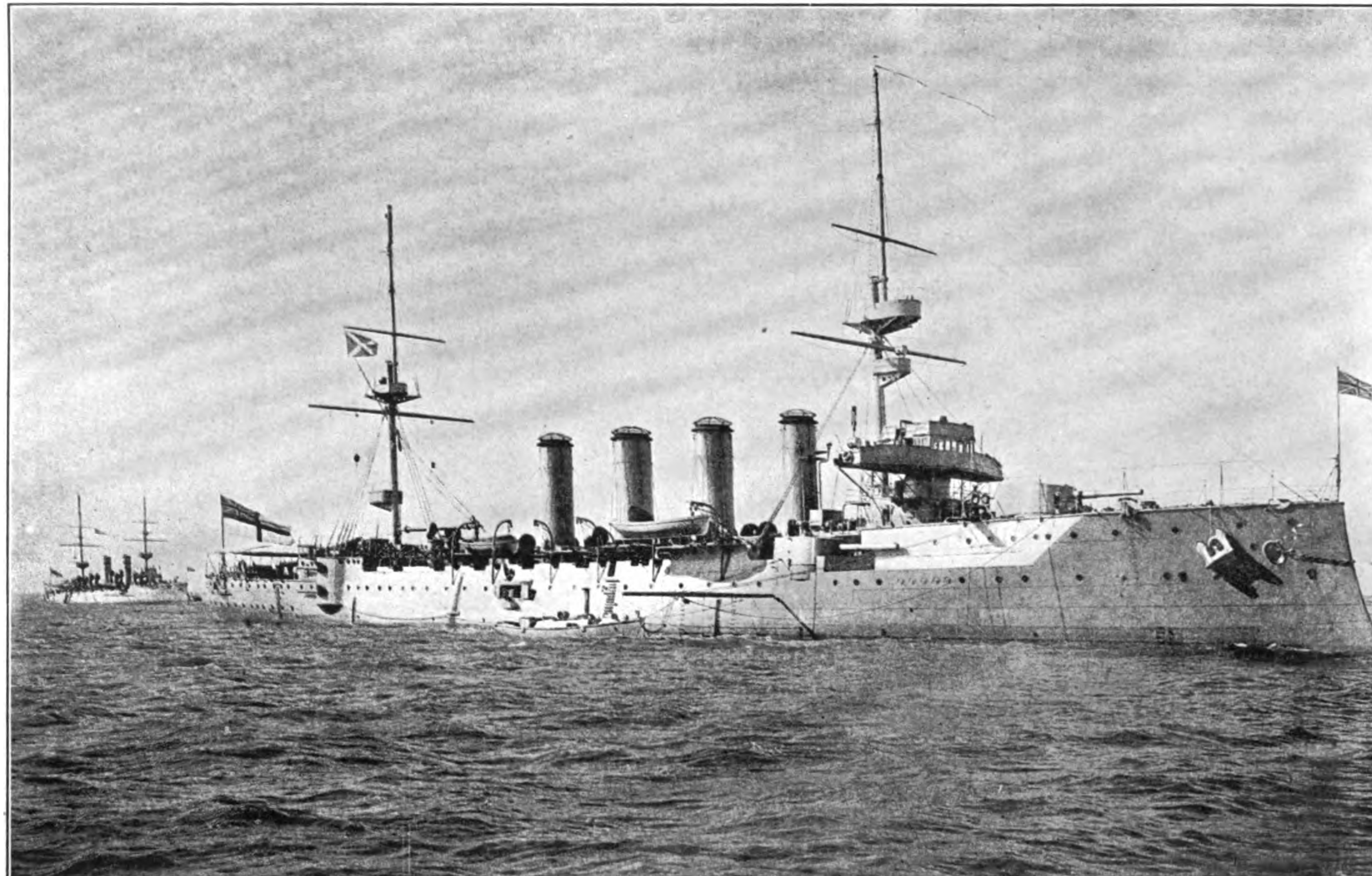
Both for accuracy and general excellence this convenient little book has attained an enviable position amonst the naval year books. Each edition appears in larger and improved form as regards contents, in the constant endeavor to make the book of greater usefulness. In the present case the fleet lists have been rearranged, and more space is given to the details of individual ships. The data include the latest information available up to December 1, 1905. The illustrations have been increased by nine plans and 67 photographs of ships, while a few of the older ones have been omitted. A good picture of the 240-ton German submarine boat, built at the Germania Works, forms the frontispiece. We note also the Lake boat Protector, now under the Russian name Ossjetr. Incidentally, we wish, however, that our New Jersey and Iowa were not labeled "New Yersey" and "Jowa."

The lists and illustrations naturally form the main part of the book; they are well arranged for ready reference, and contain in condensed form an immense amount of information.

Part II. gives comparative statements of the principal navies, fleet organization of the leading powers, naval estimates, budgets, etc. Of particular interest here are the details of the German naval development in recent years, what is being done and what proposed.

Tables of naval artillery of the world, miscellaneous information on the German navy and shipbuilding industry, conversion tables, etc., constitute the remaining sections of the book.

For completeness, general accuracy and convenience of consultation, Lieutenant Weyer's book can be cordially recommended.



BRITISH ARMORED CRUISER "CARNARVON" 10,850 TONS; 21,489-I.H.P.; SPEED 23.3 KNOTS.

ARMOR PROTECTION:—Waterline belt, 6 inches Krupp, amidships, 2 inches bow and stern; barbettes, 6 inches N. S.; hoods, 5-inches N. S.; casemates, 6 inches. Deck, 2 inches.

Four 7.5-inch, three forward, one aft: six 6-inch: two 12-pdr.; twenty-two 3-pdr.; two Maxims. Two submerged torpedo tubes.

JOURNAL

OF THE

UNITED STATES ARTILLERY

*"La guerre est un métier pour les ignorans,
et une Science pour les habiles gens."*

VOL. 25 NO. 2 MARCH—APRIL, 1906 WHOLE NO. 78

THE NEW SIEGE MATERIAL*

BY CAPTAIN GEORGE W. BURR, ORDNANCE DEPARTMENT, U. S. A.

THE 4.7-inch siege gun and carriage, Model of 1904, recently completed and now undergoing test was designed to supplant the service 5-inch siege material. The latter was laid down about 15 years ago and while still most serviceable does not embody many features which artillerists now consider necessary or desirable.

Judging by present standards, the old material lacks power, stability under firing stresses, rapidity of fire, and ease of service. These combined with requisite mobility are the essentials of modern siege artillery and are the considerations which have governed in the design of the new material. The principles of construction by which these essentials are obtained are exemplified in the 3-inch field gun and gun-recoil carriage with which the field batteries of our service are equipped. That this type of construction is the only one which satisfies all the requisite conditions for field guns is now generally admitted. The great advantages to be derived from the practical application of similar principles to heavy gun and howitzer carriages for mobile artillery were early appreciated

*Specially prepared for the JOURNAL, and published with the permission of the Chief of Ordnance, U. S. A.

by the Ordnance Department and designs with that end in view were taken in hand. As the 4.7-inch gun and carriage is the first of these new designs to be manufactured and subjected to a firing test, a description of its salient features is of interest.

Briefly stated, this new material consists of a gun of 4.7-inch caliber, firing a 60-pound projectile with an initial velocity of 1700 f.s. and recoiling 66 inches upon the carriage which remains stationary under the firing stresses. The recoil of the gun upon the carriage is checked by a hydraulic buffer and the return movement is accomplished by springs. The movement of the carriage upon the ground is prevented by wheel brakes and by a trail end spade.

The gun is a built-up steel rifle, 135 inches long, weighs 1730 lbs., and consists of a tube, jacket, locking hoop, and front clip.

On the lower side of the piece and extending the entire length of jacket, locking hoop, and clip, are formed two recoil guide clips which engage under, and secure the piece to, the guide rails of the cradle. On either side of these guide clips, the jacket and locking hoop are provided with broad longitudinal bearings which rest on bearing rails on the cradle. These bearings are placed well up on either side of the gun and are therefore so far apart as to afford lateral steadiness to the gun in transportation as well as in action. A stout lug on the lower side of the jacket at its rear end provides a place for the attachment of the piston rod of the carriage.

The gun is fitted with a breechblock of interrupted-screw type, with 4 threaded and 4 planed sectors. When the breech is opened the block is supported by the usual form of carrier, hinged to the right side of the jacket. The breech is opened and closed by a single motion of the operating lever which is pivoted on the carrier immediately under the block. The operating lever has bevel gear teeth which mesh with corresponding ones on the rear face of the block.

The firing mechanism is of the continuous-pull type in which the firing pin is cocked and fired by a single pull of the lanyard or stroke of the firing lever. The latter is attached to a non-recoiling part of the carriage. The empty cartridge cases are automatically ejected when the breech is opened.

The firing pin is eccentrically located in the block and the breechblock recess in the gun is eccentric with reference to the main bore. When the breech is closed the firing pin lies in the axis of the piece opposite the percussion primer of the cartridge. As the block is rotated to open the breech, the pin is moved to one side clear of the primer and remains in that relative position until the block is rotated back in closing the breech. This device insures safety from a premature discharge due to the protruding point of a broken firing pin striking the cap as the block is swung to its seat in closing.

The mechanism is simple and consists of few parts, which may be assembled or dismounted without aid of tools. It is rapid, powerful, easily operated, and is provided with safety devices which positively prevent a discharge of the piece before the breech is safely closed.

The carriage consists of the wheels, axle, trail, spade, shield and wheel brakes, constituting the lower carriage; the cradle with recoil and counter-recoil arrangements forming the upper carriage, and the elevating and traversing apparatus intermediate between these two.*

The wheels are a modified form of the Archibald pattern, 60 inches in diameter, with 5-inch tire. Exhaustive tests, recently concluded, indicated that no practical advantage is gained by use of wider tires on vehicles of this class and weight.

The axle is hollow and is made of forged steel in one piece. The wheel is held on the axle spindle by a collar which fits in a circumferential groove in the axle. The exterior of this collar is furnished with interrupted lugs in the inner end of the nave box. The collar is fastened to the wheel and turns with it. The nave box is dust-proof and is oiled through a self-closing oil valve without removing the wheel—a time and labor-saving arrangement which will be appreciated by those who have had to remove the wheel in order to oil the axle of a heavy carriage.

The trail is 140 inches long and is the usual construction of two pressed steel flasks of channel section tied together by transoms and plates. The front ends of the flask plates are riveted to cast steel axle bearings bored out to take the axle to which they are keyed and securely clamped. These bearings extend to the front of the axle and support between them the socket for the pivot about which the superposed parts are traversed. The location of the pivot or pintle socket in front of the axle enables a shorter trail to be used and reduces the weight at end of trail which has to be lifted in limbering up.

*This carriage was designed by Captain Charles B. Wheeler, Ordnance Department, U. S. A.

A lunette plate is riveted to the lower side of the trail near its rear end.

The spade is built up of sheet steel and has a large bearing surface to prevent recoil of the carriage on the ground, and broad horizontal wings, or floats, to prevent excessive burying in the ground. It is of the folding type, being hinged on top of the trail at its rear end. For traveling, it is turned up and rests on top of the trail; for firing, it is turned down, and, in either position, is held in place by a heavy key bolt.

The cradle supports the gun, guides it in recoil, and forms a seat for the recoil and counter-recoil apparatus. It consists of three parallel steel cylinders fastened together at the front, middle and rear by forged steel bands. The middle band is provided with two horizontal trunnions upon which the cradle rests in trunnion beds in the pintle yoke. The rear end of the cradle is supported by and pinned to the upper end of the inner elevating screw. The force which moves the gun and cradle in elevation is therefore transmitted to the latter at this point and the parts turn in elevation about the axis of the cradle trunnions as a center.

The pintle yoke rests on the pintle socket at the front end of the trail (in front of axle) and is secured by circular clips in such a manner that it is free to turn about its vertical axis. A traversing bracket rigidly bolted to the lower end of this pintle yoke extends under the axle back between the flasks and forms a lever for the application of the traversing effort as well as a support for the traversing screw and the elevating mechanism.

The traversing screw is held in bearings on the traversing bracket so that it has no longitudinal motion with reference to the latter. The traversing nut is similarly mounted in the trail, being free to accommodate itself to changes in the alignment of the screw shaft but restrained from linear movement to right or left. Turning the traversing shaft screws it through the nut and moves the traversing bracket and parts connected with it,—that is, the pintle yoke, cradle and gun,—in azimuth about the vertical axis of the yoke. The amount of this azimuth motion is 8 degrees, or 4 degrees on each side of the center line of the carriage.

The rear portion of the traversing bracket is supported by two stout cross transoms on which it slides in azimuth and to the rear one of which it is clipped. The cross-head of the double screw elevating device rests on its trunnions in the portion of the traversing bracket between these two transoms.

As a result of this arrangement, the elevating mechanism moves with the traversing bracket when the cradle and gun are traversed. It is thus always directly under the weight which it supports and all cross strains are avoided. The down thrust of the elevating screws is taken by the cross transoms referred to.

Handwheels for manipulating the elevating and traversing mechanisms are conveniently placed on each side of the trail so that change of direction or elevation can be made by cannoneers on either side of the gun.

The middle tube of the cradle is the hydraulic cylinder for checking recoil; the two outer ones contain the counter-recoil springs. The bronze-lined steel rails, which support and guide the gun in recoil, are fastened to the cradle bands and to the tops of these spring cylinders. An extension piece, bolted to the front end of the cradle and readily detachable, continues the cradle guide rails to the front clip of the gun and during recoil insures the engagement of this gun clip and the cradle rails. For traveling, this extension piece is detached and carried in fastenings provided for it under the trail.

Each spring cylinder contains 3 concentric columns of helical springs formed of round wire. The front end of each column is connected to the rear end of the one within by a steel tube or stirrup which acts as a guide rod for the springs of the outer column. The rear end of the outside column abuts against a shoulder on the cradle. The front end of the inside column of springs abuts against a shoulder on the spring rod on which the springs are assembled. The rear ends of these spring rods (one for each spring cylinder of the cradle) are secured to a cross bar or yoke which rests against the rear face of the recoil lug on the gun.

This method of using concentric spring columns connected by stirrups so as to work tandem and to telescope when at rest, has the advantage of compactness and gives a very long spring stroke with short assembled length of column.

The springs are assembled under sufficient compression to return the piece to battery at the maximum elevation—15 degrees. The power for this initial compression is provided by a geared drum located on the trail of the carriage. The drum is detachable and is carried in the trail tool box when not in use. The drum gearing is fixed in the trail and is accessible through an opening in the trail cover plate closed by a hinged lid.

The hydraulic cylinder may be filled or emptied when assembled in the carriage or it may be quickly dismounted, if desired, for this and other purposes. Its interior arrangement is as follows :

Three throttling bars, of uniform width but varying height, formed on the walls of the cylinder, register with notches cut in the piston head and thus form ports for the passage of the liquid from one side of the piston head to the other. The height of the throttling bars along the cylinder determines the areas of these ports and is varied so as to give the required cylinder resistance to recoil of gun. This required cylinder resistance is such that, increased by the spring resistance, it will not cause the wheels to jump from the ground when the gun is fired at 0 degrees elevation.

The piston rod works through a stuffing-box in the rear end of the cylinder and is fastened to the recoil lug of the gun. The front end of the rod is bored out to form a recess for the counter-recoil buffer which is secured in the front end of the cylinder.

The gun, upon being fired, moves 66 inches to the rear upon the cradle, carrying with it the piston and the spring rods. This recoil is made against the resistance offered by the cylinder and by the counter-recoil springs. The latter then return the piece to battery ; the counter-recoil buffer, acting upon the oil caught in the bore of the piston rod, and forcing it through the very small clearances around the buffer, reduces the rapidity of this return movement and eases the piece into battery without shock.

The recoil cylinder, located in the cradle directly under the gun and guarded upon either side by the spring cylinders, is thoroughly protected from injury. It is simple, and compact, and has no moving parts to get out of order and no exposed working surfaces to catch dust and dirt. It has but one stuffing box which is readily accessible for adjustment or repacking.

The carriage is fitted with hardened steel shields, 0.2-inch thick, covering the space between the wheels to a height of 68 inches from the ground. The bullet-proof quality of each plate is demonstrated by actual test before the plate is accepted. The main shield plates are rigidly attached to axle brackets and braced from the trail. The top and apron shields are hinged to the main shield ; the former is folded down and the latter is swung under the axle for traveling.

The wheel brakes are of the lever type with shoes in front of the wheels (carriage limbered). The brake beams, which carry the shoes, are hinged to the flasks and are utilized as supports for seats for the cannoneers serving the piece. The brake lever is double with one arm in front and one in rear of the shield,—the former for use from the ground in traveling, the latter for use in action; the brakes are firing as well as road brakes, and are quite useful in preventing forward movement of carriage upon counter recoil of the gun.

The arrangements for aiming the piece comprise open sights, a panoramic sight, and a range quadrant. These devices are similar to those used with the service 3-inch field material. They are supported by brackets attached to the cradle, the open sights with the panoramic sight on the left side, and the range quadrant on the right side of the piece.

The open sights have cross wires for a front and a peep for a rear sight. The shank of the rear sight is graduated in yards up to 7500, is fitted with a deflection scale for making allowance for wind, drift, etc., and with sensitive clinometer and transverse levels—the former for the quadrant elevations, the latter for correcting for difference of level of wheels.

The rear sight shank forms a standard or support for the panoramic sight. This is a telescopic sight, so fitted with reflectors and prisms that the observer, with his eye at an eyepiece fixed in position, may bring into the field of view any object upon the horizon, the image of the object appearing magnified but otherwise as if viewed directly by the unaided eye. The power of the instrument is 4, the field of view 10 degrees. It is particularly valuable in indirect aiming and also in direct aiming where the unaided vision is indistinct. A detailed description of this instrument is given in the November-December, 1903, number of the JOURNAL.

The range quadrant is provided with a transverse level for correcting for difference in level of wheels, an angle of site or quadrant level, so mounted as to correct the readings of the instrument for the angle of site of the target, and a range dial upon which the range is set off directly in yards. It is used in conjunction with the panoramic sight in indirect laying. When not in use, all of these instruments are removed from their supports and carried in padded receptacles provided for them.

For traveling, the gun is disconnected from the piston and spring rods and shoved back 40 inches upon the cradle; in this position the recoil lug is secured between two stout braces attached to a heavy trail transom. The breech of the gun is thus so supported and rigidly held in traveling that the elevating and traversing mechanisms are relieved of all strains. The braces referred to are pivoted in the trail and when not in use are turned down inside the trail,

The weight of the carriage complete is 4440 lbs., and that of the gun and carriage, 7170 pounds. The weight at the end of the trail, gun in firing position, or the weight to be lifted in limbering up, is 400 lbs. ; with the gun in traveling position, this is increased to 1150 lbs., which is the portion of the carriage weight sustained by the limber.

The latter is merely a wheeled turntable for the support of the end of the trail in traveling and has the usual arrangements for the attachment of the team. Its wheels are interchangeable with those of the carriage. The seat upon the limber for the end of trail is shaped to fit the latter and turns with it, being pivoted at one end and fitted at the other with rollers which travel in a circular path on the limber. A stud or pintle on this seat engages in the lunette on the lower side of the trail near its rear end. The weight of the gun, carriage, and limber, complete, is 8000 pounds, a figure generally accepted as suitable for an eight-horse siege team.

The ammunition used with this material has the powder charge in a metallic case combined with the projectile into a single cartridge. The case weighs 7.75 pounds, the projectile 60 pounds, and the complete round 73.75 pounds. High explosive shell and shrapnel are used.

The elevating mechanism provides for elevations from —5° to +15°; greater elevation may be obtained by sinking the end of the trail in the ground. The range corresponding to an elevation of 15° is about 7600 yards and the remaining velocity at that range 850 f.s.; since the bursting charge of the shrapnel gives its bullets an additional velocity of about 250 f.s., the shrapnel fire at extreme ranges is most effective.

No platform is required for the carriage, and consequently the transportation heretofore used for platforms can be dispensed with or devoted to other purposes. The ease and rapidity with which the carriage can be unlimbered and made ready for firing, or the reverse, is especially notable. Other prominent features of this material, not emphasized in the foregoing pages, are the great range and power of the gun, great weight of projectile when caliber is considered, rapidity of fire

Carriage Ready for Action.

Carriage Ready for Traveling.

and ease of service resulting from quickly loaded ammunition, improved sights and traversing arrangements, and stability of the carriage.

The photographic views show the carriage ready for action and the carriage and gun in traveling position.

A SCHEME FOR TESTING THE EFFICIENCY OF ELECTRICAL POWER PLANTS AND FOR KEEPING THE NECESSARY RECORDS

By Captain WILMOT E. ELLIS, Artillery Corps

THE scheme outlined herein, with some modifications suggested by experience, is one that has been in operation in the Artillery District of Portland since December 5, 1905, being embodied in General Orders No. 42, 1905, of that District. This order was prepared under authority from Headquarters Atlantic Division dated November 8, 1905, and was suggested by an order on the subject of the detection of "grounds" issued from Headquarters Artillery District of New London (G. O. No. 15, November 1, 1905.)

The necessity for a systematic scheme of tests and records is so apparent as to require scarcely any comment. The record will always speak for itself, for besides being a constant reminder to the subordinate of the necessity for keeping a watchful eye upon his work, it facilitates proper and thorough inspection by superiors. As might have been expected, experience has shown that essential data should be recorded, for good results will not be obtained when the engineer in charge of the plant is required to record superfluous data and to make inspections so frequent and extensive as to lead to perfunctoriness or to dissatisfaction.

It is thought that perhaps the best exposition of the subject matter of this article can be made by quoting the body of General Order No. 42, Artillery District of Portland, in the the form that is proposed for adoption after an experience of two months.

"3. The reports called for herein will include all plants whether operated by the Artillery, the Engineer Department or the Quartermaster's Department; *provided*, that the plant furnishes power or lights to any emplacement turned over to the artillery, or power for operating a searchlight. The same rule will apply when power is furnished from city mains.

Subject to the above provisions the test prescribed will be made for all circuits, as post lighting, operating of motors, of searchlights, distribution of power to batteries, or mining casemates.

"4. Whenever any test develops a leak in a circuit, further testing will be made with a view to locating the fault. As soon as the fault has been located, it will be remedied at once if the means at hand permit, and if no change in installation is necessary. If the fault is corrected, the fact will be noted on the 'Supplementary Monthly Report.' In case this cannot be done, a report setting forth all pertinent circumstances will be made to these headquarters at once.

"5. Monthly reports will be forwarded to District Headquarters on the first day of each calendar month. Post Commanders will satisfy themselves that testing operations are inaugurated in time to permit the rendition of reports at the times prescribed.

"6. With the first report, the following data will be submitted for each power plant:

(a) Location.

(b) Number, type and power of each generator.

(c) Source of power for each generator.

(d) Number of storage batteries, type, number of cells, in each battery, and the usual method of charging

(e) Designation of each circuit leading from power house.

(f) Designation and location of each manhole in use.

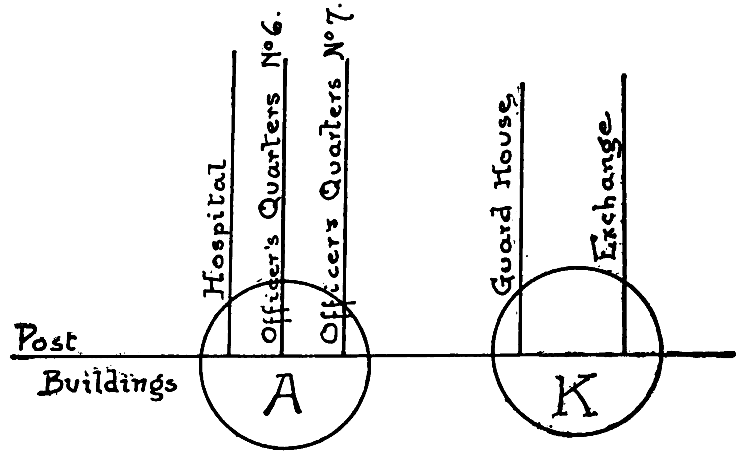
(g) A simple diagrammatic sketch showing the subdivisions or branches of each main circuit to include the switchboard installed in each building, emplacement, or station. (See sketch)."

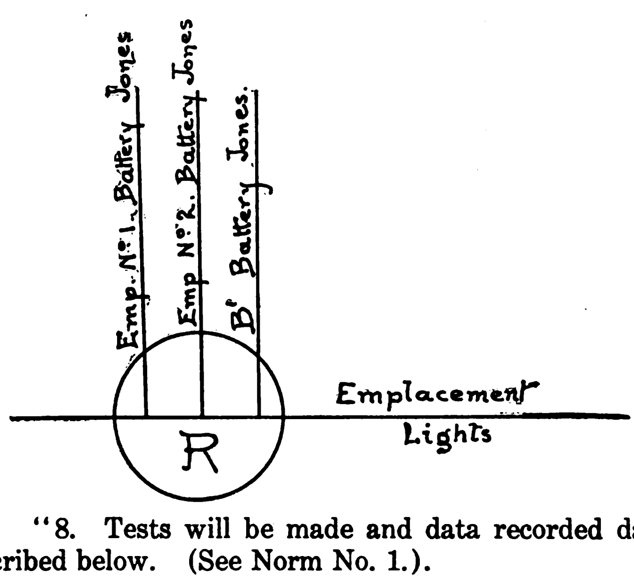
While the information called for in (6) will generally be on file at District headquarters the object of this paragraph is to secure essential data in condensed form for file with the corresponding post reports.

(By this method a leak may be designated by reference to the diagram mentioning terminals of circuits involved as:

Post buildings Powerhouse—manhole A, or
" " Manhole A—Hospital, or
" " Hospital switchboard—Ward No. 1, and so on if necessary down to the individual light causing the trouble).

"7. All switches wherever installed will be properly labelled so as to accord with their actual use. If stamped metal plates are not available, suitable labels will be made for the purpose. Switches not in use will be labelled 'Blank'.





"8. Tests will be made and data recorded daily as prescribed below. (See Norm No. 1.).

NOTES ON FORM NO. 1

Column No. 1. Enter the exact hour at which the first data are taken, or the first test made, then enter successively whole hours, interpolating an intermediate time when necessary.

Column No. 2. The Day Test for Grounds should be made with all feeder switches on main switchboard closed and when the maximum load is on as near as may be judged; in the outdoor season of artillery drill—preferably at the time when the batteries are manned.

Whenever a ground is detected, its exact location must be noted and the reading of the voltmeter across bus-bars, + to E, and — to E given. If the columns provided do not give sufficient space enter notes and data under 'General Remarks'.

Column No. 3. Same remarks as for column No. 2, except as to time of test.

The night test should be made between dark and the hour prescribed by the Commanding Officer for lights out in barracks, and always at night drill. When power for post lighting is not finished, the day test will be sufficient.

Column No. 4. Data should be taken under varying conditions and at least three times daily at considerable intervals apart.

Column No. 5. The first entry should be made opposite the hour of starting and the last at stopping engine, interpolating times if necessary, data being taken also at intermediate whole hours. Obvious modifications may be made in case an oil engine is used, or more than one generator is run at a time.

"9. The accompanying Form 2 (Electric Storage Battery Co., Form 465*) will be used in connection with weekly inspections of all storage batteries, and the directions will be strictly followed.

The inspection of cells should in no case be hurried or perfunctory. The best plan in general will be to inspect about a quarter of the number of cells each week, all of the cells being thoroughly inspected during the course of each month.

A copy of Form 2 for the last week of each month will be forwarded to District Headquarters with the other reports called for in this order. On the forwarded report under 'Remarks' will be noted the number of cells inspected each week, cells by number given especial attention during the month, stating attention given, and such other remarks as are pertinent to the history of the battery for the month.

When a cell is reported 'inspected,' it is understood to

* The Electric Storage Battery Co., under date of November, 1905, has issued "General Instructions for the Operation and Care of the Chloride Accumulator," which contain in concise form the most up-to-date information on this subject. Some decidedly new ideas are advanced, and the pamphlet is an admirable treatise in every respect. Form 465 is an addendum to this pamphlet.

mean that the cell has been carefully inspected with a portable lamp (a cell lamp if practicable) and that:

(a) Nothing unusual in the color of the plates has been noted.

(b) No short circuits exist.

(c) That the sediment does not come within half an inch of the bottom of the plates.

(d) That the electrolyte is about ¾ of an inch above the top of the plates.

(e) That if the cell reads low in S. G., or V., or does not gas freely on overcharge that the cause has been determined and removed.

When any of the above troubles are noted and not remedied at the time of submission of report, a suitable entry should be made under 'Remarks.'

End cells will be indicated by an asterisk over corresponding numbers.

"10. The monthly test of each independent power system will be made between the 20th and 27th of each month, notification being sent to the District Artillery Engineer the day before the test is to be made. For this purpose the plant will be operated for at least half an hour under conditions of maximum load, subject to conditions hereinafter prescribed. All illuminating and searchlights in the system will be turned on, all storage batteries charged, and motors of all kinds operated under full loads.

(a) In case any of the usual loads cannot be thrown on by reason of material being out of commission, the load will be simulated by inserting a rheostat resistance in the corresponding circuit, connections being made at the ends of the leads most remote from the power plant.

(b) A plant must be operated under conditions contemplated by the method of installation. In case of duplicate generators, but one will be operated at a time, alternating monthly. In case of a triplicate installation, two of the generators may be operated simultaneously. If this is done the generators will be coupled in pairs on successive months in the following order: 1-2, 1-3, 2-3. In a quadruplicate plant, generators will ordinarily be worked in pairs. If, however, the conditions are such as to require the simultaneous use of three generators they will be linked on successive months as follows: 1-2-3, 1-2-4, 1-3-4, 2-3-4.

(c) When a power system operated as prescribed (b) cannot carry the maximum load at one time, switches at the power house will be successively opened so as to cut out the necessary circuits in the following order:

Storage batteries outside of main power plant.
Lights for officers' quarters.
Lights for public buildings.
Street lights.
Storage batteries at main plant.
Motors for electric hoists.
Emplacement lights.
Searchlights.

(d) Firing of boilers will be so conducted as to attain the necessary steam pressure at the time set for the test. The prescribed readings will first be taken with no load, each load being then thrown on successively, noting readings. After the full load is on note the time, and record readings in the *same* order successively until ten have been taken, or as many as may be taken in the half-hour's run.

(e) When it is necessary to exclude one or more circuits under conditions prescribed above, they will be thrown on at the beginning of the test, and as soon as readings have been taken, they will be opened again, noting the fact in the column of remarks. (See Form No. 3.)

"11. The Supplementary Monthly Report will be submitted on Form No. 4.

"12. The semi-annual tests of each independent power plant will be made in the months of March and September, respectively, in ample time to forward on the last day of the month to District Headquarters the reports prescribed by paragraph V., G. O. No. 128, c. s., W. D. No form is laid down for these tests, but a complete record of the operations necessary to determine data for the prescribed form will be recorded in the Power Plant Journal, and one copy of this record will be forwarded to District Headquarters with the reports of Engineer Property, Stores and Installation.

(The information called for by these reports and requiring *special* apparatus embraces:

BOILERS.

Amount of coal consumed per H. P., pounds.
Quality of steam.

STEAM ENGINES.

Indicator cards at full, medium, and no load.
Efficiency, medium load, and no load.

DYNAMOS AND MOTORS.

Efficiency.

MISCELLANEOUS

"13. (a) The records called for herein will invariably be made out on the day that the respective tests are actually made. Pending the possible issue of suitable test books, the records prescribed will be kept in blank books, or on forms furnished from these Headquarters, Forms 1 and 2 to be filed separately and for monthly periods, Form 3 and 4 together and for annual periods.

(b) In addition to the above, there will be kept in each independent power plant a book entitled, 'The Fort.................... Power Plant Journal'. The engineer will enter daily in the book a record of all work done during the day; engines, boilers, generators, flues, etc., cleaned or repaired; hours of labor; names of helpers, inspections, accidents; and in general every fact of interest pretaining to his duties as engineer in charge of the plant. Each entry will be signed by the engineer.

* * * * *

(f) The resistance of each portable voltmeter will be accurately determined and the amount furnished this office. When this instrument is used in testing the fact will be noted in each case, and the number of voltmeter given.

(g) When Bristol recording ammeters are provided for storage batteries the record cards will be systematically filed for the month to which they pertain.

(h) A copy of 'The Handbook for the use of Electricians' and such instructions as may be issued by the makers of the several machine and appurtenances used in each power plant will be kept on hand and will be strictly followed in so far as they are applicable to the proper care and maintenance of efficiency of the power plant.

(i) It should be remembered that in each case of a ground, the leak should be definitely traced by a series of eliminative tests to the particular part of the circuit where the trouble exists. In this connection attention is invited to the following extract from a General Order recently received on the subject of 'grounds' from the Headquarters Artillery District of New London, (G.O. No. 15, November 1, 1905):—

'The limits of testing by the Artillery personnel in the case of a subterranean system will have been reached when tests have been made after opening branch circuits at junctions of branch feeders and local switchboards respectively. If a leak still persists after testing as above, the permanent joints connecting the various branch feeders to the main feeders at manholes will have to be investigated.

'The lead-covered cables ordinarily used are connected by soldered wiped joints for which expert work is required. The claim made that these joints are as durable and as waterproof as the cable itself seems to be justified by facts, for in no case have any of the 'grounds' investigated in this District been traced to a defective permanent joint. For methods of testing, see Signal Corps Manual No. 3, p. 169 et seq ; for splicing lead-covered cables, p. 127 et seq.

'Attention is called to the fact that the leakage indicated by the voltmeter, means the greatest leak on the line, and the leak on any part of the line cannot be ascertained by any process of subtraction. Thus, if the leak on a line leading to any lighting system is found to be 60 volts, and after the lighting system has been connected, the leak is still 60 volts, this does not prove that there is no leak in the lighting system; but simply that the leak, if any exists, does not exceed 60 volts. Should the voltage rise to 80 volts, it shows that the leakage on the lights is 80 volts. Should the voltage drop to say 50 volts when the lights are connected, it indicates a leak on the opposite side of the circuit in the lighting system.

'In a case of this kind the leakage on the lighting system may sometimes be determined within limits, as follows:

'Open the circuit on the lead at the lighting system. Ground the negative wire at the switchboard, and if the leak is found, say of 60 volts, it is manifest that a leak is on the positive side of the lead of 60 volts. Now ground the positive side and assume that a leakage is found on the negative side, say 5 volts. Then connect the positive side of the leak to the lighting system, and ground the negative, leaving the negative lead disconnected from the lighting system ; if a ground of 60 volts is still found, the leak in the lighting system does not exceed 60 volts. Then disconnect the positive lead and connect the negative, grounding on the positive side ; if the leak is still but 5 volts, the leakage on the system is less than 5 volts ; if the leak exceeds 5 volts, say reads 30 volts, then the leak on the lighting system is 30 volts.' "

FORM NO. 1.

Daily Test and Record of Electric Power Plant. Fort ____________ 190___

1	2					3					4	5							
	DAY TEST FOR GROUNDS.					NIGHT TESTS FOR GROUNDS.						ENGINE RUN.							
															Generator Readings.		Storage Battery. Pilot cell Readings.		
A. M. or P. M	Volts.	+ to E.	— to E	GROUNDS DETERMINED.	REMARKS.	Volts	+ to E.	— to E.	GROUNDS DETERMINED	REMARKS.	V. of Storage Battery on Discharge	Engine No.	Boiler No.	Steam Pressure	Volts.	Amperes.	Number of Cell	S. G	Remarks.

General Remarks:

Taken and signed by

FORM NO. 8.

[illegible] BATTERY WEEKLY INSPECTION REPORT

FORM NO. 3.

Monthly Test. Fort________________190 ________________Power Plant.

Generators Nos............................ Boilers Nos.................. First Readings no load...........M First Readings full load...........M

Last Readings full load...........M. Kind of coal...Lbs. coal used. Feeder circuits open during full load test...........

Load.	Description of of Load	Steam Pressure.	Amperes.	V Bus-bars.	V + to E	V —to E.	Remarks.
None......................							
Load 1							
Load 2							
Load 3							
Load 4							
Load 5							
Load 6							
Full Load 1							
Full Load 2..........							
Full Load 3..........							
Full Load 4..........							
Full Load 5..........							
Full Load 6..........							
Full Load 7..........							
Full Load 8..........							
Full Load 9..........							
Full Load 10.........							

(Action of Commanding Officer and date).

Respectfully submitted,

...., Artillery Corps, Commanding.

....Lieutenant, Artillery Corps, in charge.

FORM. NO 6

Supplementary Monthly Report. Fort ______________ 190__

Ground Detected during Month of	Date	Action taken and Date.	Particulars as to each Ground Detected (Method employed, readings taken, how remedied).

(Action of the Commanding Officer and Date).

Respectfully submitted,

..............................Artillery Corps, Commanding. ....Artillery Corps, Artillery Engineer.

APPARATUS FOR ELECTRIC SIGNALING AND FIRING FOR MORTAR BATTERIES

By Captain WILLIAM C. DAVIS, Artillery Corps

UNDER the new Provisional Drill Regulations, whenever the mortars of a pit have been loaded and laid, and the pit is clear of men, it is necessary to convey this intelligence, by some signal, to the battery commander's station; likewise, when the moment for firing has arrived, the battery commander must signal that fact to the pit, inasmuch as it is now prescribed (very properly) that all firing shall be done at the pit.

Formerly the telephone was relied upon, as a rule, for the transmission of these messages, but the increased rapidity of plotting makes it desirable that the use of the telephone be restricted to the transmission of ballistic data only.

REQUISITES FOR SIGNALING APPARATUS

The following may be considered to be the important requisites for this signaling service: (1) Reliability and certainty of action; (2) Ability to correct instantly any erroneous signal, and to distinguish between signals from (or to) different pits; (3) Facility in testing signal circuits, and in locating and correcting faults in same; (4) Economy in installation and renewals.

We will briefly consider the above requisites in connection with the vibrating call bell, battery and push button which have been provisionally adopted for this service.

As regards (1), it must be said of the vibrating call bell that it is one of the most unreliable of electrical devices in common use. Its faults, briefly, are: Contact points gather moisture and oxidize; parts work loose and get out of adjustment; considerable current is necessary to operate it, involving a relatively large battery and frequent renewals; if a push button stick, or the lines become short-circuited, the entire battery may be wasted between drills. Moreover, the person who presses the button at one end of the line can never be sure that the bell, at the other end, has responded.

Bells which have been tested and found to function properly immediately before target practice have in some cases been shaken out of adjustment by the first discharge and thereafter failed to work when most needed. As indicative of the unreliability of vibrating bells it is significant that all telephone manufacturers have been compelled to substitute therefor the much more expensive magneto call box except for very short lines where insulation and other conditions are exceptionally good.

Condition (2) is not fulfilled by the vibrating bell at all. If a person accidentally should brush against a push button he may transmit a false signal, which he has no means of correcting except by use of the telephone or other outside means of communication. Furthermore, it is difficult, especially in the B. C. station, to distinguish which pit has signaled (or been signaled); a bell signal is but momentary, whereas a visual signal, by lamp, indicator, or semaphore, once made, can remain in place until answered or obeyed. Finally, all unnecessary noise should be avoided.

The third condition is also unfulfilled; the bell may fail to respond when the button is pushed, but in itself it affords no assistance in locating the fault, which may arise from a short circuit, an open circuit, a lack of battery power, a bad contact, or a poor adjustment.

The fourth condition—that of cheapness—appears on the surface to be satisfied, for a vibrating bell and push button outfit can be purchased cheap; but when the expense of battery renewals is considered, together with the value of the labor required to keep the apparatus serviceable and efficient, the outfit may after all prove expensive.

REQUISITES FOR ELECTRIC FIRING APPARATUS

There are at least five conditions which electric firing apparatus for mortars should satisfy. These in order of importance are: (1) Safety; (2) Certainty of action; (3) Convenience in manipulation; (4) Facility for testing and repairs; (5) Economy in installation.

(1) *Safety* demands, (a) that the mortar cannot, under any circumstances, be fired electrically until the breech is closed and the mortar has an elevation sufficient for the projectile to clear the parapet (say 40 degrees). It is understood that this

has been accomplished by devices which the Ordnance Department is about to attach to all mortars.

(b) Inasmuch as the single-wire primer completes the electric circuit through the breechblock (thus causing one side of the firing lead wires always to be grounded), it is essential that *the firing switch should break both poles of the firing battery* or other source of electricity. That this has not been properly appreciated is evident from the fact that nearly every device for mortar firing which I have seen has made use of a single-pole firing key. A glance at the annexed sketch will make this matter clearer. In the diagrams of Plate A, marked I, II, III, & IV, respectively, B represents the firing battery, K the firing key, P the primer, M the mortar (grounded at G), and L a leak to the ground (G′) on one of the firing leads.

In Fig. I., it is seen that some current will flow from the upper pole of the battery through L, G′, G, to the lower pole without the key K being closed. The amount of this leakage will depend, other things being fixed, upon the resistance of the ground, G′. As none of this current passes through the primer, the leak is not a source of danger, but would cause a waste of power, and a probable misfire if the ground G′ be very "bad", *i.e.* of very low resistance.

In II., however, *as soon as the primer is inserted*, some current will immediately flow from the upper pole of the battery through P, G, G′, L, to the lower pole, and, if the resistance of G′ be sufficiently low, a premature explosion will immediately follow. (If a safety device has been placed on the trunnions, the explosion will occur as soon as the mortar has been sufficiently elevated to close the circuit.)

In III. and IV., the firing key, K, has two poles, making and breaking both sides of the battery simultaneously. In III. there is no escape of current due to L, as the circuit is still broken at the lower contact point of K. Similarly in IV. there is no escape through L, since the circuit is broken at the upper contact of K. Should it happen that both leading wires in III. or IV. be simultaneously grounded, there would still be no circuit through the primer (until the key is depressed), and the worst that could result would be a loss of current and a possible misfire in case the grounds were of sufficiently low resistance.

Since switchboard connections may be reversed, and grounds are likely to occur in any line however well constructed, it follows, on the one hand, *that it is exceedingly dangerous to rely upon a single-pole firing key in electric firing;* while on the other hand, *a key that positively breaks both sides of the firing battery is absolutely safe from premature firing of the kind above discussed.*

(c) Safety further demands that one man, and one only, be charged with the duty and responsibility of firing. That duty, by drill regulations, now devolves upon the gun commander; he should wear on his person the firing key, so that in his absence the firing of the pit by any one else, either through accident or design, is impossible. Furthermore the design of the key should be such as to prevent the gun commander himself from accidentally closing the circuit ahead of time.

It is sometimes urged that safety in electric firing can be increased by having several switches all of which must be closed to complete the firing circuit. This reasoning, while plausible, is entirely wrong; either one (or more) switches may be overlooked and left open at the moment of firing resulting in the loss of a pit salvo, or else the operator, thinking some other switch open, may close the firing switch at the wrong time, and with fatal results. One double-pole switch will break the firing circuit as effectively as fifty, and can be looked after with far greater assurance of proper manipulation.

(d) Still another safeguard requires that the person who fires the pit should be able to see, the instant before firing, that the pit is clear of cannoneers. This means that the firing must be done at the pit, as now required, and that the firing panel be placed so as to afford the operator a good view of the interior of the pit.

(2) *Certainty of action.* To insure this, the leading wires should be in good condition, free from serious grounds; all contact points should be kept clean and bright (the number of contacts and joints should be as few as practicable); and a battery, or other source of power, of sufficiently high voltage and low internal resistance to yield the necessary firing current (about $\frac{3}{4}$ ampere per primer) must be employed. While under favorable conditions a few dry cells in series will set off a primer in a mortar, my experience has been that a much higher voltage is necessary *to insure ignition under ordinary service conditions.* For instance the oil and grease habitually used about the breech mechanism and in the primer seat, unless very carefully removed, will add many ohms to the resistance; the connection between the primer wire and the fork is not

always well made, while the residue of burnt powder which clings to the primer seat after a few rounds, increases the resistance still more. In investigating the cause of electrical misfires I have found the resistance of a mortar circuit to be in some cases as high as 50 ohms. Under these circumstances a high firing voltage is required in order to break down the resistance and insure ignition.

At a target practice at the Presidio a firing battery of 24 large dry cells, in series, having an e. m. f. of 35 volts, with an internal resistance of only 12 ohms, proved a failure for the reasons above given, although when tested shortly prior to the practice it gave satisfactory results. At subsequent practice, power was taken direct from the 110-volt mains, and there were no misfires except in one case of defective primer.

(3) *For convenience of manipulation,* all switches both for signaling and firing should be mounted on one panel, where they will be under the eye of the gun commander, who is charged with their use. The number of switches, as before stated, should be reduced to a minimum.

(4) *To facilitate testing and repairing,* all cable cores should be tagged and terminate in strong binding posts on suitable panels; the cables should be laid in conduits with convenient manholes; suitable testing instruments should be installed permanently as a part of the apparatus, or at least always kept on hand available for use.

(5) *Economy* should be the last consideration in a firing installation; the best devices, material, and workmanship will in the end undoubtedly prove the cheapest.

DESCRIPTION OF PROPOSED APPARATUS FOR ELECTRIC SIGNALING AND FIRING FOR MORTAR BATTERIES

The equipment described herein was devised with a view to satisfying, more or less completely, the conditions previously discussed, and has been in successful operation in a mortar battery at the Presidio during the past year. It has been used exclusively for electric signaling at all drills and target practice, and was also used for electric firing at all service practice until the issue by the Ordnance Department of instructions forbidding electric firing of mortars not provided with that department's safety devices.

A diagrammatic sketch, showing circuits, is given in Plate B. A vertical switchboard panel (in this case made of 2″ hard wood, thoroughly seasoned and painted with asphaltum varnish) is mounted in each mortar booth by the side of the windows, so that the operator faces towards and has a clear view of the entire pit. This panel carries a main switch, S, which should preferably be an overload switch adjusted to about 20 amperes, a pilot lamp, P, which illuminates the panel and indicates when the firing battery (or power mains) is on the board, a fuse block F, a double-pole double-throw switch, S′, for signaling and firing (represented diagrammatically only), four double-pole mortar switches, S^2, and and a low-reading switchboard voltmeter, B-v. There is also housed in the booth a testing and signaling battery, B, consisting of a few dry cells, and two 100-ohms resistance units, R and R′, connected direct to the battery terminals. In the B. C. station there is also a panel carrying two voltmeters, A-v and B-v, identical with the voltmeters at the respective pits; also in each circuit a galvanometer key, S^3, normally closed, but opening the circuit when pressed.

The *modus operandi* will now be apparent. Suppose pit "B" to be loaded, and clear, and ready for firing, and that the gun commander desires to send that intelligence to the B. C. station. The mortar switches 1, 2, 3, and 4, being closed on the panel, the gun commander inserts his key (to be described later) in the switch S′, and closes it to the right; current from the signal battery, B, now passes in series through the resistance units, R and R′ and the two voltmeters, B-v, thence dividing and completing the circuit through the mortar switches and their primers, in an evident manner. The needles of the two voltmeters, B-v, should now rise from zero to a point about midway on the scale, and remain there—thus signaling "pit clear" to the battery commander. Should for any reason it become necessary for a cannoneer to re-enter the pit after this signal and before firing, the gun commander immediately opens the signal switch, the needle falling to zero, and the battery commander will understand that, for some reason, the pit is not ready to fire, despite the first signal. The needles indicating "pit clear", the battery commander sends to the pit the preliminary signal for firing, or "ready", a few seconds in advance of the moment of firing, by pressing the galvanometer key S^3 in the B.C. station (thus opening and closing the voltmeter circuit) three or four times in quick succession, causing the voltmeter needles to swing back and forth over the scale; to signal "fire", he holds the galvanometer key down—both needles falling to zero and remaining there. The gun commander, on receiving this latter signal, fires the pit by simply reversing the switch S′ from the signal leads and closing it down on the firing poles. If the service switch, S, be closed, current will flow direct from the high voltage firing mains through the primers and fire the pit. A spring (diagrammatically indicated) automatically breaks the firing circuit as soon as the pressure on the switch is removed. The gun commander now withdraws his key thus opening both circuits and making it impossible for anyone else either to signal or to fire.

SIGNAL AND FIRING SWITCH

In place of the double-pole double-throw switch, S′, shown in Plate B, a special signal and firing switch has been designed, which is shown detail in Plates C and D. It consists essentially of a contact strip carrier, made of ebonite or other insulating material, see Pl. C, Fig. 2 and 3, which revolves about a spindle carried by a bushing set into the switch panel, Pl. D, Fig. 5 and 6. The top, or front surface, of the carrier carries two signal or testing contacts strips, TS, made of spring brass, which, when the carrier is turned to the proper position, complete the signal battery circuit through the corresponding contacts, T C, mounted on the rear face of the cover (Fig. 1). On the other side, or next to the switch panel, the carrier carries two other contact strips, FS, intended to complete the firing battery circuit through the contact points FC (Fig. 5). A spiral spring (Fig. 6) holds the carrier normally away from the switchboard, causing the contact surfaces of the strips, TS, to press against the metal segments inserted in the rear face of the cover (Fig. 1). The cover has a slotted key-way, S, with a corresponding recess in the front of the carrier (Fig. 2,) into which a key (Fig. 4) fits. This key is worn by the gun commander on his person, and serves to turn the carrier about its spindle. When the key is withdrawn from the switch, the key recess in the carrier lies opposite the slot in the cover; in this position of the carrier, its contact strips, both firing and signaling, are revolved 45 degrees from their corresponding contact points, consequently both signal and firing battery circuits are broken. When the pit is loaded and clear, the gun commander inserts his key and turns the carrier right-handed 45 degrees (until the key handle is horizontal) thus bringing the signal contact strips upon their corresponding contact points and completing the signal battery circuit through the voltmeters, as previously explained. When signaled from the B.C. station to "fire", the gun commander turns the carrier 90 degrees further to the right (until the handle is vertical), and then shoves the carrier bodily along its spindle towards the switch panel, compressing the spiral spring, and forcing the firing contact strips against their corresponding contact points, FC, (Fig. 5), thus closing the firing circuit. This longitudinal motion of the contact strip carrier is possible in this position only, in which the safety lug (Fig. 6) is opposite its slot in the switchboard bushing (S′ Fig .5). As soon as the pressure is relieved the spiral spring brings the carrier back against its cover, thus breaking the circuit. The gun commander then turns the carrier 45 degrees further to the right opening all circuits and withdraws his key, which is possible only when the key slot in the carrier comes opposite its corresponding slot in the cover.

To prevent oxidizing, all contact points are tipped with platinum. Connections with the switch are made by binding posts on the back of the panel.

This switch has been tested and found to operate very satisfactorily. It is believed that it renders accidental firing impossible, since it normally leaves *both sides* of the firing circuit open, can only be operated by the possessor of the key, and requires sucessive motions of rotation and translation in order to fire. Moreover the gun commander has normally one switch, and one only, to look after, and there can be no excuse on his part for failing to fire at the proper moment.

SPECIAL FEATURES IN REGARD TO THIS APPARATUS

Since the signal battery current runs through the primers, it is impossible for the gun commander to signal "pit clear" until the primer has been inserted and electrical connections of at least one mortar have been properly made; on the other hand it is impossible for the battery commander to signal "fire", unless the gun commander has previously signalled "pit clear" and the signal is still standing on the B.C. voltmeter.

As all signals are visual, and remain in place until ordered changed, there is no opportunity of mistaking the signal pertaining to one pit for that pertaining to the other. Moreover as the voltmeter in the pit must read the same as that in the B. C. station, both battery commander and gun commander can always tell whether a signal sent from one station has been registered at the other. The voltmeter, unlike a vibrating bell is not likely to get out of order, requires no adjustment, and is operated by a very minute current, about 0.002 ampere for the apparatus here described. While this current passes through the primers, there is absolute no danger of a premature explosion, since the resistance of each voltmeter, B-v, and of each resistance unit, R and R′, see Plate B, in itself provides a large factor of safety. A similar system has with perfect safety been used for years in connection with the torpedo service.

The system is admirably adapted for testing the circuits and locating any trouble or faults therein. Thus, immediately before drill or target practice the gun commander should enter the booth, insert his key, and close the signal switch S′, all other switches on the panel being open; the voltmeter needle should give no appreciable deflection; this is a test of the insulation of the switch panel and of the leads to the battery commander's station. Next he should close and open in succession mortar switches Nos. 1, 2, 3, and 4, and note the deflection, which should not exceed a few divisions in any case upon the voltmeter scale. This tests the insulation of the leads to the mortars. Next insert a primer in each mortar, elevating same, and close and open switches 1, 2, 3, and 4, again in succession; the voltmeter needle should now rise, in each case, to a fixed point about midway on the scale; this indicates that there is a good circuit to and through each mortar. These tests take but a few minutes to make and will show at once whether the electric firing apparatus is in serviceable order. If not serviceable, an electrician should be able to locate the fault immediately by means of the voltmeter on the switch panel. A graphic resistance chart, or resistance table, should be prepared and posted near the voltmeter.

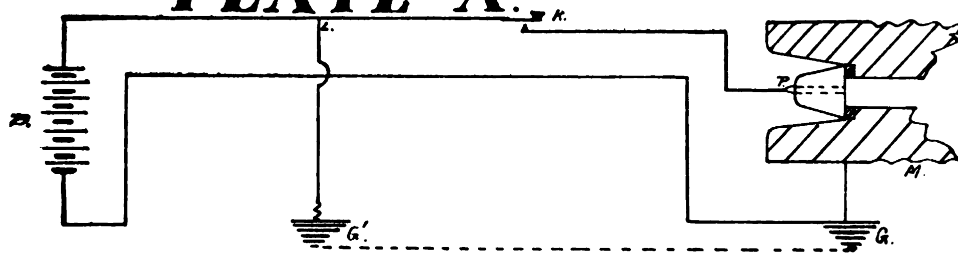
To test his primers, the gun commander need only close his signal switch, and then touch the primers across the mortar bus-bars on the switch panel—the shell on one bar, the wire on the other. In this way 100 primers can be tested in a few minutes.

If current for firing be taken from the electric light mains, or from a high voltage storage battery (as is most strongly recommended), there should be a resistance of about 10 ohms in each set of mortar lead wires to guard against a heavy rush of current due to a possible short circuit at a mortar, in the primer or elsewhere,. This is indicated in Plate B diagrammatically by the small resistance units, R^2.

It may be noted in passing that signals can be sent by this apparatus when drill primers are used as effectively as with service primers; electric firing should not, of course, be attempted with the drill primer. The attempt, however, with the apparatus here described would cause no harm beyond opening the overload (service) switch S, or blowing the fuses in the fuse box F.

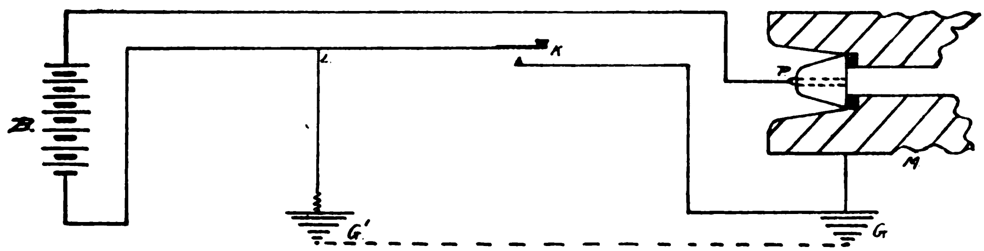
It is believed that this apparatus satisfactorily fulfils all the conditions hereinbefore discussed, and that if regularly installed in all our mortar batteries would give general satisfaction.

PLATE - A.



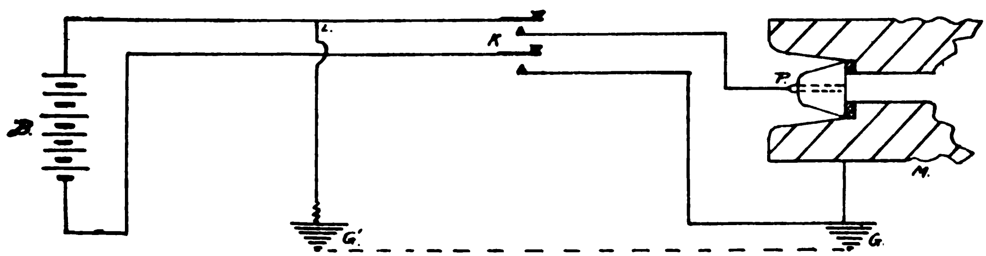
I.

SINGLE POLE SWITCH BETWEEN PRIMER AND FIRING BATTERY.
LINE BETWEEN SWITCH AND BATTERY GROUNDED.



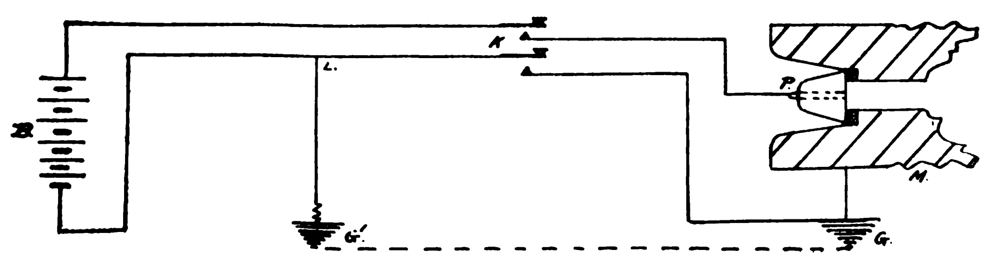
II.

SINGLE POLE SWITCH BETWEEN GROUND (OR MORTAR) AND FIRING BATTERY.
LINE BETWEEN SWITCH AND BATTERY GROUNDED.



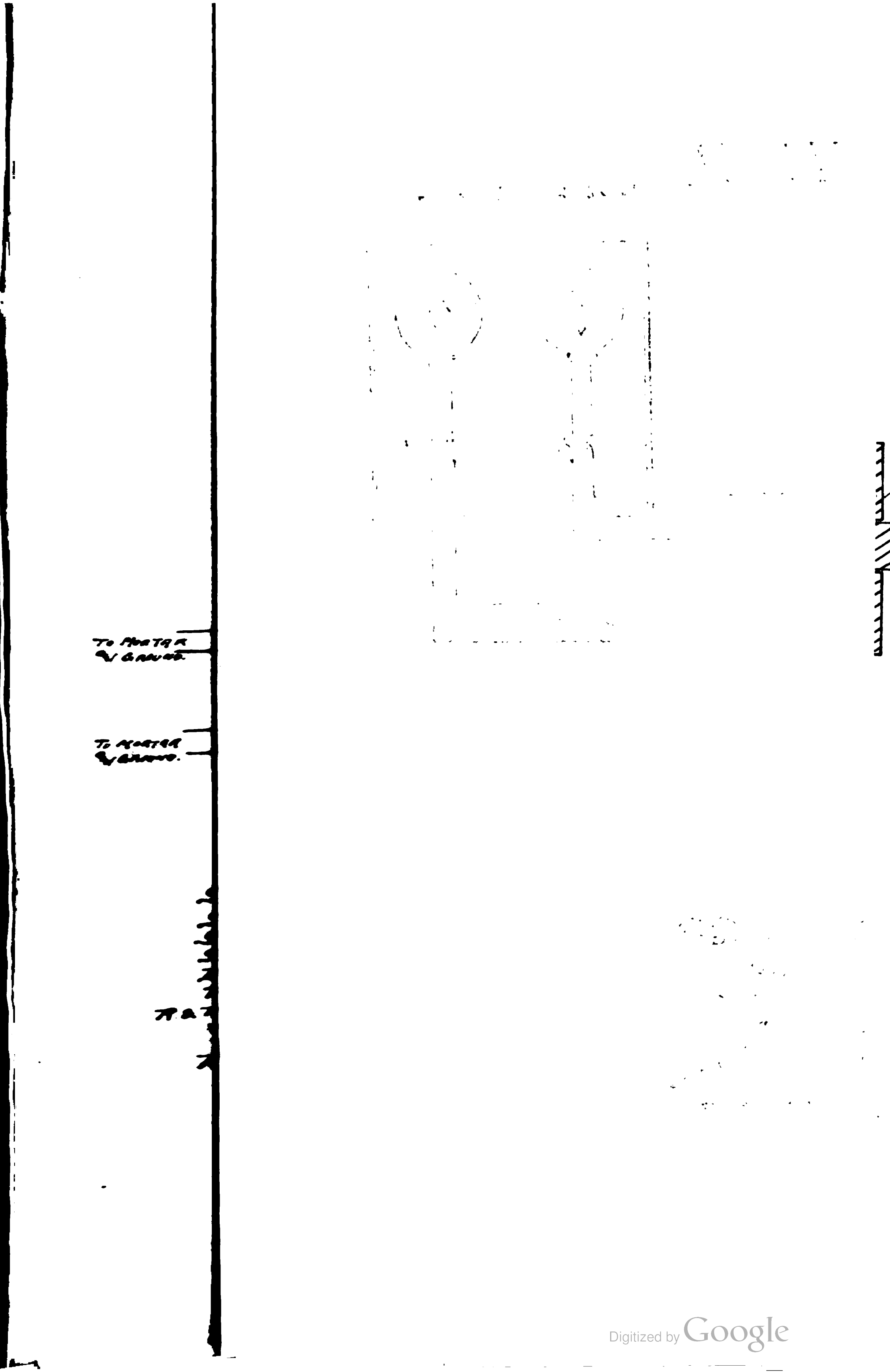
III.

DOUBLE POLE SWITCH BETWEEN PRIMER, GROUND, AND BATTERY,
LINE BETWEEN BATTERY, AND PRIMER GROUNDED.



IV.

DOUBLE POLE SWITCH BETWEEN PRIMER, GROUND, AND BATTERY,
LINE BETWEEN BATTERY AND GROUND (OR MORTAR) GROUNDED.



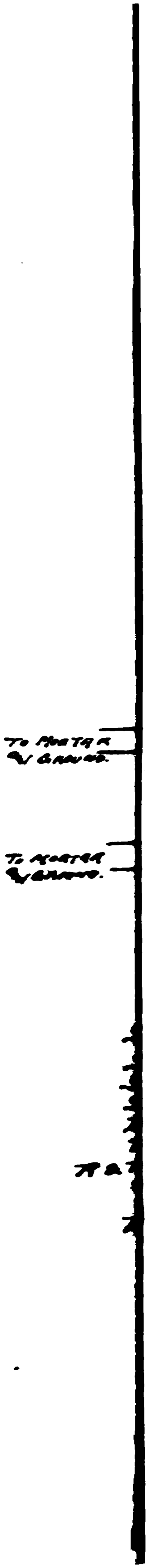


PLATE-C.

COVER. (EBONITE).

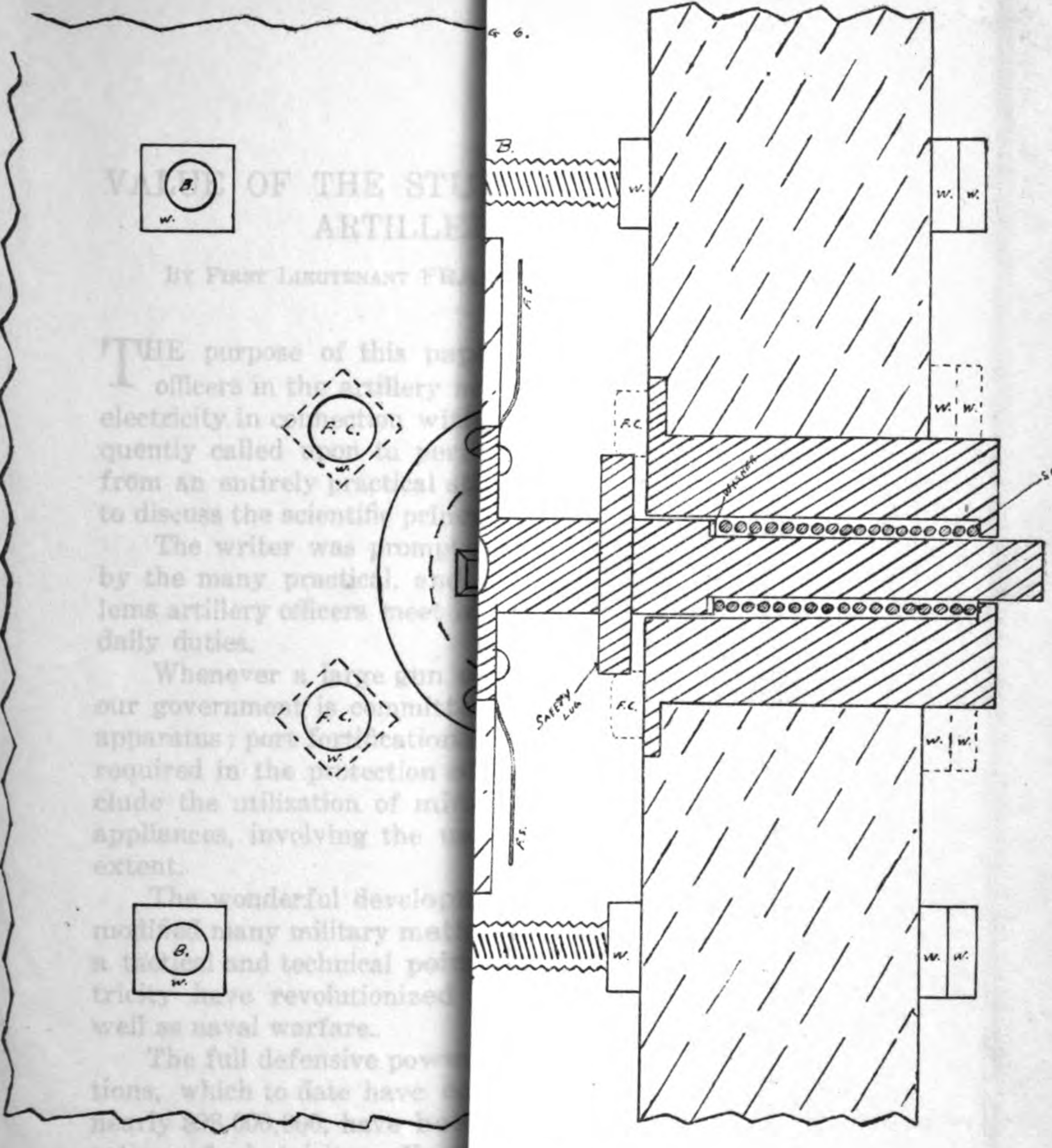
FRONT : SHOWN FULL

REAR : " DOTTED

CONTACT STRIP CARRIER. (EBONITE).

FRONT : SHOWN FULL.

REAR : " DOTTED.



LED SWITCH.

SECTION THROUGH THE LINE A.-B.

PLATE ring circuit contacts. T.S.-Testing W.-Nuts.

VALUE OF THE STUDY OF ELECTRICITY TO ARTILLERY OFFICERS

By First Lieutenant FRANK T. HINES, Artillery Corps

THE purpose of this paper is to invite the attention of officers in the artillery service to the value of the study of electricity in connection with the many duties we are now frequently called upon to perform. The subject is considered from an entirely practical standpoint, and no attempt is made to discuss the scientific principles involved.

The writer was prompted in the selection of this subject by the many practical, and sometimes very perplexing, problems artillery officers meet in the proper performance of their daily duties.

Whenever a large gun or a mine is to be used for defense our government is committed to the installation of electrical apparatus; port fortifications and other defenses, most urgently required in the protection of our vast coast line, nearly all include the utilization of mines, torpedoes, or other defensive appliances, involving the use of electricity to a less or great extent.

The wonderful development of electricity has materially modified many military methods of long standing. Both from a tactical and technical point of view steam, armor, and electricity have revolutionized the methods of coast defense as well as naval warfare.

The full defensive powers of our modern seacoast fortifications, which to date have cost the United States Government nearly $98,000,000, have been made possible only by the application of electricity. From the report of the Secretary of War, 1904, it is estimated that about $54,000,000 will be required to complete the fortifications of our proposed coast defense. Upon this assumption it is safe to say that the total cost will reach the round sum of $150,000,000. The electrical installation of this defense will cost approximately $5,000,000, or 3⅓ per cent. of the total amount. This amount is represented in our seacoast forts by electrical apparatus with the necessary accessories, such as boilers, engines, both steam and oil, dynamos, motors, storage batteries, telephones, searchlights and telautographs.

If we should do away with this equipment, or discard the electrical features of same, our modern armament, or rather the effective use of our large caliber guns, on which the safety of the coast of the United States depends in case of war, would be impaired to at least half of its value. Eliminate the electrical appliances, the range finders, telautographs, and other apparatus now utilized in fire control work and the efficiency of our coast defense will be depreciated nearly 75 per cent.

This may seem unduly to enlarge the value or importance of electricity, yet suppose in action the generators or engines failed to do the work or the storage battery fails to light the emplacements, or the telephones and telautographs fail to convey orders and ballistic data, what then becomes of our system of fire control or direction? In connection with this it may be assumed, in nine cases out of ten, that the failure of the foregoing apparatus to work properly is due to unskilled attendants or lack of careful care and preservation.

We cannot and should not expect an enlisted man receiving $13.00 per month, or even an electrician sergeant on his small salary of $40.00 per month, to give this equipment the care and attention required for its preservation and efficient operation without at least being properly instructed by officers over them, who in a measure are more adequately compensated.

To enable officers to give the necessary instructions, requires them first to prepare themselves properly for this work by a diligent and careful study of the subject of electricity and its many applications. Not only should all artillery officers be able to install and operate the instruments and equipment of of the modern fortifications, but they should also be familiar with so much of the theory of electricity as bears directly on their work. This does not seem to be a very unreasonable requirement when one considers that the enlisted men of the Signal Corps, electrician sergeants, and master electricians, must all possess this practical and theoretical knowledge, in a certain degree, in order to perform their daily duties efficiently.

The Chief of Artillery in his report for the year 1901 found it necessary to make the following recommendation :

"It is recommended that the employment of expert civilian electricians be continued, one for each Artillery District."

With the aid of our service schools at Forts Monroe and Totten, and the assistance of well qualified master electricians, it is hoped that in the future reports from the same source, it will not be found necessary to call upon the civilian electrician to assist the artillery in any other than work connected with the first installation. The chief reliance for the proper care and operation of our electrical installation must be obtained from the commissioned personnel of the artillery, assisted by properly instructed and qualified enlisted attendants.

The direct handling of this equipment must, of course, be intrusted to specially trained and efficient attendants selected by officers in charge of such work.

The personnel assigned to the work of operating the electric apparatus of our modern fortifications should be superior to that engaged in similar work in civil life, because the conditions under which this work is carried out are, from the nature of things, more exacting and difficult, and the result of failures much more disastrous.

Under the present system electrician sergeants are assigned to one or more posts in a district equipped with such apparatus, and the care of very expensive and elaborate electrical plants is intrusted to them. I feel justified in saying that with very few exceptions electrician sergeants who are graduated from the school at Fort Totten are as well qualified for their work as we should expect, and one hundred per cent. better qualified than any civilian electrician that could be induced to accept a similar position for the same emoluments. Yet these men cannot be expected to accomplish much without the assistance and support of those over them as well as under them.

It would seem that an electrical detachment at each post under charge of an electrician sergeant and under the direct supervision of the artillery engineer would be of great value in the proper care and operation of this expensive installation.

The remark of the Chief of Artillery in his last annual report that "it ought not, however, be forgotten that the best coast armament loses most of its value unless it is served by a carefully trained and skilled personnel," and that "the better the armament the greater is the relative loss of efficiency if it is not served by such a personnel," applies most forcibly to the personnel connected with the operation and care of our electrical installation.

The estimated annual maintenance of this equipment when completed is placed at $300,000, assuming the deterioration of the electrical plants at ten (10) per cent. Unless officers, in whose charge these plants are placed, are qualified to perform the important duty of supervising the care of the telautographs, master clocks, storage batteries, telephones, and all other numerous component parts of the new system of fire control installation, we must reasonably expect more rapid deterioration and greater expense associated with impaired efficiency.

To qualify officers for the more efficient performance of their duties, especially in the technical branches thereof, the service schools have been modernized. The object of these schools, judging from a tour thereat, would seem to be more to teach the student officer what to study and where to find it, than to attempt to go into the depths of theory. Owing to the limited time allotted, the tendency of the school is to make the course practical rather than theoretical, the time devoted to theory being limited to what is necessary to enable the practical work to be carried out efficiently.

The departments of electricity and mines at both the service schools at Forts Monroe and Totten are rapidly advancing in the scale of importance to where they properly belong.

Looking back eighteen years we find no separate department for the subject of electricity but find it combined in the department of artillery, with ballistics, gun construction, explosives, torpedoes, organization and administration.

This insignificant place was assigned this subject by the Artillery Council convened at New York, October 3, 1887, for the purpose of a full and free consideration and discussion of the needs of the artillery arm of the service.

No more striking example of the rapid advance of electricity in the artillery service can be given than by a comparison of the importance given the subject in the service schools of eighteen years ago and those of to-day.

Starting with the desire to light the emplacements the first important application of electricity to coast fortifications was the incandescent light. To the simple question of lighting is now added the problems of furnishing power for the ammunition service, as a device for labor saving; the maneuvering of the guns, by traversing, elevating and lowering; the machine shops for the use of the ordnance and artillery machinists; the storage battery as a reserve, the telautograph and telephone systems for the transmitting of orders and balistic data to the guns; the searchlight, and finally the several means of firing the guns, both from the battery or battery commanders' stations, and the effective operation of submarine mines.

By considering these purposes separately and, in connection with each, solving a few practical problems relating thereto, it is hoped that the true value of the study of electricity by artillery officers, the object of this paper, will be made more apparent.

Communications.—In order to join the several links in the chain of tactical command, the necessity for communication has become of vital importance. The district commander must be in direct communication with the battle commanders, and the latter with the fire commanders, who, in turn, are in touch with their respective battery commanders. The battery commander then from his B. C. station directs the personnel at the guns. So important has this chain of communication become that no pains or money have been spared in an effort to determine a model system. From not a dollar in the possession of the Signal Corps three years ago, for the purpose of purchasing electrical equipment for this installation, its importance and necessity have become more apparent to Congress, until the appropriation for the last year has reached the sum of $550,000.

The application of electricity particularly as a means of communication is of very recent growth, and owes its most important advances to the officers of the Engineer, Signal, and Artillery Corps.

Without this application to the system of fire control in connection with our position finders, the efficiency of the coast fortifications would be very materially curtailed and the shots fired, especially at ranges over 3500 yards, practically thrown away. If these lines of communication are kept in perfect order by constant care and operation, and the lines so laid out as to be secure from all interruptions or interference, the large caliber guns are effective, and shots will tell up to the extreme range of 10,000 yards.

From all the tests conducted in connection with the trial systems of fire control installation, the defects involved, almost without exception, have been traced to failures on the part of the operators to comply with the simplest and plainest instructions, or the lack of such instructions.

Cases of batteries being exhausted by constant connection caused by forgetting to use the switches properly, tampering with connections and binding posts, etc., are a few of the dere- lictions commonly met with.

The following can be assumed as fair examples of problems which artillery officers may be called upon to solve in connection with work relating to this subject:

Problem I. (a) How many pounds of No. 12 B. & S. bare copper wire would be required to connect two stations 3000 yards apart? (b) How many pounds of iron wire having an equal resistance would be required, and what its English standard gauge number?

Solution:

3000 yds. $\times$ 2 = 6000 yds. = length of wire necessary.

$\frac{6000}{1760}$ yds. = 3 9/22 miles.

Weight of No. 12 B. & S. wire per mile = 103 lbs.

103 lbs $\times$ 3 9/22 = 351.1 lbs. Ans. to (a).

Resistance of this wire per mile = 8.44 ohms.

8.44 ohms $\times$ 3 9/22 = 28.76 ohms = total resistance.

C. M. (circular mils) $= \frac{18000 \times 63.35}{28.76} = 39650.$

in which 18000 = number of feet of wire necessary,

63.35 = resistance per mil. foot of copper.

39650 C. M. = diameter of 199 mils, or .199″, and from tables No. 6 English standard gauge would be selected.

Weight of No. 6 iron wire per mile = 590 lbs.

590 $\times$ 3 9/22 = 2011 lbs. Ans. to (b).

Problem II. Make a calculation to determine the arrangement of cells best adapted, (a) for economy, (b) for maximum current. Both through an external resistance of .3 ohms.

The internal resistance of each cell assumed as 3 ohms.

Solution:

(a) *Grouping for best economy.*

This is attained when the cells are so arranged that their united internal resistance is very small compared with the external resistance; also so that the material of the battery will be consumed slowly and the current not drawn off at its maximum strength, and with minimum waste of energy.

For Example:

Assume 16 cells all in parallel; E of each cell = 1 volt. R = 3 ohms, and r for each cell = 3 ohms.

$$C = \frac{1}{\frac{3}{16} + 3} = \frac{16}{51} = .314 \text{ amperes.}$$

$$\text{Efficiency} = \text{economy} = \frac{3}{3 + \frac{3}{16}} = \frac{48}{51} = 94.3 \text{ per cent.}$$

(b) *Grouping for greatest current.*

This is obtained by so arranging the cells that they give the largest steady current through given external resistance (R), and at the same time the internal resistance will equal the external resistance.

For Example:

Let n = number of files of cells. m = number of cells in series in each file.

m × n = number of cells = 16.

e = electromotive force for each cell = 1 volt.

E = m × e.

r′ = resistance of each cell.

r′ × m = resistance of each file of cells.

$$r = \frac{m}{n\,r'}.$$

$$C = \frac{m \times e}{\frac{m}{n} r + R}$$

Assuming 4 cells in series and the four (4) groups in parallel we have:

$$C = \frac{4}{\frac{4}{4} \times 3 + 3} = .66\tfrac{2}{3} \text{ amperes} = \text{maximum current.}$$

$$\text{Efficiency} = \frac{3}{3 + 3} = 50 \text{ per cent.}$$

Problem III. Assume 12 cells in circuit with an external resistance of 3.0 ohms. The e. m. f. of each cell is 2 volts, and its internal resistance is 1.0 ohm. Consider all possible combinations from all in series to all in parallel, and plot curves of current and efficiency.

Solution:

R = 3 ohms. r = 1 ohm. V = 2 volts.

(1) *all 12 cells in series.*

$$C = \frac{24}{12 + 3} = \frac{24}{15} = 1.6 \text{ amperes.}$$

Efficiency = 3/15 = 1/5 = 20 per cent.

(2) *six (6) cells in series, two (2) groups in parallel.*

$$C = \frac{6 \times 2}{\frac{6}{2} + 3} = \frac{12}{6} = 2 \text{ amperes.}$$

Efficiency = 3/6 = 1/2 = 50 per cent.

(3) *Four (4) cells in series; three (3) groups in parallel.*

$$C = \frac{2 \times 4}{\frac{4}{3} + 3} = 1.84 \text{ amperes.}$$

$$\text{Efficiency} = \frac{3}{\frac{4}{3} + 3} = \frac{9}{13} = 69 \text{ per cent.}$$

(4) *Three (3) cells in series; four (4) four groups in parallel.*

$$C = \frac{3 \times 2}{\frac{3}{4} + 3} = \frac{24}{15} = 1.6 \text{ amperes.}$$

$$\text{Efficiency} = \frac{3}{\frac{15}{4}} = \frac{12}{15} = 80 \text{ per cent.}$$

(5) *Two (2) cells in series; six (6) groups in parallel.*

$$C = \frac{4}{\frac{2}{6} + 3} = \frac{12}{10} = 1.2 \text{ amperes.}$$

$$\text{Efficiency} = \frac{3}{3 + \frac{1}{3}} = \frac{9}{10} = 90 \text{ per cent.}$$

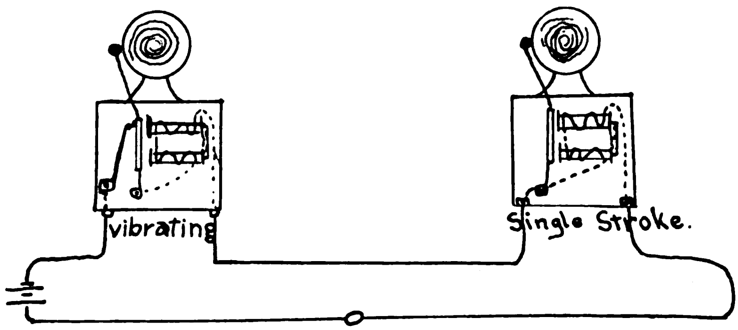
(6) *All cells in parallel.*

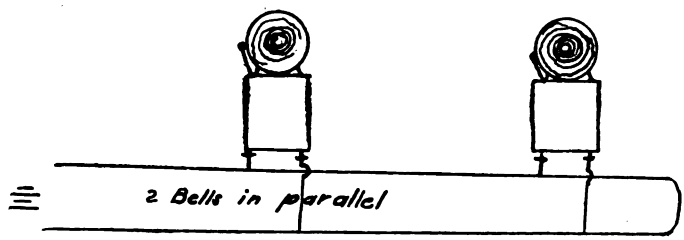
$$C = \frac{2}{\frac{\quad}{12} + 3} = \frac{24}{37} = .65 \text{ ampere.}$$

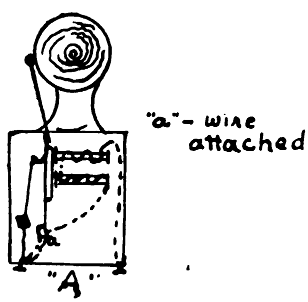
$$\text{Efficiency} = \frac{3}{3 + \frac{1}{12}} = \frac{36}{37} = 97 \text{ per cent.}$$

Problem IV. Make diagram of the following: Electric bells — (1) vibrating; (2) single stroke; (3) of two bells in parallel; (4) two bells in series, and then make one a single stroke.

Solution:





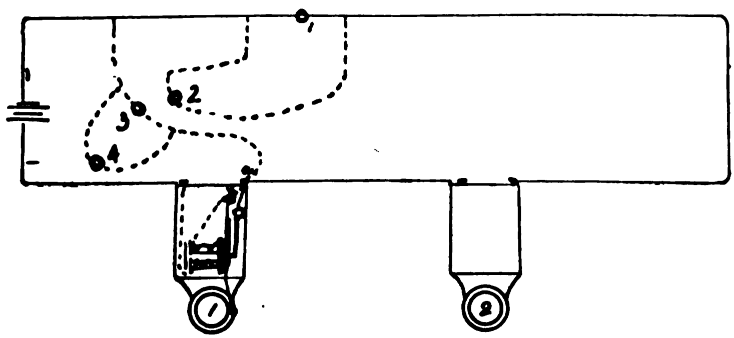


Problem V. Make a diagram: Electric bell circuit, (a) two bells and four buttons; (b) two buttons to ring both and two to ring but one bell. The bells are quite dissimilar, one vibrating twice as fast as the other.

(Make one single stroke. Which?)

Bell diagram should indicate a single stroke bell. But one battery to be used.

Solution:



Bell No. 1 made a single stroke by putting wire from "a" to "x" as indicated.

Buttons Nos. 1 and 2, ring both bells.

Buttons Nos. 3 and 4, ring but one bell.

The Telephone. The telephone was announced as a success at Philadelphia in 1876, and while it has served the public faithfully ever since, it has not proven entirely satisfactory in connection with coast artillery installation. The most general faults seem to be: that the bridging of three or more instruments on the same line has been found impractical; the sending of simultaneous messages to several guns is rendered impossible by the ensuing confusion; the varying capacity of men to use the telephone properly, and the uncertainty that ballistic data will be transmitted accurately, especially if it is done rapidly.

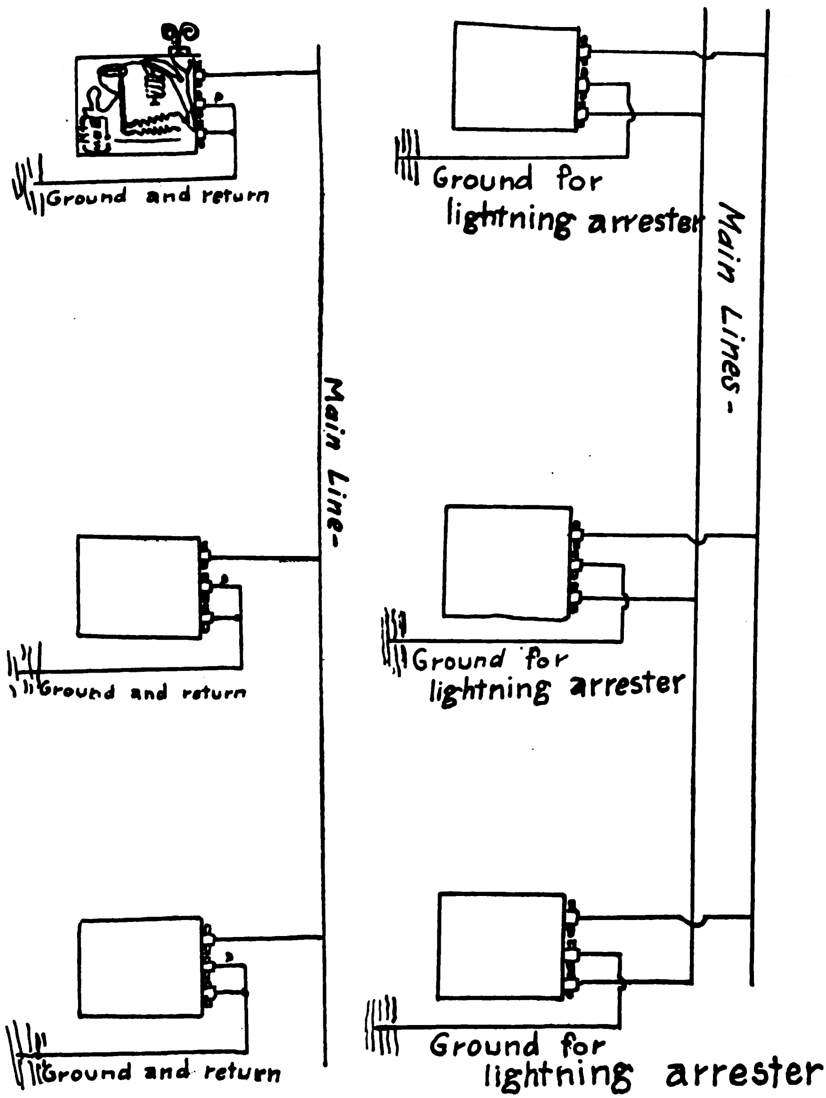
Many of the faults can be obviated if officers to whom telephones are entrusted will familiarize themselves with their construction and operation, and by practice learn the tests necessary to locate the usual troubles that arise in the service. Experience is the best guide in locating faults, and with the aid of a primary knowledge of electricity little trouble need be expected.

The use of a storage battery on telephone circuits seems to have been decided upon, and undoubtedly better results are to be expected.

Problem I. Diagram of three service telephones with ground return and lightning arresters.

(a) Ground wire for lightning arresters.

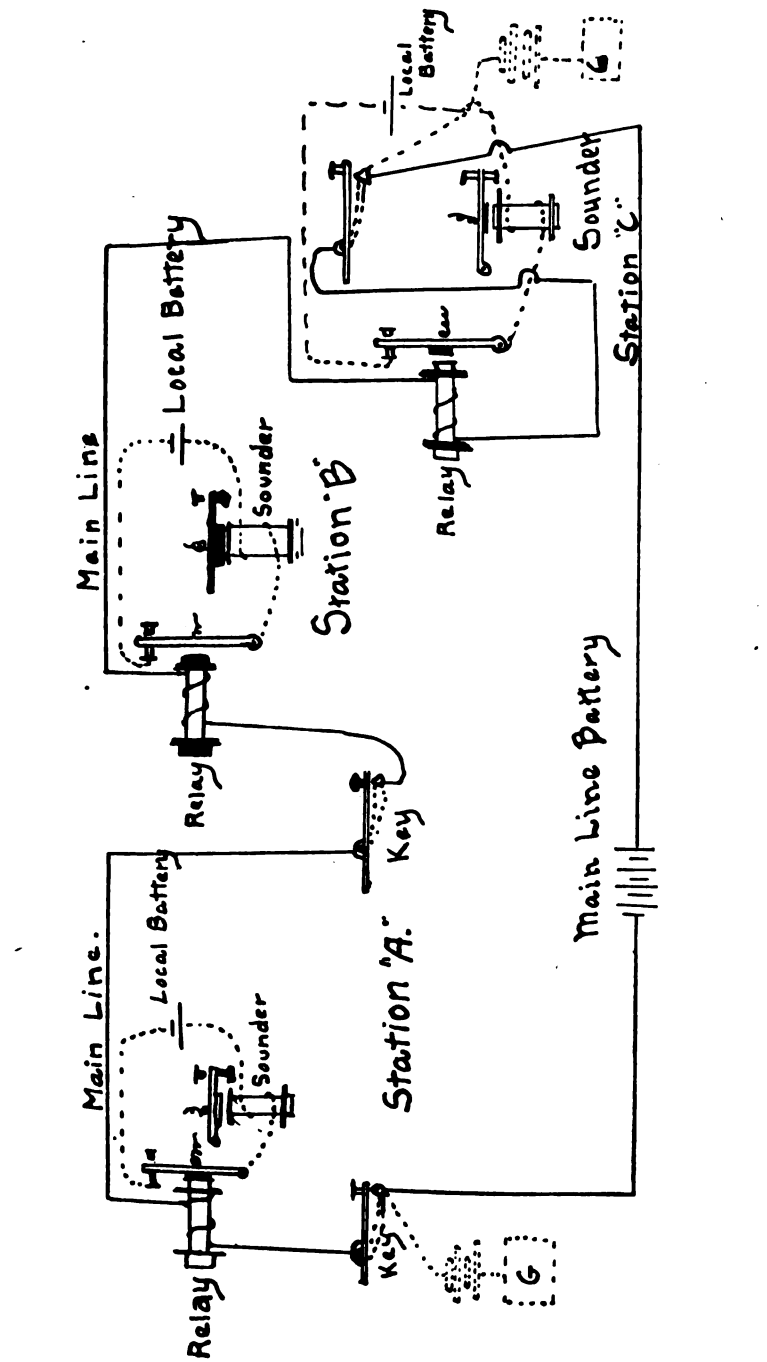
Problem II. Diagram of three service telephones with metallic return and lightning arresters.



In addition to this system of conversational communication it will undoubtedly be necessary to be in telegraphic communication with the fortress or higher commander.

Under such circumstances a problem similar to the following may have to be solved :

Problem III. Diagram of a telegraph circuit connecting three stations.



In connection with the subject of telephones it would seem desirable to only allow those who are familiar with the construction and use of telephones to disconnect the instruments.

The Telautograph. A great deal of money and time have been spent within the last two years on the improvement of the service telautograph, and with excellent results, notwithstanding the undecided position this instrument occupies at the present time.

These improvements, while greatly simplifying many of the once complicated parts, make it still very necessary and important for officers to be well equipped in an electrical way to take up comprehensively the installation and operation of these instruments and make the few tests required; unless such is the case any small defect, no matter how simple, would result in throwing a part at least of the system out of working order. Owing to the complex character of the telautograph only those officers and enlisted men experienced in the use of electrical devices can safely make any repairs or adjustments.

The faults found at the Barranacas tests have all been remedied, and the new models seem to be satisfactory. The most important improvements have been made in the voltage adjustment, better wiring, and the use of wall terminals and sockets, which permit of quick dismantling or transferring of instruments. The use of water-proof boxes at exposed points tends to the better preservation of the instruments and the new system of the cutting out of damaged receivers is a marked improvement in the installation.

The circuits of the service telautograph are more or less complicated, but to enable the operator to make the necessary tests and correct such faults as occur in the service, a clear understanding of the circuits is of imperative necessity.

For the successful operation of the telautograph constant voltage is necessary at the instrument, this at some posts may involve a problem of this nature.

Problem I. Assume battery voltage 110, current 5 amperes; resistance of leads 20 ohms, what is the necessary boost to bring the voltage up to 75 volts at terminals of leads?

Solution:

$V = C \times R$.

$20 \times 5 = 100 = 100$ volts = drop in voltage due to resistance of leads.

110 V—100 v = 10 volts still available from battery.

75 V—10 volts = 65 volts = necessary boost in voltage.

The Storage Battery. The value of the storage battery in many commercial pursuits is now well recognized. Its use is growing in importance, and it is keeping pace with the rapid progress made in the many applications of electricity.

In this connection it must be remembered that the artillery is now being called upon to provide the necessary skilled men to care for and operate these storage batteries as they are being erected and put in commission throughout the service.

To obtain the results desired from the operation of these batteries it is absolutely essential that proper, careful and methodical attention be given to all the details of successful operation of the same.

The placing of the battery in commission, the charging and discharging, the condition of the electrolyte, are most important and should be thoroughly understood. Officers and those in charge should know the indications of a complete charge, how to determine the maximum voltage and specific gravity, the conditions at the end of a charge which affect the voltage and what remedy to apply when different faults arise.

Many problems arise in the proper care and operation of storage batteries, and it is with much difficulty that those most pertinent are selected.

Problem I. An approximate rule for the normal charging rate of a storage cell is 6 amperes per square foot of surface of positive plate (counting both sides); is this independent of the number of cells in series? Assuming this rule, calculate the rate for battery of Type E-5.

Solution:

(a) This rate is independent of the number of cells in series because same current goes through all the cells.

(b) Type E-5 means five plates (two positive and three negative). E-type = 7 3/4″ × 7 3/4″.

Therefore the normal charging rate equals:

$$\frac{7.75 \times 2 \times 2 \times 2 \times 6}{144} = 10.0104 \text{ amperes for eight (8) hours.}$$

Problem II. Assume a battery of 34 cells, 21 plates to each cell, size $15\frac{1}{2}$ x $30\frac{3}{4}$ inches. Calculate normal rate by rule and compare with catalogue (furnished by Storage Battery Co.) rate. What type of cell is this? What is its normal rate?

Solution:

There are ten positive plates to each cell, therefore normal charge rate by rule $= \frac{15.5 \times 30.75 \times 2 \times 10 \times 6}{144} = 397.1875$ amperes.

Normal rate from catalogue = 400 amperes. Also found to be Type "H" cell.

Problem III. Given 60 cells of type "F" accumulator, 13 plates per cell, what is the range of voltage in a generator suited to charge them in in series from 1.7 to full voltage; also the two halves of the battery in parallel? Make diagram of circuits.

Solution:

$$\left.\begin{array}{l}1.7 \text{ volts} \times 60 = 102 \text{ volts} \\ 2.8 \text{ ''} \times 60 = 168 \text{ ''}\end{array}\right\} \text{Range of voltage in series.}$$

$$\left.\begin{array}{l}1.7 \text{ volts} \times 30 = 51.0 \text{ volts} \\ 2.8 \text{ ''} \times 30 = 84.0 \text{ ''}\end{array}\right\} \text{Range of voltage two halves in parallel.}$$

Problem IV. It is contemplated to supply lights with a constant pressure of 110 volts. How many cells are needed?

(a) When end cells are used?

(b) When end cells are not used?

(c) How many will be end cells in case given in (a)?

Solution:

(a) 55 cells (not including end cells) raising voltage to standard by means of end cells as it falls.

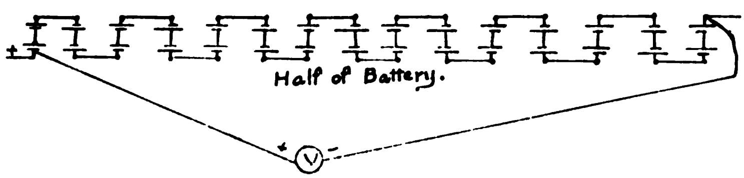
(b) 64 cells using either rheostat or c.e.m.f. cells to adjust voltage at start.

(c) To keep voltage at standard when voltage of battery has fallen to lowest limit nine (9) cells will be required.

For service conditions where voltage seldom falls below 1.9 volts per cell, three (3) cells will be sufficient.

Problem V. Find internal resistance of storage battery quite approximately by discharging through adjustable resistance.

Make diagram.



Readings.

$$\text{On open circuit} \left\{\begin{array}{l}\text{Section No. } 1 = 61.0 \text{ volts.} \\ \text{Section No. } 2 = 61.5 \text{ volts.}\end{array}\right.$$

$$\text{Closed circuit} \left\{\begin{array}{l}\text{Section No. } 1 = 58.0 \text{ volts.} \\ \text{Section No. } 2 = 58.5 \text{ volts.}\end{array}\right.$$

Normal current flowing = 15 amperes; therefore, internal resistance equals : $R = \frac{I - V}{c}$ or $R = \frac{122.5 \text{ volts} - 116.5 \text{ volts}}{15 \text{ amperes}} = \frac{6}{15} \times .4 \times .4$ ohms.

In our service, accumulators are usually arranged so that they can be divided into two equal parts for charging in parallel and discharging in series, as shown in diagram under Prob. III.

Charging and discharging at frequent intervals is absolutely necessary for the preservation of the plates, and this may take place thousands of times without injury if properly directed.

Problem III.—Diagram of Circuits.

(a) Charging

Searchlights.—It is of the utmost importance that artillery fire at night shall be as effective as by day. This can be accomplished when the target is so illuminated by the electric searchlight as to be readily seen at the guns.

Searchlights can be operated efficiently only by the use of electricity, and this continuous and perfect operation is a paramount necessity in the modern defense.

While some mention was made by the Endicott Board of nineteen years ago of this important accessory to the coast defense, its use then prescribed seemed to relate only in connection with the torpedo defense, and its utilization for gun defense against naval attacks was not even mentioned.

It was not until the Army and Navy Maneuvers in Portland Harbor in 1903, that the effectiveness of the searchlight was really made apparent. Since that time a more expensive, but apparently satisfactory, form of distance control has been provided, and now it is possible for the district or other commander effectively to direct the training of his searchlight from his station, even though the position of such light be as much as three miles away.

With the searchlight partial efficiency does not produce partial results, and if these lights are not handled perfectly and continuously they do more harm than good.

Lighting.—Closely connected with the supply of power for these searchlights, is the lighting of the emplacements and garrison, and the handling of the new ammunition hoists. While with the use of the lantern we could manage at the emplacement, and with manual labor run the hoist, without electricity for the searchlights they are absolutely of no use.

The danger of explosion from ignition in our magazines is practically eliminated by the use of the incandescent lamp, not mentioning its effect upon the air as compared with other means of lighting.

The following problems may prove of interest in connection with this subject:

Problem I. Across two light mains between which a constant difference of potential of 100 volts is maintained three lamps are connected having resistances of 50, 75 and 100 ohms respectively, what will be the total resistance between the mains and the amount of current in each lamp if they be wired; (a) in series; (b) in parallel.

(b) The joint conductivity $= \frac{1}{50} + \frac{1}{75} + \frac{1}{100} = \frac{13}{300}$ mhos.

The joint resistance $= \frac{300}{13} = 23\frac{1}{13}$

$\frac{100 \text{ volts}}{50 \text{ ohms}} = 2$ amperes through lamp No. 1.

$\frac{100 \text{ volts}}{75 \text{ ohms}} = 1\frac{1}{3}$ amperes through lamp No. 2.

$\frac{100 \text{ volts}}{100 \text{ ohms}} = 1$ ampere through lamp No. 3.

Problem II. The average resistance of a 16 c. p. incandescent lamp on a 110-volt circuit is 220 ohms when hot. What will it cost to burn five of these lamps for six hours per night for thirty nights if the charge is 7 cents per k. w. hour?

Solution:

$C = \frac{110 \text{ volts}}{220 \text{ ohms}} = \frac{1}{2}$ ampere.

K. W. $= \frac{E \times C}{1000} = \frac{110 \times .5}{1000} = .055$ for one lamp.

.055 K. W. $\times$ 5 $\times$ 180 = 49.5 kilowatt hours.
lamps hours

At 7 cents per K. W. H.

$.07 $\times$ 49.5 = $3.46½

Problem III. A dynamo lights 400 standard 55 watt incandescent lamps at 110 volts. The resistance of leads is 0.1 ohm each.

(a) What voltage at brushes?

(b) If internal resistance of the dynamo is 0.4 ohms, what voltage must it generate.

(c) What size generator would be required?

Solution:

Assuming lamps to be all in parallel.

(a) $W = C \times E$.

$400 \times 55 = C \times 110 \therefore C = 200$ amperes.

voltage used up overcoming resistance of leads $= V = 200 \times .2 =$ 40 volts.

110 volts + 40 volts = 150 volts at brushes.

(b) $V = C \times r$.

200 amperes $\times$ .5 ohms = 100 volts.

150 volts + 100 volts = 250 volts generated.

(c)

K.W. $= \frac{V \times C}{10000}$

$\frac{150 \text{ volts} \times 200 \text{ amperes}}{1000} = 30$ K. W.

$\therefore$ 30 K. W. 150 volts generator would be required.

Solution:

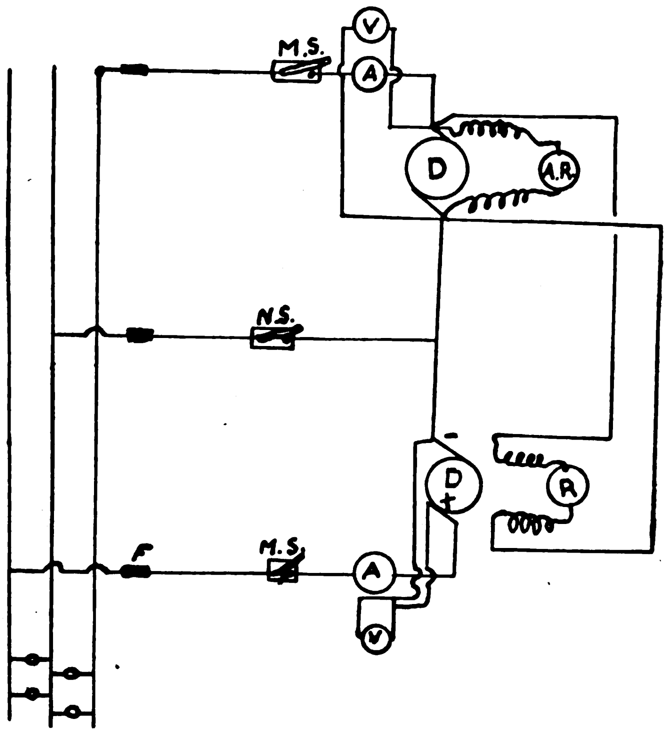
(a) 50 ohms + 75 ohms + 100 ohms = 225 ohms = total resistance.

$C = \frac{E}{R} = \frac{100 \text{ volts}}{225 \text{ ohms}} = \frac{4}{9}$ amperes = amount of current in each lamp.

Correction:—

The last four lines on page 134, beginning "*Solution:*", should be at the *top* of the page, just above "(b)".

Problem V. Make a diagram showing connection and switches, etc., of two generators on a three-wire system.



The following diagrams and problems relating to dynamos and motors if well understood may prove of great assistance in locating faults and solving some troublesome problems:

FIG. 1. Diagram of circuits of series dynamo, lamps as load.

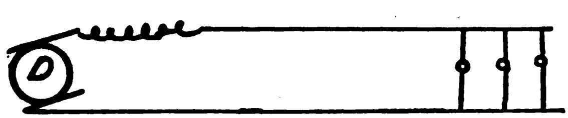


FIG. 2. Diagram of circuits of shunt dynamo, lamps as load.

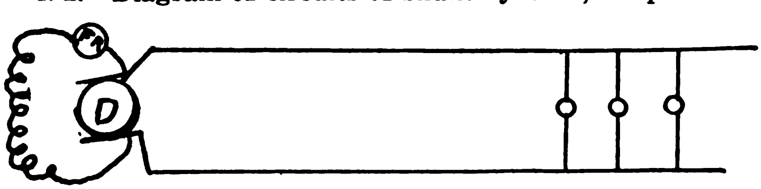


FIG. 3. Diagram of circuits of: (a) series; (b) shunt; (c) compound dynamos, each with external circuit.

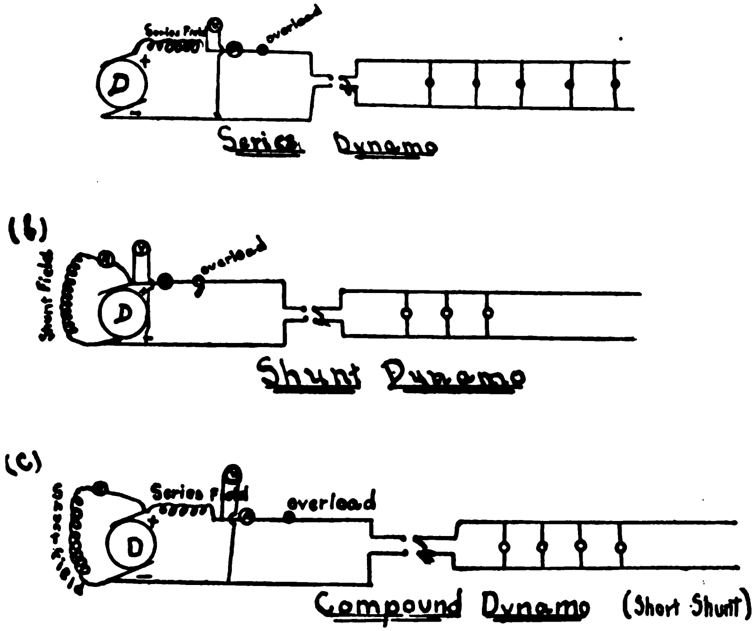


FIG. 4. Diagram showing method of locating grounding on the frame of a dynamo.

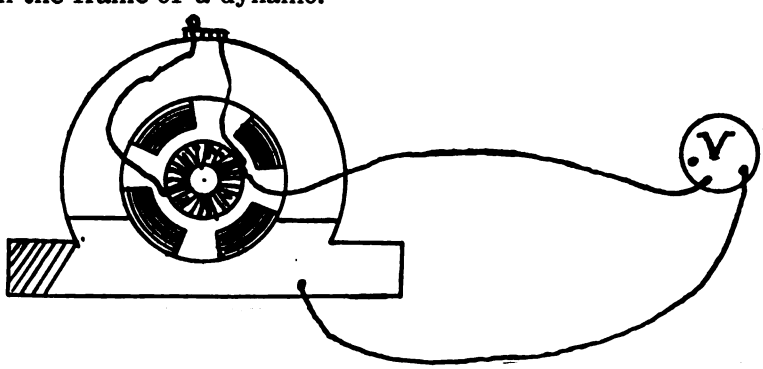


FIG. 5. Diagram of circuits of a cumulative compound generator.

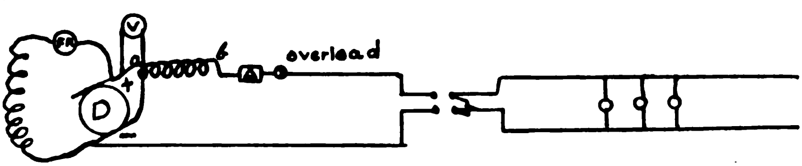


FIG. 6. Diagram of a separately excited generator with lamps as load.

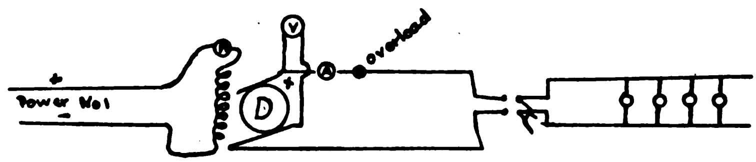


FIG. 7. Diagram of circuits of a shunt motor.

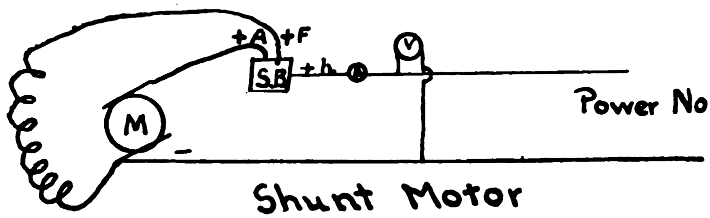


FIG. 8. Diagram of circuits of a cumulative compound motor.

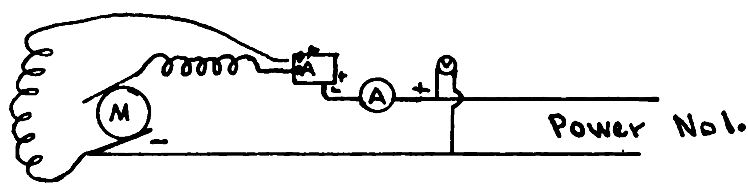


FIG. 9. Diagram of two dynamos in parallel on lamp circuit.

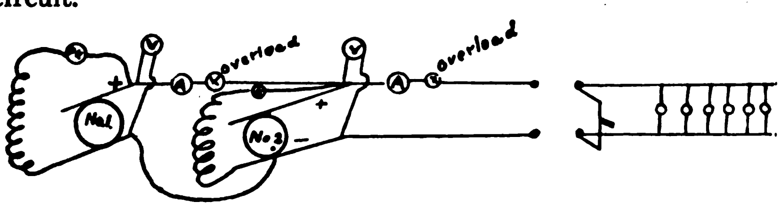


FIG. 10. Diagram showing compounding shunt used to maintain constant potential under varying load and to compensate for "drop" caused by additional current flowing through armature.

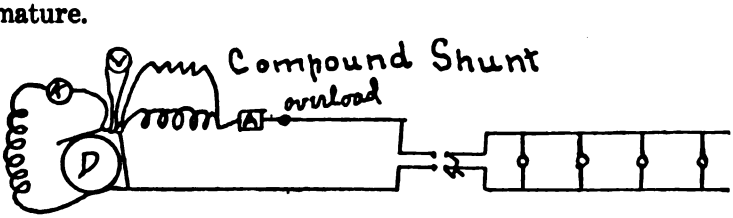
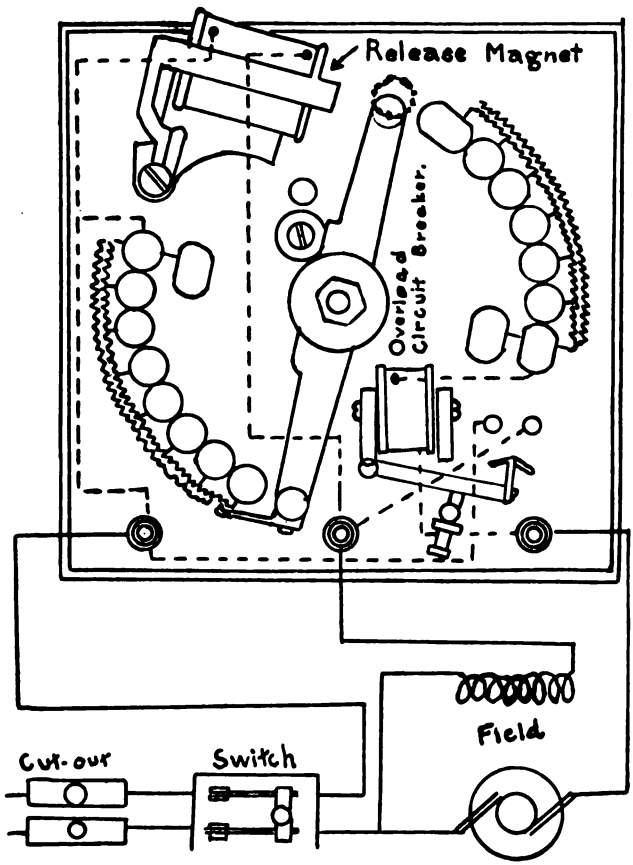


FIG. 11. Diagram of General Electric Co.'s starting box.



Mines.—In compliance with the Act of February 2, 1901, the duty of caring for and operating the submarine mines and torpedo defense was transferred to the artillery from the engineers.

In consequence of this change one of the most important problems devolving upon the artillery is to provide sufficient force, both officers and men, well enough qualified to operate the mining defense of our coast line.

The Torpedo Board at Fort Totten considers that a personnel adequate for this defense should consist of at least one hundred and seventy-four (174) officers and about 5200 men.

In considering this personnel it must be borne in mind that a higher type of man than those ordinarily received at posts will be required to perform the duties of planting, operating, and caring for this equipment. For the present, at least, no greater inducements can be offered to obtain these men, so it will develop upon the commissioned personnel of the artillery to develop by careful instruction from the material received the type of man required.

To be able to do this officers must have a theoretical and practical knowledge of electricity, especially as applied to the instruments and machines used in connection with this work. In order to accomplish the desired results, the apparatus must be, what appears to the novice, more or less complicated, and it is necessary that a part of the corps must be especially trained for this work.

In time of necessity the people of this country have a right to expect that this defense will, by its perfect operation, give the protection to our large harbors that in time of preparation is claimed for it.

Daily tests of the system, when properly made, will readily discover any damage thereto, and it is of the greatest importance that officers should learn to infer from these tests their true meaning.

The necessity for the study of electricity in connection with submarine mining alone may be estimated from the recommendation of the Torpedo Board at Fort Totten, N. Y., "that an officer of each class be detailed for a year's course in practical electrical engineering at some large works."

Testing.—All that is necessary to make the usual tests required is a thorough understanding of the instruments used, how to set them up, what the results mean and the exercise of a little ordinary care.

Before starting out the tester should set up the instruments for the various tests and see that everything is in perfect repair and good working order. Very often the value of an instrument can be saved by first learning something about it.

The testing of cable is now required of all Artillery Engineers, and this is of the utmost importance, as often by making these regular tests incipient faults are located in time to to make repairs, and thus save what would otherwise be useless material.

FIG. 12. Diagram of connections for making test of cable by drop of potential method.

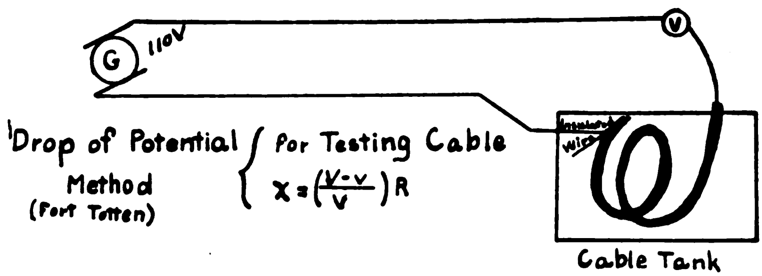
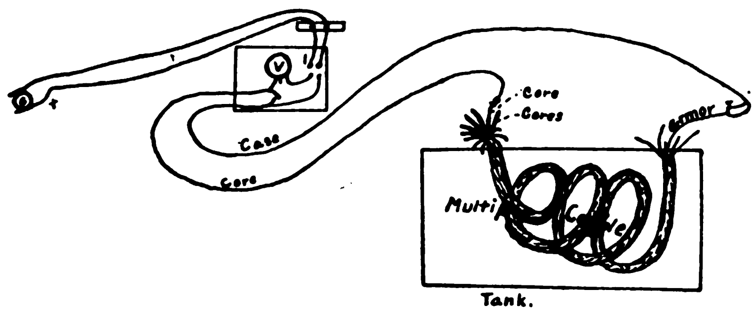


FIG. 13. Diagram of method of testing insulation resistance of cable in tank.

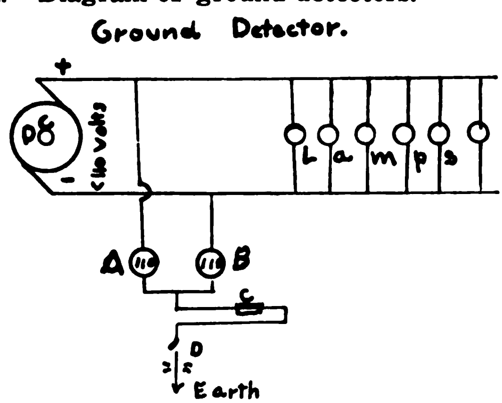


E = 350.5 volts. V = 297.5 volts. Therefore X, insulation resistance equals

$$\left(\frac{350.5-297.5}{297.5}\right) 32325 = 5807.5 \text{ ohms.}$$

32325 = resistance of voltmeter.

FIG. 14. Diagram of ground detectors.



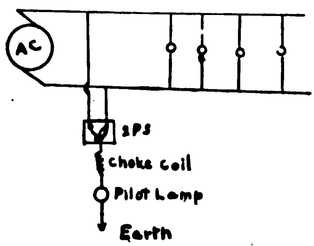
A and B = Two 110 volt pilot lamps. C = Safety fuse. D = Switch.

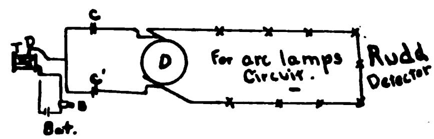
No ground on line: Two lamps burn dimly but with equal candle power

Ground on + wire: Lamp B will brighten up and lamp A becomes dim.

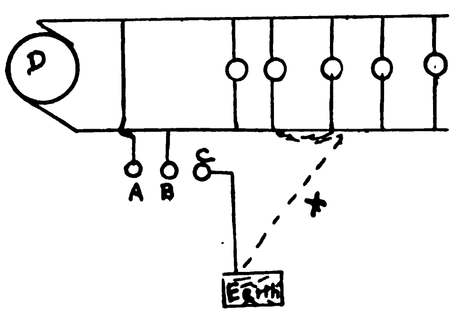
Ground on — wire: The reverse. Both wires grounded, almost equal resistance, both lamps burn dimly.

Ground Detector for Alternating Circuit.





Weston Ground Detector



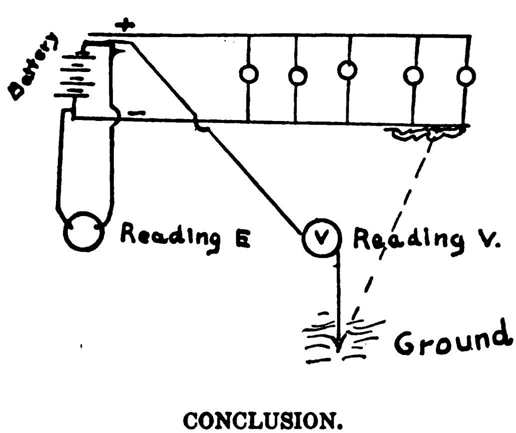
C and C′ = condensers.

T. D. = telephone-drop.

B = Bell.

Shutter of telephone will drop when ground occurs, completing bell current and giving notice of same.

FIG. 15. Diagram of connections and position of ground indicated, for voltmeter test.



CONCLUSION.

While it is believed that in time the course in electricity at the Artillery School and Fort Totten will qualify all officers in the service to master more easily the practical problems in electricity at the several posts, the study of electricity by officers individually, however slight, cannot fail to produce good results.

The student once started on this subject is led on by its wonderful achievements in connection with the many things used in his daily duties until he finds himself in the very heart of the subject.

THE NEEDS OF THE COAST ARTILLERY

By Captain EDWIN LANDON, Artillery Corps

THE article bearing the above title and appearing in the last number of the JOURNAL must be a surprise to many. The remedy for our needs proposed by "Coast Artillerist", viz., transfer of Coast Artillery administration to the Navy Department finds no support in contemporary events known to the writer.

Since the Spanish-American War, Coast Artillery has become increasingly prominent under War Department administration, especially so since the office of Chief of Artillery was established. It is believed that an impartial examination of the progress made in Army efficiency during recent years would show that of all arms the Coast Artillery has made the most consistent and unhalting advance. In large measure this has been due to pursuance of the consistent policy which Colonel Pettit advocates for the whole service. Let us not forget, however, that our advancement has also been due to the comparatively great room for improvement which has existed in the Coast Artillery.

That Colonel Pettit indulged in an intentional "fling" at the Coast Artillery the writer, for one, is not prepared to believe. That he is "not impressed by the great demands of the Coast Artillery" is the expression of a personal view, and should not be interpreted as a "sweeping assertion". Later in his article he concedes a part of these demands as he evidently interprets them. Certainly nothing is to be gained by crying "all's over" because the Artillery has failed to impress all its needs on an individual officer of another arm, much as we should like to have done so.

But let us examine some of these demands and see what is being done to grant them.

First of all, the demand for increased personnel. All coast artillerymen believe we should have more officers and men. Officers of other arms advance two objections to this demand. First, they themselves need an increase, which is admitted; and they fear that if our needs are too readily granted theirs will be indefinitely postponed. This is natural. The only sound objection we can urge to their attitude is that it is too apt to be negative. Colonel Pettit's attitude in this instance is more positive than any I have seen assumed. He said we should have on a peace footing fifty regiments of infantry of six hundred men each. He provides for an expansion in war to eighteen hundred men per regiment, which is three times the peace footing. Here is something to go by. What is the relative importance to the nation of ninety thousand regular infantry on a war footing and of thirty thousand Coast Artillery men? Secondly, they say our claim of inability to expand suddenly is a brand new idea in military organization. To quote Colonel Pettit's figures:—the infantry can expand 200% provided there is a proper reserve to draw upon; the Coast Artillery should be able to expand 150% given the same sort of reserve.

Without replying specifically to these objections, suffice it to say that the War Department is now urging on Congress an increase of five thousand officers and men in the Coast Artillery, nearly 50% of the present peace footing. Is there any reason to believe that the Navy Department would do more on the spur of the moment?

Another great need is a higher standard of efficiency for Artillery officers. The War Department has done all it legally can to set such a standard, at least all that it has been asked to do; could the Navy Department do more?

A third great need is an increase of pay for enlisted men trained to special positions peculiar to the Coast Artillery, as well as a common need of the whole service, increased pay for non-commissioned officers. These measures of relief are now being advocated by the War Department; could the Navy Department do more?

A fourth great need is a completed equipment at coast forts. The report of the Taft Board has just been published. A majority of the members of each committee of this Board were Chiefs of Supply Departments. No one who reads the report can detect any uncertainty as to its opinions on the need of a completed equipment. In addition they specifically provide for complete co-ordination in their efforts with the Chief of Artillery. Again, could the Navy Department do more?

One might go on indefinitely. The writer, for one, believes that the Coast Artillery is not dissatisfied with the present attitude of the War Department toward its needs.

Let us turn now from the practical to the theoretical side of the question. "Coast Artillerist" quotes from another believer in Navy Department administration where he says:— "By the very nature of their work the Coast Artillery and Navy are required to co-operate; and the line of distinction between the functions of the two when co-operating in the defense of a particular harbor is so faintly drawn that many hindrances to perfect co-operation must surely arise as long as the common head is so far removed as the White House. Whereas, if the Navy Department included both Coast Artillery and Navy, the common head could be effectively represented on the spot". He asserts a simplification of supply by the proposed union and speaks of educational advantages. He expresses the opinion that "a development of the Coast Artillery is, under present conditions, practically impossible because of lack of sympathy with, and understanding of, the work of the Coast Artillery, on the part of the field forces with whom it is only legally related."

If the field forces do not understand the needs of the Coast Artillery, it is not seen that much practical difference results, at the present moment, so long as the War Department does.

How many more naval officers than army officers understand our needs in the sense here meant? How many Coast Artillery officers understand the needs of the cavalry, the field artillery or the infantry? What besides specialization is the object of separate arms?

But is the relation only legal? It does not seem so to the writer. Let us consider war conditions. Can the Coast Artillery fight its enemy unsupported? What will that support be? The Navy? No—unless it has been defeated or crippled, when it will be in no condition to support. The Coast Artillery will be a part, and numerically a small part, of the fortresses which will be organized at points threatened with attack. The Taft Board lays down as a governing principle in harbor defense (p. 15), "If the armament will compel the enemy to land in order to effect its capture, it has fulfilled its function, and any increase in armament thereafter is an unwarrantable expense in material and personnel"; and again, "Since it is a naval maxim that the enemy's fleet is the primary objective, it follows that harbor defense cannot depend on the presence of any war vessel to resist attack. While it is possible such vessels may be in port, their presence will not be a part of a plan for harbor defense by naval co-operation". The Board which lays down these principles included representatives of the Navy.

Coast Artillery efficiency as such consists in largest measure in ability to force the enemy to land. The best naval co-operation consists in practical tests of our methods and state of instruction to determine whether we are really prepared to do this. This kind of co-operation has been most effectively rendered in the combined Army and Navy maneuvers we have had in recent years and which owe their inception to the War Department.

Colonel Pettit's statement that "ships have a wholesome dread of fortifications" is not complete; "efficiently manned" should be added. We believe that our fortifications as a whole are not efficiently manned and that the efficiency of the existing personnel would be ruined by an attempt to increase it by 150% at the outbreak of war. That our judgment has been accepted as sound is shown by the attitude of the War Department.

Now when the enemy has landed what will become of the Coast Artillery? Are all these highly trained and disciplined officers and men to remain at their guns looking out to sea? With a big convoy of transports and a supply service to protect and look after, their army on shore, our navy off the sea, is the enemy's navy going to risk doing what they have already given up doing? Having decided to attempt capture by land operations and actively entered on such attempt, will the enemy still be willing to risk his fleet. Soldiers are more easily replaced than ships. Sea power is a slow and expensive growth. There may continue to be feints and attempts at counter-mining mine fields, but with a besieging army on shore and the large proportion of untrained or partially trained troops we would have to oppose them, does any one believe that the commanding general would not utilize a large part of of his coast artillery in the land defense? Furthermore, are these troops to be used as infantry when trained artillerists will be the greatest immediate need, not field artillery so much as artillery of position? The law organizing the Artillery Corps defines Coast Artillery as that branch: "Charged with the care and use of the fixed and movable elements of *land* and coast fortifications, including the submarine mine and torpedo defenses; * * *Provided,* that this shall not be construed to limit the authority of the Secretary of War to order coast artillery to any duty which the public service demands * * ".

We have been so busy trying to get ourselves ready for the duty of forcing the enemy to land that we have almost entirely lost sight of preparing for our duties after he has landed. For these duties there can be no question that the War Department is better prepared to assist and direct us than the Navy Department could possibly be. And what a host of things remain to be done in preparing for the latter duties! Indeed, practically everything. Here we are where the Act of February 2, 1901, found us. In any great siege we would have to use high power guns of position directed inland, some of them borrowed no doubt from the sea fronts. These would have to be mounted in solid emplacements, provided with range finders, searchlights and other accessories and a different kind of ammunition. To undertake this work is not particularly foreign to duties we now perform, nor would any branch of the service be so well prepared to take them up; besides the law requires it.

Again, let us consider what would happen in the event of a war carried to the enemy's country, the command of the sea definitely settled in our favor. Suppose such a foreign campaign to culminate in a siege, a most probable event. Would 30,000, or even our present 12,000 men, trained in the discipline of the regular army, be left in coast forts, or would they want to be left there? It is not conceivable to the writer, especially as long as we continue our present trust-to-luck military policy in preparing for war.

American Army officers, in view of their very small number, are far more valuable individually to the Government than officers of foreign armies. Men already trained will be in very great demand in the event of a foreign war of even moderate proportions. To the writer it is inconceivable that either the Government or that coast artillery officers should wish so to narrow the possible usefulness of the latter as would be the logical consequence of the policy advocated by "Coast Artillerist".

Personally I see little in common with our legitimate activities and those of the Navy. We would be of no value as a naval reserve. Our methods of handling and firing heavy guns are essentially different from Navy methods and must continue to be so. On the other hand there is an increasing similarity between methods of handling and firing heavy field artillery and coast artillery.

The fact that certain foreign Governments assign coast artillery administration to their Navy Departments has no bearing on this question. However, this was not assigned by

"Coast Artillerist" as a reason for the change proposed.

The water's edge outside the limits of navy yards is the natural and logical demarcation between Army and Navy activities. Navies have nothing to do with fortresses but to attack them or take shelter within them. Efficient coast fortifications are more important to the United States than to any other great nation. The sea side of these fortifications requires a long time to construct and arm and they must be ready to use and have trained users at hand when war is declared. Our claim to a relatively greater ratio of peace to war strength than that maintained in other arms rests almost entirely and exclusively on these conditions. But these conditions are peace conditions, not war conditions; and in war, after the first brush, we will be used for other purposes than waiting in our batteries for fleets already out of action to come to life or for those otherwise engaged to put in an appearance.

So tremendous have been our deficiencies for our first duty that we are probably not even yet ready to start active preparations for further duties. But can anyone doubt that the time is rapidly approaching when we must take up this other work? Routine is often now so burdensome that we scarcely have time for it, but with increased numbers and perfected equipment, this condition will disappear.

The Coast Artillery, being actually stationed on the very sites of the coast fortresses which must be constructed and organized in war to complete our defense, are the natural War Department agents for the study and planning of these defenses under the direction of division commanders and the General Staff. The proper organization of such fortresses is a subject utterly absent from the new Field Service Regulations and one which should appear there in great detail. Our present artillery district commanders are the logical choice of fortress commanders as chiefs of the artillery of position.

Active co-operation with naval fighting units, if it ever occurs, will be but momentary, at most. Active co-operation with the army defenders will be a real and long continued necessity. The War Department has given us a very substantial start toward the efficiency we desire, let us recognize it by increasing our usefulness to that Department.

We are legally and logically a part of the United States Army, and, under American conditions, a most important part. Whatever the needs of the Coast Artillery, transfer from War Department administration is not one of them.

A CONTRIBUTION TO INTERIOR BALLISTICS

By Colonel JAMES M. INGALLS, U. S. A., Retired

CHAPTER III.

APPLICATIONS

SOME of the applications given in this chapter were published in the Journal U. S. Artillery for November-December, 1903. But the treatment of the experimental data was different from that adopted here and far less satisfactory. In that article the third term in the general expressions for velocity and pressure was omitted and the values of M and N were determined without reference to the travel of projectile when the powder was all burned. Indeed it was assumed that this took place in all cases when the projectile was about to leave the muzzle. Other changes and improvements in the applications of these formulas, as well as in the formulas themselves, will be noted by those who have read the article referred to above. Many of the examples in this chapter are worked out in full for the benefit of the younger officers of our Artillery Corps for whom this article is principally prepared.

Methods for determining the constants M *and* N. The constants M and N, upon which all the other constants depend, may be determined when the given experimental data are such that two independent equations can be formed involving M and N. In the applications of the formulas of Chapter II. to actual firing two general cases will arise requiring separate treatment:

1. Two measured velocities of the same shot at different positions in the bore are known.
2. The muzzle velocity and crusher-gauge pressure are given.

In addition to these all the elements of loading, as well as the powder and gun constants, are supposed to be known.

FIRST CASE

Let v_1 and v_2 be two measured velocities in the bore at the distances u_1 and u_2 from the origin, which is the base of the shot when in its firing position. From the gun and firing constants compute z_0 by equation (21″), and then x_1 and x_2 corresponding to u_1 and u_2, by the equation

$$x = \frac{u}{z_0}$$

With these values of x_1 and x_2 as arguments, interpolate from the table of the X functions the corresponding values of log X_0 and log X_1, distinguishing them by accents. There may now be formed two sets of independent equations from (47) depending upon whether the characteristics of the grain require two or three terms in the second member,—that is, whether μ is zero or not.

(*a*) *When there are but two terms in the second member of (47).* For the grains where μ is zero λ is generally negative, and we thus have from (47) the two following independent equations:—

$$v_1^2 = MX_1' \left\{ 1 - NX_0' \right\}$$

$$v_2^2 = MX_1'' \left\{ 1 - NX_0'' \right\}$$

Note: In these equations v_2, X_0'' and X_1'' are greater than v_1, X_0' and X_1'.

For simplicity make the following substitutions:

$$a = \left(\frac{v_2}{v_1}\right)^2 \frac{X_1'}{X_1''} \text{ and } b = \frac{X_0'}{X_0''}$$

We then have in a form well adapted for logarithmic computation,

$$N = \frac{1 - a}{X_0'' \, (1 - ab)}$$

and

$$M = \frac{v_1^2}{X_1' \left\{1 - NX_0'\right\}} = \frac{v_2^2}{X_1'' \left\{1 - NX_0''\right\}} \qquad \text{(a)}$$

(b) *When there are three terms in the second member of (47).* In this case the second term may be negative and the third positive, or the second may be positive and the third negative. To prevent confusion these will be considered separately.

(*1*) *Second term negative and third term positive.* The independent equations in this case are

$$v_1^2 = MX_1' \left\{ 1 - NX_0' + \frac{\mu}{\lambda^2} N^2 X_0'^2 \right\}$$

$$v_2^2 = MX_1'' \left\{1 - NX_0'' + \frac{\mu}{\lambda^2} N^2X''^2\right\}$$

Put for convenience,

$$m = \frac{\mu}{\lambda^2}, \qquad a = \left(\frac{v_2}{v_1}\right)^2 \frac{X_1'}{X_1''}, \qquad b = \frac{X_0'}{X_0''}$$

$$c = \frac{1 - ab}{2mX_0''(1 - ab^2)} \quad \text{and} \quad d = \frac{2c\,(1 - a)}{X_0''\,(1 - ab)}$$

Then the quadratic equations give, using the sign applicable to this problem,

$$N = c - \sqrt{d^2 - c}$$

and (b)

$$M = \frac{v_1^2}{X_1'\left\{1 - NX_0' + mN^2X_0'^2\right\}} = \frac{v_2^2}{X_1''\left\{1 - NX_0'' + mN^2X_0''^2\right\}}$$

(2) *Second term positive and third term negative.* The expressions for a, b, c and d, are the same as before; but N becomes

$$N = c + \sqrt{d^2 + c}$$

and (c)

$$M = \frac{v_1^2}{X_1'\left\{1 + NX_0' - mN^2X_0'^2\right\}} = \frac{v_2^2}{X_1''\left\{1 + NX_0'' - mN^2X_0''^2\right\}}$$

APPLICATIONS TO SIR ANDREW NOBLE'S EXPERIMENTS*

These very important experiments were made at the Elswick works, Newcastle-on-Tyne, with a six-inch gun. They are thus described by Sir Andrew on page 207 of the volume of "Proceedings" referred to in the foot note. "The energies which the new explosives are capable of developing, and the high pressures at which the resulting gases are discharged from the muzzle of the gun, render length of bore of increased importance. With the object of ascertaining with more precision the advantages to be gained by length, the firm to which I belong has experimented with a 6-inch gun of a 100 calibers in length. In the particular experiments to which I refer, the velocity and energy generated has not only been measured at the muzzle, but the velocity and pressure producing this velocity

*"Report (1894) on methods of measuring pressures in the bore of guns"; and "Researches on Explosives, Preliminary Note," from Proceedings of the Royal Society, Vol. 56. An abstract of these papers may be found in the "English Text-book of Gunnery," 1902, and in "Nature" for May 24, 1900.

have been obtained for every point of the bore, consequently the loss of velocity and energy due to any particular shortening of the bore can at once be deduced.

"These results have been obtained by measuring the velocities every round at sixteen points in the bore and at the muzzle. These data enable a velocity curve to be laid down, while from this curve the corresponding pressure curve can be calculated. The maximum chamber pressure obtained by these means is corroborated by simultaneous observations taken with crusher gauges, and the internal ballistics of various explosives have thus been completely determined".

The velocities at the sixteen points in the bore were determined by registering the times at which the projectile passed these points; and the registering apparatus is thus described by Sir Andrew in the "Report," page 11. "The chronoscope which I have designed for this purpose consists of a series of thin discs made to rotate at a very high and uniform velocity through a train of geared wheels. The speed with which the circumference of the discs travels is between 1200 and 1300 inches per second, and, since by means of a vernier we are able to divide the inch into thousandths, the instrument is capable of recording the millionth part of a second.

"The precise rate of the discs' rotation is ascertained from one of the intermediate shafts, which, by means of a relay, registers the revolutions on a subsidiary chronoscope, on which, also by a relay, a chronometer registers seconds. The subsidiary chronoscope can be read to about the $\frac{1}{5000}$th part of a second.

"The registration of the passage of the shot across any of the fixed points in the bore is effected by the severance of the primary of an induction coil causing a spark from the secondary, which writes its record on prepared paper gummed to the periphery of the disc. The time is thus registered every round at sixteen points of the bore.

"I have ascertained by experiments that the mean instrumental error of this chronoscope, due chiefly to the deflection of the spark, amounts only to about three one-millionths of a second. Usually the pressures were deduced from the mean of three consecutive rounds fired under the same circumstances."

The following table* gives the recorded experimental data for the various kinds of smokeless powders employed at the

*Proceedings, Vol. 56, page 220.

Elswick firings, and which will be used in the following discussions:

Kind of powder	Weight of charge	density of loading	mean crusher gauge pressure	Measured velocity when projectile had traveled			
				16.6 ft.	21.6 ft.	34.1 ft.	46.6ft.
	lbs.		lbs.	f.s.	f.s.	f.s.	f.s.
Cordite (0″.4)	27.5	0.55	47040	2794	2940	3166	3284
Cordite (0″.35)	22.0	0.44	30352	2444	2583	2798	2915
Cordite (0″.3)	20.0	0.40	36960	2495	2632	2821	2914
Ballistite (0″.3)	20.0	0.40	33936	2416	2537	2713	2806
French B. N.	25.0	0.50	44912	2422	2530	2700	2786

The cordite used in these experiments contained "37 per cent of guncotton (trinitro-cellulose with a small proportion of soluble guncotton), 58 per cent of nitroglycerine, and 5 per cent of a hydrocarbon known as vaselin." The ballistite "was nearly exactly composed of 50 per cent of dinitro-cellulose (collodion cotton) and 50 per cent of nitroglycerine. The cubes were coated with graphite, and the nitrocellulose was wholly soluble in ether alcohol." "The French B.N. powder consists of nitrocellulose partially gelatinized and mixed with tannin, with barium and potassium nitrates."*

FIRST APPLICATION

Experiment with ballistite. We will first discuss, by means of the formulas of Chapter II., the results obtained with ballistite pressed into cubes of three-tenths of an inch on a side. The gun, powder and firing data are as follows:—

$$c = 6 \text{ inches} \qquad \Delta = 0.4$$
$$\alpha = 3 \qquad \delta = 1.56$$
$$\lambda = -1 \qquad \tilde{\omega} = 20 \text{ lbs.}$$
$$\mu = \tfrac{1}{3} \qquad w = 100 \text{ lbs.}$$

We will give the calculations in full for this first application. First compute a^2, z_0, and then the values of x for those values of u for which velocities are given in the preceding table. In the computations which follow, the "-10" is omitted from the logarithm of a number less than unity, as its presence is usually unneccessary, and it can always be supplied when desired.

Computation of a, z_0 *and* x.

$$\delta = 1.56$$
$$\Delta = 0.40$$
$$\log 1.16 = 0.06446$$

*Proceedings, pages 212-215.

$$\begin{aligned}
\log 1.16 &= 0.06446 \\
\text{co-log } \Delta &= 0.39794 \qquad \text{(See Chap. 1, page 202)} \\
\text{co-log } \delta &= \underline{9.80688} \\
\log a^2 &= 0.26928 \\
\text{Const. } \log &= 0.46789 \\
\log \bar{\omega} &= 1.30103 \\
\text{co-log } c^2 &= \underline{8.44370} \\
\log z_0 &= 0.48190 \qquad \therefore z_0 = 3.0332 \text{ ft.} \\
u = 16.6 \text{ ft.} \qquad \log u &= \underline{1.22011} \\
\log x &= 0.73821 \\
x &= 5.437
\end{aligned}$$

In the same way are found the values of x for $u = 21.6$, 34.1 and 46.6 ft. Having found these we take from the table, employing second differences, the corresponding logarithms of X_0, X_1 and X_2. For convenience of reference these logarithms together with the corresponding velocities are given in the following table :—

u	x	log X_0	log X_1	log X_2	v
ft.				−10	f. s.
16.6	5.473	0.79917	0.46513	9.66596	2416
21.6	7.121	0.84069	0.54181	9.70112	2537
34.1	11.242	0.91049	0.66339	9.75289	2713
46.6	15.363	0.95685	0.73940	9.78255	2806

Substituting the *form* characteristics of a cubical grain in the expressions for M, N and N′ on page 36, they become

$$M = \frac{3v^2}{X_1}, \qquad N = \frac{1}{X_0} \quad \text{and} \quad N' = \frac{1}{3X_0^2} = \frac{1}{3}N^2$$

and these in equations (40) (47) and (50) give, for cubical grains, by obvious reductions,

$$\frac{y}{\bar{\omega}} = \frac{3}{X_0}X_0 \left\{ 1 - NX_0 + \tfrac{1}{3}N^2X_0^2 \right\}$$

$$v^2 = MX_1 \left\{ 1 - NX_0 + \tfrac{1}{3}N^2X_0^2 \right\}$$

and

$$p = M'X_3 \left\{ 1 - NX_4 + \tfrac{1}{3}N^2X_5 \right\}$$

Also for this particular gun and charge equation (74) becomes in connection with (49′),

$$p_m = [8.11476\text{—}10]\, M \left\{ 1 - [0.48444]N + [0.45875]N^2 \right\}$$

by means of which the maximum pressure may be computed when the values of M and N have been satisfactorily determined.

To determine the values of M and N for this shot we make use of equations (b), using a selection of the numbers in the table on page 154 as follows: $u_1 = 16.6$ ft., $u_2 = 46.6$ ft., $v_1 = 2416$ f.s., $v_2 = 2806$ f.s., $\log X_0' = 0.79917$, $\log X_0'' = 0.95685$, $\log X_1' = 0.46513$, $\log X_1'' = 0.73940$ and $m = \frac{1}{3}$.

We must first compute a, b, c and d in the order named.

Computation of a.

$$\begin{aligned}
\log v_2 &= 3.44809 \\
\log v_1 &= \underline{3.38310} \\
& 0.06499 \\
& \underline{2} \\
& 0.12998 \\
\log X_1' &= 0.46513 \\
\text{a.c. } \log X_1'' &= \underline{9.26060} \\
\log a &= 9.85571 \qquad \therefore a = 0.71732 \\
& \qquad\qquad 1 - a = 0.28268
\end{aligned}$$

Computation of b.

$$\begin{aligned}
\log X_0' &= 0.79917 \\
\log X_0'' &= \underline{0.95685} \\
\log b &= 9.84232 \qquad \therefore b = 0.69554 \\
\log a &= \underline{9.85571} \\
\log ab &= 0.69803 \qquad \therefore ab = 0.49892 \\
\log b &= \underline{9.84232} \qquad 1-ab = 0.50108 \\
\log ab^2 &= 9.54035 \qquad \therefore ab^2 = 0.34702 \\
& \qquad\qquad 1-ab^2 = 0.65298
\end{aligned}$$

Computation of c.

$$\begin{aligned}
\log (1-ab) &= 9.69991 \\
\text{a.c. } \log 2m &= 0.17609 \\
\text{a.c. } \log X_0'' &= 9.04315 \\
\text{a.c. } \log (1-ab^2) &= \underline{0.18510} \\
\log c &= 9.10425 \qquad \therefore c = 0.12713 \\
\log c^2 &= 8.20850 \qquad \therefore c^2 = 0.016162
\end{aligned}$$

Computation of d.

$$\begin{aligned}
\log 2c &= 9.40528 \\
\log (1-a) &= 9.45130 \\
\text{a.c. } \log X_0'' &= 9.04315 \\
\text{a.c. } \log (1-ab) &= \underline{0.30009} \\
\log d &= 8.19982 \qquad \therefore d = \underline{0.015842} \\
& \qquad\qquad c^2-d = 0.000320
\end{aligned}$$

Computation of N.

$$\begin{aligned}
\log (c^2-d) &= 6.50515 \\
\log (c^2-d)^{\frac{1}{2}} &= 8.25257 \\
(c^2-d)^{\frac{1}{2}} &= 0.01789 \\
\therefore N = 0.12713-0.01789 &= 0.10924 \\
\text{and } \log N &= 9.03838
\end{aligned}$$

Computation of M ($u_2 = 46.6$ ft.)

$$\begin{aligned}
\log m &= 9.52288 \\
\log N^2 &= \underline{8.07676} \\
\log N' &= 7.59964
\end{aligned}$$

log N' = 7.59964
log X_0^2 = 1.91370
(add unity) 1.32609 = 9.51334

log N = 9.03838
log X_0 = 0.95685
(subtract) 0.98908 = 9.99523
0.33701 = 9.52764
log X_1 = 0.73940
log denominator = 0.26704
log V^2 = 6.89617
log M = 6.62913
log Const. + log w/a $\tilde{\omega}$ = 8.25836
log M′ = 4.88749

Computation of M (u_1 = 16.6 ft.)

log N' = 7.59964
log $X_0'^2$ = 1.59834
(add unity) 1.15775 = 9.19798

log N = 9.03838
log X_0' = 0.79917
(subtract) 0.68794 = 9.83755
0.46981 = 9.67192
log X_1' = 0.46513
log denominator = 0.13705
log v^2 = 6.76619
log M = 6.62914

The agreement of these two values of log M shows that the calculations have been correctly made.

The equations for velocity and pressure sought are therefore

$$v^2 = [6.62913]X_1 \left\{ 1 - [9.03838-10]X_0 + [7.59964-10]X_0^2 \right\}$$

and

$$p = [4.88749]X_3 \left\{ 1 - [9.03838-10]X_4 + [7.59964-10]X_5 \right\}$$

This equation for velocity will of course give the observed velocities for u = 16.6 ft. and u = 46.6 ft.

It should also give the observed velocities, if our method is correct, when u = 21.6 ft. and u = 34.1 ft., and indeed for every point in the bore from the firing seat to the muzzle. In computing a velocity it is best to begin with the third term. The following is the entire computation for u = 21.6 ft., using the numbers in the table on page 154.

log N' = 7.59964
log X_0^2 = 1.68138
(add unity) 1.19099 = 9.28102

(add unity)	1.19099	
		$\log N = 9.03838$
		$\log X_0 = 0.84069$
(subtract)	0.75696	$= 9.87907$
	0.43403	$= 9.63752$
		$\log X_1 = 0.54181$
		$\log M = 6.62913$
		$\log v^2 = 6.80846$
		$\log v = 3.40423$
		$v = 2536.5$ f.s.
		observed $= 2537.0$
		difference $= 0.5$

In the same way we find for $u = 36.1$ ft.

$v = 2710$ f.s.

observed $= 2713$

difference $= -3$

These differences between the computed and measured velocities are well within the limits of probable error in making the measurements, and may be regarded as *nil.* We may therefore regard the expressions for v^2 (or its square root) as the true equation of the velocity curve for a travel of projectile of 30 ft., (46.6−16.6), and this while the powder is burning. From the manner of deriving the factor M′ and the functions X_3, X_4, and X_5 as explained in Chap. II., it follows that if the velocities agree with experiment the derived pressures must also be correct.

We will now complete the calculations pertaining to this shot by computing $\overline{u}$, p_m, $\overline{v_1}$, τ, f, and in deducing expressions for y, V and P.

The distance traveled by the projectile when the powder is all burned is determined by means of $\overline{X_0}$ and the table of the X functions. We have

$$\overline{X_0} = \frac{\lambda}{N} = \left(\frac{\mu}{N'}\right)^{\frac{1}{2}}$$

and both these expressions give the same value to $\overline{X_0}$, namely,

$$\log \overline{X_0} = 0.96162$$

Corresponding to this value of $\log \overline{X_0}$ we find by interpolation from the table,

$$\overline{X} = 15.8702, \quad \log \overline{X_1} = 0.74702 \text{ and } \log \overline{X_2} = 9.78539$$

Therefore $\overline{u} = \overline{x}\, z_0 = 15.8702 \times 3.0332 = 48.1375$ ft. This shows that the charge was not all burned in the gun.

To compute $\overline{v}$ we have the equation, $\overline{v^2} = \frac{1}{2} M \overline{X_1}$

$$
\begin{array}{rl}
\log M = & 6.62913 \\
\log \bar{X}_1 = & 0.74702 \\
\log \tfrac{1}{3} = & 9.52288 \\
\hline
\log \bar{v}^2 = & 6.89903 \\
\log \bar{v} = & 3.44951 \qquad \therefore \bar{v} = 2815 \text{ f.s.}
\end{array}
$$

V_1^2 is given by the equation

$$V_1^2 = \tfrac{1}{3} M\bar{X}_0$$

$$
\begin{array}{rl}
\log M = & 6.62913 \\
\log \bar{X}_0 = & 0.96162 \\
\log \tfrac{1}{3} = & 9.52288 \\
\hline
\log V_1^2 = & 7.11363 \\
\log V_1 = & 3.55681 \\
V_1 = & 3604.2 \text{ f.s.}
\end{array}
$$

Computation of maximum pressure. This is computed by the formula on page 154.

$$
\begin{array}{lrl}
 & \text{Const. } \log = & 0.45875 \\
 & \log N^2 = & 8.07676 \\
\text{(add unity)} & 1.03432 \qquad = & \overline{8.53551} \\
 & \text{Const } \log = & 0.48444 \\
 & \log N = & 9.03838 \\
 & \underline{0.33329} \qquad = & \overline{9.52282} \\
 & 0.70103 \qquad = & \overline{9.84574} \\
 & \log M = & 6.62913 \\
 & \text{Const } \log = & 8\ 11476 \\
 & \log p_m = & \overline{4.58963} \qquad \therefore p_m = 38871 \text{ lbs.}
\end{array}
$$

Sir Andrew Noble's pressure curve shows a maximum pressure of 36400 lbs. and a crusher-gauge pressure of 34000 lbs. With regards to the difference between the computed maximum pressure and that given by the crusher gauge, the following remarks by Sir Andrew are apropos : "As a general rule it may be said that when the powders are slow in lighting and no wave action exists, the chronograph pressures are generally somewhat higher than those of the crusher gauge; but the case is very different when the powder is of a highly explosive or quick-burning description. With such powders the crusher-gauge pressures are greatly above those of the chronoscope. The chronograph takes little or no note of the violent oscillations of pressure acting during exceedingly minute intervals of time."

We will now compute the values of the characteristics f and τ, which will be found useful in solving problems involving changes in the weight of charge.

Computation of τ *by equation (62').*

$$\begin{aligned} \text{Const log} &= 8.56006 \\ \log a &= 0.13464 \\ \tfrac{1}{2}\log(w\bar{\omega}) &= 1.65051 \\ \log X_0 &= 0.96162 \\ \text{co-log } c^2 &= 8.44370 \\ \log \tau &= 9.75053 \qquad \therefore \tau = 0.56303 \text{ sec.} \end{aligned}$$

We evidently have, in free air,

$$\text{Velocity of burning} = \frac{l_0}{\tau} = \frac{0.15}{0.56303} = 0.26642$$

The velocity of burning, under atmospheric pressure, of this particular powder, is, therefore, 0.26642 inches per second. The writer has no means of knowing whether this theoretical velocity of combustion of ballistite is even approximately correct, and gives it for what it may be worth.

Computation of f *by equation (63').*

$$\begin{aligned} \text{Const. log} &= 5.55617 \\ \log V_1^2 &= 7.11363 \\ \log w/\bar{\omega} &= 0.69897 \\ \log f &= 3.36877 \qquad \therefore f = 2337.6 \text{ lbs.} \end{aligned}$$

This result would mean, if the problem under consideration were completely solved, that one pound of the gases of this powder, at temperature of combustion, confined in a volume of one cubic foot, would exert a pressure of 2337.6 pounds per square inch. But the problem is very far from being solved rigorously. In the deduction of equation (29) there were neglected the following energies:

1st. The heat loss by conduction to the walls of the gun.

2d. The work expended on the charge, the gun and carriage, and in giving rotation to the projectile.

3d. The work expended in overcoming passive resistances, such as forcing, friction along the grooves, the resistance of the air, etc.

It may be seen, however, from a careful consideration of equation (29) and the use made of it in deducing the functions X_0, X_1 etc., that these functions are independent of the value of f; and that when this latter factor has been determined so as completely to satisfy such experiments as we have just been considering, these neglected energies are practically allowed for. Similar remarks apply to τ whose value as deduced from (23), depends upon the exponent of p_0/p, about which there is considerable uncertainty. In fact the characteristics τ and f are unnecessary in determining the equations of the velocity and pressure curves for a given charge. But they are of use in deducing the circumstances of motion when the charge varies, as will be illustrated.

Expressions for weight of powder burned. The weight of powder burned for any travel of the projectile is given by the formula, deduced from equation (69),

$$y = \tilde{\omega}\frac{\overline{v^2 X_2}}{v^2 X_2}$$

If we substitute in this expression, for $\tilde{\omega}$, $\overline{v^2}$ and $\overline{X_2}$ their known values, and reduced, we having the working formula:

$$y = [4.18739-10]\ \frac{v^2}{X_2}$$

Computation of P′ *by equation* (*65′*).

$$\begin{aligned} \text{Const. log} &= 1.79538 \\ \log f &= 3.36877 \\ \text{co-log } a^2 &= 9.73072 \\ \hline \log P' &= 4.89487 \qquad \therefore P' = 78500 \text{ lbs.} \end{aligned}$$

Expressions for V *and* P. These expressions can now be written down and are as follows :—

$$V^2 = V_1^2 X_2 = [7.11363] X_2$$

$$P = \frac{P'}{(1+x)^{\frac{4}{3}}} = \frac{[4.89487]}{(1+x)^{\frac{4}{3}}}$$

Table of velocities and pressures. To determine whether the X functions really give the true velocity of the projectile from the starting point up to a travel of 16.6 ft., we have computed the following table for comparison with the deductions from Sir Andrew Noble's velocity and pressure curves. Unfortunately these curves, us published, are drawn to so small a scale and are so mixed up with other curves that it is impossible to get from them the velocities and pressures with much precision.

The first column of the table gives the values of x for which the velocities and pressures are computed. The second column gives the corresponding travel of projectile, in feet. The next two columns give the velocities and pressures. The fifth column gives the weight of powder burned in pounds, computed by the formula above. The last two columns give the velocity and pressure on the supposition that the charge was all burned before the projectile had moved from its seat. The numbers in these columns were computed by the formulas for V and P given above.

Note: The velocities and pressures in the second and third columns were computed by formulas slightly different from those on page 156. But these differences are so small as to be of no account in the discussion.

Table of velocities and pressures in the bore of a 6-inch gun loaded with a charge of 20 lbs. of ballistite and a projectile weighing 100 lbs.

x	u ft.	v f.s.	p lbs. per in².	y lbs.	V f.s.	P lbs. per in².
0.000	0.000	0.0	0.0	0.0	0.0	78500
0.001	0.003	12.449	4196.4	0.7162	65.786	78397
0.01	0.030	68.889	12672.	2.2065	207.40	77466
0.05	0.152	221.52	25254.	4.6831	457.78	73557
0.1	0.303	359.32	32007.	6.3566	637.37	69132
0.2	0.607	569.36	37680.	8.4645	875.21	61560
0.4	1.213	869.33	39439.	10.967	1174.0	50122
0.6	1.820	1087.2	37567.	12.549	1372.5	41948
0.8	2.427	1257.7	34846.	13.686	1520.3	35852
1.0	3.033	1396.6	32050.	14.557	1637.0	31153
2.0	6.066	1842.4	21268.	17.043	1995.9	18143
3.0	9.100	2093.0	15013.	18.225	2192.5	12363
4.0	12.133	2257.1	11164.	18.892	2322.4	9181.5
5.0	15.166	2374.2	8645.1	19.299	2416.9	7200.2
5.473	16.6	2419.0	7741.6	19.435	2453.5	6507.1
7.121	21.6	2538.0	5500.2	19.742	2554.9	4809.1
11.242	34.1	2710.0	2893.0	19.979	2711.8	2782.3
15.363	46.6	2806.0	1889.7	20.000	2806.0	1889.7

The computed velocities in the third column of this table, corresponding to the travels of projectile in the second column, agree very well with those deduced from Sir Andrew Noble's velocity diagram, from the origin of motion to the muzzle, a travel of 46.6 ft. Indeed if a curve of these computed velocities were drawn to the same scale it would coincide throughout with Sir Andrew's velocity curve. As the velocities are thus shown to be correct the pressures in the fourth column are, from their manner of derivation, as given in Chapter II., necessarily correct also. That is, they correspond to the energy of translation of a hundred pound projectile. In this respect they are more accurate than the pressures given by Sir Andrew's pressure curve, which was derived from his velocity curve by graphic methods which are not sufficiently precise for such tremendous accelerations as are encountered in ballistic problems.

The writer is indebted to Major Lissak, Instructor of Ordnance and Gunnery at West Point, for the accompanying diagram of the velocity and pressure curves whose co-ordinates are given in this table. Many interesting facts may be gleaned from an examination of these curves, and the formulas by which their co-ordinates were computed.

The two velocity curves (v and V) are both zero at the origin but immediately separate, attaining their greatest distance apart when the projectile has moved but a short distance. They then approach and become tangent to each other when u = 46.6 ft., or at the point when the powder is all consumed. Both curves are tangent to the axis of ordinates at the origin, and parallel to the axis of abscissas at infinity. The pressure curve (p) begins at the origin, attains its maximum when the projectile has traveled about 15 inches, changes direction of curvature when u is about six feet and meets the axis of abscissas at infinity. The pressure curve P is convex toward the axis of abscissas throughout its whole extent. It lies above the curve (p) from u = 0 to u = 30 inches (about); then passes below p and finally becomes tangent to it at the point when the powder is all consumed, u = 46.6 ft. Finally the total areas under the two pressure curves (p and P) are equal. The powder curve is parabolic in form, like the velocity curves. It will been seen that half the charge is burned when the projectile has moved about a foot, and that only about one-twentieth of the charge remained to be burned during the last 30 ft. of travel.

We will now give a few examples of the use of some of the other formulas of Chapter II.

Example 1. How far had the projectile moved when the charge was (a) $\frac{7}{8}$ burned? (b) When the charge was $\frac{999}{1000}$ burned?

Solution. (a.) In equation (71) put $k = \frac{7}{8}$ and it becomes

$$X_0 = \overline{X_0}\left(1 - \left(\frac{1}{8}\right)^{\frac{1}{3}}\right) = \frac{1}{2}\,\overline{X_0}$$

$$\therefore \log X_0 = 0.66059$$

Therefore from the table, $x = 2.38$, and

$$u = 2.38 \times 3.0332 = 7.219 \text{ ft.}$$

(b) In the same way is found

$$X_0 = \tfrac{9}{10}\,\overline{X_0}, \quad x = 11.652 \text{ and } u = 35.343 \text{ ft.}$$

Example 2. How much of the charge was burned in the gun? Employ equation (70)

$$\begin{aligned} \log X_0 &= 0.95685 \\ \log \overline{X_0} &= \underline{0.96162} \\ \log 0.98908 &= 9.99523 \end{aligned}$$

$$\log 0.98908 = 9.99523$$
$$\log 0.01092 = 8.03822 \qquad \text{(multiply by 3)}$$
$$\log 0.0000013 = 4.11466$$
$$k = 0.9999987 \text{ Ans}$$

Example 3. Suppose the charge, in the example under consideration, to be increased from 20 to 25 lbs. Deduce the equations for velocity and pressure.

The characteristics of this powder, which, for a moderate variation in the charge, are practically invariable, are all known and are as follows :—

$$f = 2337.6 \text{ lbs.}$$
$$\tau = 0.56303 \text{ sec.} \quad (\text{for } 0''.3 \text{ grains only})$$
$$\alpha = 3$$
$$\lambda = -1$$
$$\mu = \tfrac{1}{3}$$

We also find for the new charge

$$\Delta = 0.5$$
$$\log a^2 = 0.13321$$
$$\log z_0 = 0.44277 \qquad \therefore z_0 = 2.7719 \text{ ft.}$$

From (62′) we have

$$\overline{X}_0 = [1.43994] \frac{c^2\tau}{a\sqrt{w\omega}}$$

and from (63′)

$$V_1^2 = [1.44383]\, f \frac{\omega}{w}$$

by means of which we find

$$\log X_0 = 0.97642$$

and

$$\log V_1^2 = 7.21054$$

From (54′) we have

$$M = \frac{\alpha V_1^2}{X_0}$$

We now have all the data and formulas for computing the factors M, M′, N and N′ for the new charge of 25 lbs. Their logarithms are

$$\log M = 6.71124$$
$$\log M' = 5.00876$$
$$\log N = 9.02358-10$$
$$\log N' = 7.57004-10$$

The required expressions for velocity and pressure are, therefore,

$$v^2 = [6.71124] X_1 \left\{ 1 - [9.02358-10] X_0 + [7.57004-10] X_0^2 \right\}$$

$$p = [5.00876] X_3 \left\{ 1 - [9.02358-10] X_4 + [7.57004-10] X_5 \right\}$$

The travel of projectile when the powder is all burned is found by means of the computed value of $\log \overline{X}_0$. By reference to the table we find, corresponding to $\log \overline{X}_0$, $\overline{x} = 18.56$; and since

$$\overline{u} = \overline{x}\, z_0,$$

we have
$$\overline{u} = 18.56 \times 2.7719 = 45.1 \text{ ft.}$$

Example 4. Compute the maximum pressure, and velocity when the projectile has traveled 16.6 ft., for a charge of 25 lbs.

Maximum pressure.

$$\begin{aligned}
&& \log N' &= 7.57004 && \\
&& \log X_5 &= 0.93587 && (x = 0.45) \\
\text{(add unity)} & \quad 1.03206 & &= 8.50591 && \\
&& \log N &= 9.02358 && \\
&& \log X_4 &= 0.48444 && \\
& \quad 0.32212 & &= 9.50802 && \\
& \quad 0.70994 & &= 9.85122 && \\
&& \log X_3 &= 9.85640 && \\
&& \log M' &= 5.00876 && \\
&& \log p_m &= 4.71638 && \therefore\ p_m = 52045 \text{ lbs.}
\end{aligned}$$

Velocity when u is 16.6 ft.

$$\begin{aligned}
\log u &= 1.22011 & \\
\log z_0 &= 0.44277 & \\
\log x &= 0.77734 & \therefore\ x = 5.9888
\end{aligned}$$

For this value of x the table gives

$$\log X_0 = 0.81349 \qquad \log X_1 = 0.49198$$
$$\log X_3 = 9.54568 - 10 \qquad \log X_4 = 1.00040 \qquad \log X_5 = 1.94413$$

$$\begin{aligned}
&& \log N' &= 7.57004 \\
&& \log X_0^2 &= 1.62698 \\
\text{(add unity)} & \quad 1.15741 & &= 9.19702 \\
&& \log N &= 9.02358 \\
&& \log X_0 &= 0.81349 \\
& \quad 0.68718 & &= 9.83707 \\
& \quad 0.47023 & &= 0.67231 \\
&& \log X_1 &= 0.49198 \\
&& \log M &= 6.71124 \\
&& & 2)\,6.87553 \\
&& \log v &= 3.43776 \\
&& v &= 2740 \text{ f.s.}
\end{aligned}$$

The measured velocity for a travel of 16.6 ft., was 2416 f.s. By increasing the charge therefore from 20 lbs. to 25 lbs. the velocity would be increased 324 f.s., with an increase in the maximum pressure of about 13000 lbs. To lessen the maximum pressure the grains must either be made denser so as to burn more slowly, or they must be increased in size and thus diminish the burning surface. The latter alternative is probably the more feasible and we will adopt it.

Example 5. Suppose with the data of Ex. 3, that the cubes of ballistite were increased to 0.″45 on a side. What effect would this increase have on pressure and velocity ?

We know that τ is equal to the quotient of half the least dimension of the grain divided by the velocity of burning. That is, in this case

$$\tau = \frac{0.225}{0.26642} = 0.84454 \text{ sec.}$$

Substituting this value of τ in the expression for $\overline{X}_0$ given on page 163, we have

$$\log \overline{X}_0 = 1.15729$$

V_1^2 will of course be the same as before, that is

$$\log V_1^2 = 7.21054$$

With this data we find

$$\log M = 9.53037$$
$$\log M' = 4.82789$$
$$\log N = 8.84271\text{—}10$$
$$\log N' = 7.20830\text{—}10$$

The expressions for velocity and pressure for 25 lbs. of this new grain are, therefore,

$$v^2 = [6.53037] X_1 \left\{ 1 - [8.84271-10] X_0 + [7.20830-10] X_0^2 \right\}$$

and

$$p = [4.82789] X_3 \left\{ 1 - [8.84271-10] X_4 + [7.20830-10] X_5 \right\}$$

By means of this last formula the maximum pressure is found to be 38745 lbs., practically the same as was found for a charge of 20 lbs. of 0″.3 grains.

We will now see what velocity this charge of 25 lbs. of the larger grains can develop when the projectile has traveled 16.6 ft., and the corresponding pressure. The X functions to be employed have already been given in the solution of Ex. 4. Substituting these in the expressions for v^2 and p we find for a travel of 16.6 ft.

$$v = 2545 \text{ f.s.}$$
$$p = 10524 \text{ lbs.}$$

We also find by means of (69), for this travel of projectile,

$$y = 21.022 \text{ lbs.}$$

Comparative initial surface. From equation (18), Chap. I., it follows that for two equal charges made up of grains differing only in their size (thickness of web) the entire surface of the grains of the two charges vary inversely as the thickness of web. Therefore the surface of the charge of 0."45 grains is 30/45 = $\frac{2}{3}$ of the surface of the same charge of 0."3 grains. This accounts for the two charges giving practically the same maximum pressure.

It will been seen from the results of this last example that the velocity of the projectile for a travel of 16.6 ft., can be increased 129 f.s. by increasing the weight of charge 5 pounds and at the same time enlarging the grain from 0."3 to 0."45 on a side,—and this without increasing the maximum pressure, though the mean pressure of course is considerable greater.

The muzzle pressure with a charge of 20 lbs. of the smaller grains was 7741 lbs.; and with the charge of 25 lbs. of the larger grains the muzzle pressure would be 10524 lbs. The powder actually burned during this travel of projectile is a little more in the latter case than in the former and the space in which it has been confined during its expansion is less, both of which facts account for the greater work performed.

It will be found by performing the necessary calculations that the distance that must be traveled by the projectile in the bore prolonged, before these large grains could be entirely burned is 169.4 ft.; and that the velocity and pressure corresponding to this travel are 3486 f.s. and 584 lbs. per square inch, respectively. About 96 per cent of the powder would be burned however, when the projectile had reached the muzzle of gun, as may be shown by equation (70) as follows :—

$$\begin{aligned} \log X_0 &= 0.97016 \\ \log \overline{X}_0 &= \underline{1.15221} \\ \log \underline{0.65758} &= \underline{9.81795} \\ \log 0.34242 &= 9.53456 \\ & \quad\;\; \underline{\qquad 3} \\ \log 0.04015 &= 8.60368 \\ \therefore k &= 0.95985 \end{aligned}$$

The small weight of powder burned during the long travel of 169.4—46.6 = 122.8 ft. is accounted for by the diminished pressure and by the increased speed of the projectile.

[To be continued.]

A MANUAL FOR SMALL BOATS

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IN drilling boat's crews we are often at a loss as to the proper procedure. All of us are not blessed with Navy friends from whom we are able to get pointers, and many of us have had no great amount of experience in this line of drill. When there is added to this, the difficulty of obtaining any printed directions on the subject, the combination offers a formidable obstacle to progress. It is the object of this paper to outline a manual of small-boat drill that is appropriate to whatever "gigs" or "cutters" may be found at our seacoast forts and will also, without serious alterations, apply to our submarine mining "yawls" as well. This manual is patterned after that used in the navy, and the variations therefrom will, it is hoped, be allowed as well as taken. If some of the statements below appear superfluous or axiomatic it should be remembered that perhaps, to some of us, they may be new and not exactly self-evident.

PARTICULARS CONCERNING BOATS

Boats are built in three different ways, as follows,—*Carvel-built*, the planks running fore-and-aft, their edges meeting but not overlapping. *Clinker-built*, the planks running fore-and-aft, their edges overlapping. *Diagonal-built*, the planks running diagonally, in two layers, the inside layer running in a diagonally opposite direction to those of the outside layer.

Boats are called *single or double-banked*, according as they have one or two oarsmen to a thwart.

Thwarts are the seats on which the crew sit; the space abaft the after thwart is called the *stern-sheets*.

The notches for the oars in the wash-streak of boats are called *rowlocks*. This name is also applied to the metal objects that accomplish the same purpose. If, instead, wooden pins are set in the rails, they are called *thole-pins*.

Oars are said to be *double-banked* when two men pull one oar.

Feathering is the term applied to the operation of turning the blades nearly flat to the water after the stroke, with the upper edge turned forward. Especially valuable in rowing against a head wind.

Boat-falls are purchases made with two blocks and a length of rope, used for hoisting boats.

The *painter* is a length of line made fast to a ring-bolt in the stem of boats and used for mooring the boat, etc.

The *gunwale* of the boat is the upper rail.

The *yoke* is a piece of wood or metal fitting across the head of a boat's rudder.

Yoke lines are pieces of rope made fast to the yoke, by which the rudder is turned and the boat steered.

The *plug* is the wooden stopper fitted into a hole in the bottom of the boat to let water in or out.

Floorings and *gratings* are the bottom boards of a boat. They prevent weight from bearing directly upon the planking.

A *boat-breaker* is a small keg used for carrying fresh water.

A *boat recall* is an understood signal made to order a boat's return.

BOAT ORDERS

Oars and rowlocks having been placed in the boat, blades of oars towards the bow, rudder and yoke (if any) stepped and the yoke lines clear, the men board and take their proper seats. The man pulling the bow oar is No. 1, the next man is No. 2, and so on, to the man pulling the stern oar, who is called the "stroke oar". The men being seated, with oars handy, the bow man who may be No. 1 or an extra man, as convenient, holds onto the wharf, side or piling, as the case may be, with his boathook.

SHOVE OFF! At this command the bow man shoves the boat clear, giving her headway if possible. He stows his boathook and takes his seat, if he pulls an oar.

UP OARS! The crew simultaneously seize and raise their oars smartly to the vertical (guiding on the stroke oar) and hold them directly in front of them, the blades fore-and-aft and the handles clear of the boat's bottom; the oarsmen rowing on the port side of the boat holding their oars with the left hands down and the others holding theirs with the right hands down.

LET FALL! The oars are eased down into the rowlocks together, brought level with the gunwale, blades horizontal and all trimmed on the after oars. Oars must not be allowed to splash under any consideration.

(1) *Give way together!* (2) GIVE WAY! At the 1st command the men reach well forward, blades nearly vertical, ready for the stroke. At the 2d command they dip their oars at the same time as the stroke oar and commence rowing, keeping stroke exactly and all lifting their blades to the height of the gunwale on the return. (Or higher if waves render this necessary.)

TO MAKE A LANDING

In running alongside a vessel or up to a float-stage or wharf, when several lengths away from same, give the command (while the oars are in the water), IN BOWS!

The bow oarsman (if there be no extra man in the bow) finishes his stroke, then "tosses" his oar, lays it in the boat, blade to the bow and stands ready with the boathook to fend off and hold the landing. When there is sufficient headway to carry the boat properly to the landing, give the command, WAY ENOUGH!

This order is given while the oars are in the water; the men finish the stroke, then toss their oars together and lay them in the boat with as little noise as possible. The oars are next the rail, the after oars to the outside of the bow oars. If the stroke oarsman is provided with a boathook, he grasps it and stands ready to help the bow man.

If it be desired to stop rowing temporarily, give the preparatory command, (1) *Stand by to lay on oars!* at which the crew pays strict attention. Then, when ready, give, (2) OARS!

At this command, given while the oars are in the water, the crew finish the stroke and bring their oars level with the gunwale, blades horizontal, trimmed on the after oars. This position is also used for salutes, as noted hereafter.

If you are going to pass so close to another boat that a collision of oars seems probable, command, (1) *Trail!* (2) OARS!

At the 2d command, given while the oars are in the water, the men finish the stroke, and then, while the oars are still in the water, by lifting the handles with their outboard hands, the looms as thrown out of the rowlocks. The men carry their hands outward till the backs of their wrists rest on the rails and the oars trail astern.*

To bring the oars inboard, command, OARS!

* This movement is used in shooting bridges, etc., where lack of head room precludes "tossing."

At this command the men raise the handles lower the looms into the oarlocks and *then* raise the blades out of the water and swing the oars to the regular position of "Let Fall".

In order to turn the boat short round, (being stationary or nearly so) command,—
(1) *Give way starboard ; back port!* (2) GIVE WAY!
(1) *Give way port ; back starboard!* (2) GIVE WAY!
The crew keep stroke just as regularly as in pulling straight away. As soon as the boat points in the desired direction command,— *Give way together!* GIVE WAY!

If it be desired to check the boat's headway, command, HOLD WATER!

At this command the men drop their blades vertically into the water and keep them there. Inexperienced men are apt to be yanked from their seats by this maneuver, if the boat has great headway. To prepare the crew for rowing, command "Oars" at which they resume the position described under the heading "Let Fall".

To move the boat astern, command,— STERN ALL!

At this command the men "back water" keeping stroke as regularly as in ordinary rowing. To resume the position of attention, give the command of "Oars" as before.

To toss oars, command, (1) *Stand by to toss!* (2) TOSS!

The command of execution is given while the oars are in the water, the stroke is completed and the oars raised smartly to the vertical, remaining in the position described for "Up Oars". To place the oars in the boat, give the command, BOAT YOUR OARS!

And at this command the oars are lowered toward the bow (not swung outboard) and laid in the boat as before described. This command may be given from the position of "Let Fall", in which case the men toss their oars and proceed as above.

NOTES

In rowing the blade of the oar should be raised as high as the gunwale after leaving the water, and feathered by dropping the wrist. A barely perceptible pause should be made, and the oar next thrown well forward and dropped edgewise into the water, taking care to avoid splashing and chopping. Now swing the oar smartly through the water without giving it any final jerk, and repeat as above. With green crews it may be found necessary for the coxswain to call "stroke, stroke" etc., in order to get the men to pull exactly together.

There should be a mark on the loom of the oar (about the height of the eyes when the oar is at a "toss") to show when the blades are for-and-aft, thus avoiding the necessity of the men gazing up for the purpose of finding out when this is the case. Never allow a boat's crew to splash with their blades when executing "Let Fall". When resting on oars, insist that they be kept level with the gunwale and at right angles to the keel. Talking among the crew and turning the heads to look at any object should never be allowed while the boat is under way.

In most cases, boats should be permanently equipped with a small breaker of fresh water, a spare oar and oarlock and a suitable anchor or grapnel. The anchor rope, to withstand a storm, should be 6 times as long as the greatest depth liable to be used as an anchorage. For any small boat in our service a 20 lb. anchor and 12 thd. (about 1 inch) Manila hawser should easily weather a hurricane. A boat should never go out at night without a good, well filled lantern. Many a boat has been run down through its inability to make its presence known. Before leaving the shore in foggy weather, provide the boat with some sort of a foghorn and a compass, and calculate as nearly as possible the bearings of the landing you wish to make. Take the opposite of this upon returning, making due allowance for tide and wind in both cases. To ride out a gale of wind in an open boat, lash the oars and grating, etc. together, making them into a bulky bundle and weight them if possible; span them with the painter and pitch them overboard. This will keep the boat's head to the sea and prevent her from drifting fast. Assist the boat to take the seas head-on by means of a steering oar. In rowing through a chop, where the rudder is apt to be pitched clear of the water, it should be unshipped and a steering oar used instead. Remember, in making a landing, that the heavier the boat is laden the longer she will keep her way.

If you are being towed by a steamer, make her give you a line, instead of using your own, and belay it so it can be cast loose in a hurry, if necessary. Carefully avoid weighing down the bow, and keep to a short tow-line, unless it is made fast along the tow boat's side. Never go close under a steamer's stern unless it is absolutely unavoidable.

Officers in boarding a war ship, use the starboard gangway, although they may use the port gangway. Enlisted men use the port gangway or the booms.

It seems almost unnecessary to state that the left hand side of a boat or ship, looking towards the bow is the "port" side and the other is the "starboard" side. The men who row on the port side are called the "port oars" and those rowing on the starboard side are called the "starboard oars".

Boat salutes.—The following salutes should be exchanged between boats meeting or passing each other. No junior should pass ahead of a senior without permission.

The junior should always salute first and the senior should return the salute by touching his cap.

Salutes should be exchanged whenever boats pass near enough to each other for the senior officer to be recognized, whether he be in uniform or not.

Officers without flag or pennant flying, though in uniform, and those in civilian clothes should be saluted with the hand only.

When a commissioned officer is in a boat and meets an officer in another boat ranking with or higher than his commanding officer he lays on oars and salutes. If the second boat contains some other commissioned officer ranking lower than his commanding officer, neither boat lays on oars, but they simply exchange salutes.

When a non-commissioned officer is in a boat and meets another boat containing an officer, he stands and salutes. If the officer in the second boat is of the same or higher rank than the commanding officer, the non-commissioned officer lays on oars in addition to the above.

Officers of the Navy and Marine Corps, and foreign officers in boats should always be saluted when recognized.

Coxswains in charge of boats shall always rise and salute when officers enter or leave their boats.

Boatkeepers shall stand up and salute officers passing in boats and remain standing until the boat has come alongside or passed.

Boat calls, etc.—In instructing the men, they should be divided into separate "crews", there being an extra man or two for replacing absentees. These crews should be given numbers, such as 1st crew, 2d crew, etc. Then, after the required number of men of the command have been instructed, the best should be selected for the permanent boat crews of the post, and given practice together. Each properly situated seacoast fort should have at least two permanent well drilled boat crews.

It is found convenient at most posts to have some call for assembling the crews. It is used in the same manner as "fire call" is, the men proceed to their boats as quickly as possible.

This call is sounded at "athletics" every morning, (if the rowing instruction is given them) in order that the men might become familiar with it. If there be more than one permanent crew, there could be one or more blasts blown at the end of call, to designate the 1st, 2d crew, etc., or whatever crew is to turn out.

PROFESSIONAL NOTES

SEARCHLIGHTS IN COAST DEFENSE

Translated by Captain Wirt Robinson, Artillery Corps, for the Military Information Division, General Staff.

The Russo-Japanese war will be fruitful in teachings. It will probably indicate the path into which henceforward the applications of science to war will have to be directed, and it will bring out new methods in attack and defense. Among the latter, one of the most important rests upon the employment of searchlights, valuable instruments, which from now on are indispensable in coast defense and which tomorrow perhaps will be so for armies in the field. This apparatus, however perfected it may be at the present time, is almost a new object from the point of view of the utilization which ought to be made of it. It is useless simply to state that its role is very important. Do all those who will have to use it know what are the best conditions for its use, what may be expected of it, and what should not be demanded of it? It does not come within the limits of this brief sketch to lay down these conditions. We wish simply to point out as examples the principles formulated on this subject by the English Regulations. But, before giving the text of these regulations, we are going to give a rapid outline of the general structure of searchlights and of the terminology employed in reference to them.

GENERALITIES ON SEARCHLIGHTS

A searchlight consists essentially of a strong arc light placed in front

Arc in focus.
Good adjustment.
Concentrated beam.

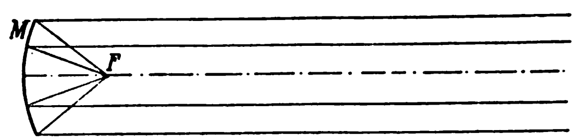

Fig. 1.

Arc too close.
Poor adjustment.
Divergent beam.

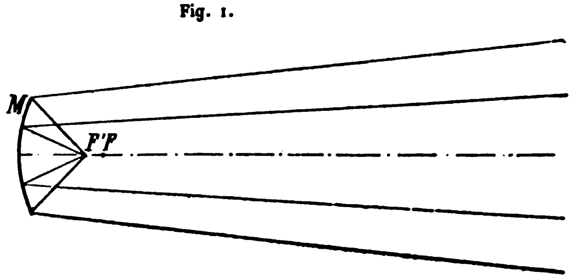

Fig. 2.

of a mirror (figs. 1, 2, 3). This mirror reflects the light and would give a luminous, cylindrical beam if the mirror were perfect and if the arc were a point located at the focus of the mirror.

Arc too far out.
Poor adjustment.
Divergent beam (interference).

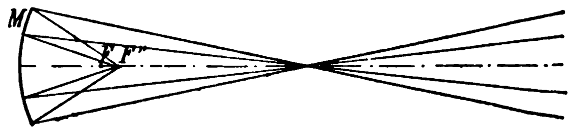

Fig. 3.

The mirror is held in a sort of drum closed in front by a door of plate glass. This glass has parallel faces, consequently the cylindrical beam remains cylindrical in traversing the glass. In front of this glass there may be placed, generally, a second one composed of prismatic strips which spread the beam in a horizontal direction.

It should be observed that the best possibly regulated beam is not cylindrical. At any point whatever of the mirror M (fig. 4) the incident luminous cone, whose base is the positive crater of the arc, gives a reflected

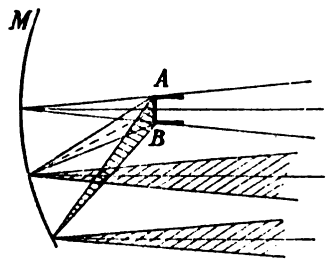

Fig. 4.

cone of the same divergence. The axes of all these elementary reflected cones are parallel to the axis of the mirror, but the angle of divergence of

Concentrated beam. (Is not cylindrical, on account of width of crater.

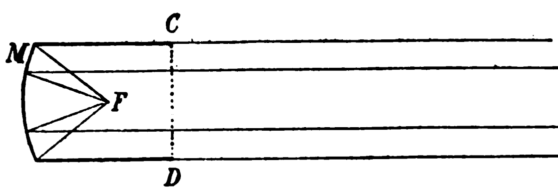

Fig. 5.

Dispersed beam. (In the horizontal direction only.)

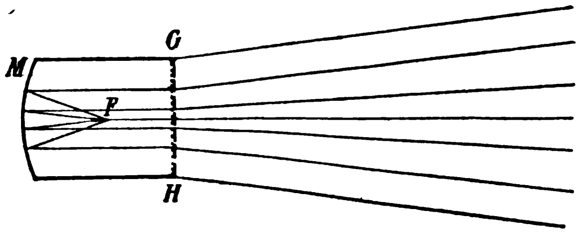

Fig. 6.

the beam is at least equal to the angle of divergence of the largest of the incident cones, which is the one whose vertex is on the axis of the mirror

In other words, the minimum angle of divergence of the concentrated beam is that subtended at the summit of the mirror by the positive crater.

According to the English Regulations: The *concentrated beam* is the well adjusted beam of the searchlight; the *dispersed beam* is the beam spread by means of the prismatic strips.

Terms which to us seem preferable are:

1.	Concentrated beam (fig. 1) Divergent beam (figs 2 and 3)	considered from the point of adjustment.
2.	Concentrated beam (figs. 4 and 5) Dispersed beam . . . prismatic strips of glass (fig. 6)	Considered from the point of tactical use.

The following is the chapter of the English Regulations*, which lays down the general rules for the use of searchlights.

SEARCH LIGHTS AND OBSTRUCTIONS

Electric lights will, as a rule, be used only in connection with defense against raiding attacks by torpedo boats and torpedo boat destroyers, or to aid in the defense of mine fields.

For the purpose of defense against raiding attack, lights may be either dispersed or concentrated beams. The former will be almost invariably fixed and used to illuminate only certain definite areas. The latter may be either fixed or search lights.†

Night attacks by large war vessels are not probable, and therefore the use of electric lights must be considered principally as regards their connection with Q.F. guns, and not as regards the heavy guns of a fortress, unless the latter are provided with special case shot for use against torpedo boats.

The effective range of electric lights is a matter which it is very difficult to settle definitely.‡ Much depends on the weather, the amount of dispersion given to the beam, the height at which the projector and the observer or guns are placed, and the position of the observer or guns with reference to the light. Experience has shown that the effective range of various lights, as regards the laying of guns, would be on an ordinary night without fog, on British coasts, approximately as follows:—

A concentrated beam	2,000 yards.
A 16° dispersed "	1,300 "
A 30° " "	800 "
A 45° " "	600 "

The light in each case is assumed to be near sea level and the observer about 50 feet above and close to the light. For purposes of observation only, the range of the lights will be about 50 per cent. longer than above. Thick weather renders electric lights almost useless, except at very close ranges, and for this reason would if possible be selected for attack.

It is therefore necessary that boats should be obliged, in order to push home their attack, to pass over water which is at close range from the

* "Garrison Artillery Training", 1904, vol. II.

† The roles of the two kinds of lights are quite distinct and appear quite reasonable.

‡ Trials (experiments) alone can solve this very important question of the range of search lights and fix the relation of the various factors which enter into play. Among these factors there is one especially interesting; it is the position of the observer with reference to the search light. Between the searchlight which illuminates and the gun which strikes the target, the observer is the intelligent organ which discovers and sees. Thanks to means of control from a distance, and especially thanks to the telephone, he may be considered as absolutely independent and the only care in the choice of his post should be that of seeing well.

electric lights. That fire may be effective under all conditions of weather, the range from the guns should also be short. To obtain these advantages for the defense it is generally necessary to narrow artificially the waters through which attacking boats must pass, or temporarily to close them altogether. This is done either by some form of permanent obstruction, such as breakwaters or piles, or by temporary obstructions, such as booms.* Where traffic demands it, which will be the case almost without exception, an entrance or gateway must be left, and this would probably be closed only at night. This entrance is likely to be a weak spot, and its protection will demand especial forethought and vigilance. The water in front of it, and of the obstructions generally, should be thoroughly well lit up, while the guns and the obstructions themselves should be in darkness. In the event of a boat being hung up in the obstructions, it should be possible to light her up. At the same time the locality of the obstructions should be in no way indicated by the disposal of the lights if it can be avoided. The disposition to be aimed at is such as will tend to conceal from the boats the positions of the guns until they open fire, and of the obstructions in general, and of the gateway in particular. Maneuvers have shown that boats, even when thoroughly acquainted with the port, are likely to experience great difficulties in finding their way, especially in thick weather, if proper dispositions are made. The inner edge of the illuminated water should almost coincide with the outer limit of the obstructions, otherwise boats which have succeeded in passing the light may attempt the destruction of obstacles under cover of the darkness, or, if brought up by the obstructions, may be out of view from the guns. A boat attempting to charge obstructions would invariably go at full speed, and if unsuccessful at the first attempt, must retire some distance in order to get up speed for a second rush. The arrangements of the lights should prevent the possibility of boats being able to do this unobserved.

Advanced concentrated beams, termed "sentry beams," and also search lights, are likely to be of great help to the defenders by detecting boats, and giving warning to the guns of their approach. The power of early detection which their use confers on the defense would also probably have an influence on the tactics of the boats by compelling them to pass at full speed through any waters which the lights may cover, and so further expose themselves to detection from the noise of their engines, and often from the flame at their funnels.

The continuous illumination which will be required of electric lights in war time imposes on them a task which peace maneuvers have shown them to be often unequal to. Occasional break down of individual lights is at present inevitable. Lights will therefore be disposed if possible in pairs, so that the temporary breakdown of one or two of them may not be so serious a disadvantage to the defense. The projectors of each pair should however be sufficiently far apart to prevent damage to both from a

* The English Regulations insist upon the employment of obstructions combined with searchlights. When one wishes to pick up a hostile vessel, one is immediately struck with the fact that the difficulty of finding it increases very rapidly with the angular extent of the suspected zone as well as with the distance over which the search is made. The use of obstacles, such as are described, is then logical since its object is

1st, to diminish the suspected zone,

2d, to diminish the distance.

But such an association requires a great supply of means to be employed and a great vigilance of personnel, and can be really effective only by use of rapid-fire guns.

single shell. A shell of the same power as that of the 4.7-inch Q.F. is probably the most powerful which need be considered in this connection, as guns of this caliber are the largest carried by craft of the class likely to be used in raiding attacks.

To sum up; we may draw from the provisions of the regulations the following principles.

The defense seeks especially to ward off attacks by torpedo boats or destroyers.

For this, it strives to restrict the accessible zones by obstructions.

Then it lights up clearly the approaches to the zones forbidden to the hostile vessels so that no vessel can approach without being seen. (Use of fixed lights dispersed or concentrated; use of concentrated lights as searchers at mean or short distance).

The defense likewise lights up the approaches to the open channels, (fixed lights, dispersed or concentrated).

The use of searchlights for this close defense is intimately connected with that of rapid fire guns.

Search at long distance is carried out by searchlights placed in advanced positions (sentinel lights, concentrated lights).

The searchlights in pairs is laid down with the object of reducing the chances of their being put out.

From the especial point of view of the use of the lights, the following rules must be remembered:

1st. The dispersed light is used as a fixed light at short distance to light up well defined zones.

2d. The concentrated light may be employed as a fixed light or as a search light.

Fixed light—at greater distance than the dispersed light, under the same conditions.

Search light—in forbidden zones, for search at mid distance.

3rd. Certain concentrated lights placed in advanced positions carry out search at long ranges. These are sentinel lights.

REMARKS ON THE ORGANIZATION OF THE PLAN OF ILLUMINATION OF A SEACOAST FORTICATION

There are found laid down in this chapter of the English Regulations the general rules for the use of searchlights.

We are going to try to bring out a particular point relative to the organization of the plan of illumination of a seacoast fortification.

It has been said that "boats are likely even when thoroughly acquainted with the port to experience great difficulty in finding their way if proper dispositions are made."

Further on, the regulations prescribe the doubling of searchlights on account of their inability to operate continuously for a long time, and in order that an accident happening to one of them may not cause a weak point in the defense. It is then necessary that the final plan should be drawn up with units in sufficient number so that if one should fail, its functions may be immediately carried on by one or several others. But also suitable dispositions must be taken to assure the hostile vessels the maximum amount of difficulties in the search of their route.

If the searchlights are established at fixed points, it is certain that after a few nights of attack the lights with which the coast is dotted will become familiar to the attacking vessels and will guide them like so many light houses.

On the contrary, if the lights have several positions to occupy at only some hundreds of meters distance, or if they are able to change their position, the aspect of the coast will vary constantly and the lights, having become essentially variable, will no longer guide the enemy. This result may also be obtained by doubling the lights, the same zone being lit up now by one, now by the other.

Searchlights have especially to fear fire against their personnel. Light shelters will be sufficient, for a searchlight being backed up by one or by several others will be able to escape shots by extinguishing.

There is a simple means of realizing these desiderata. The manufacturers can furnish groups of very mobile searchlights on wheels. Some of these groups added to the fixed lights would constitute a sort of mobile defense whose role would be precisely to change the aspect of the coast by inserting themselves in variable places from night to night. They would be, moreover, always ready to come and take the place of a disabled light.

Illumination by searchlights has become one of the important points in the defense of a fortress. It is therefore important that it should be assured in as regular a fashion as possible. One may conceive this illumination assured by certain searchlights solidly installed under armored turrets or under concrete shelters, others enjoying a certain mobility thanks to two or more combat positions, the whole being completed by essentially mobile lights, searchlights on wheels, which can easily be arranged on automobile carriages.

It must not be forgotten that a seacoast fortification includes also the defense of a land front, and to show the utility of the searchlight on this front we can not do better than to reproduce the following lines taken from the "Revue du Genie," February 1905, p. 157, which indicates the advantages which the Russians were able to obtain from their searchlights in the defense of Port Arthur.

"Night attacks having been numerous, searchlights have played a capital role. They have placed themselves in the same rank as machine guns, perhaps even above, if we may believe the impressions of a Japanese officer. One moment the light struck full in their faces, then it disappeared leaving them in a disconcerting and alarming obscurity. They could see nothing and had only the crackling of the enemy's musketry to guide their fire. They could do nothing against a defender who was sheltered behind a screen of light. They were forced to conceal themselves in the declivities of the ground where the rays could not reach them. A terrible fire burst upon them, a fire of musketry and machine guns which at this range and on open ground mowed down the ranks. The Japanese could see nothing and do nothing. Death was among them and they knew not how to escape it. Blinded and helpless, they knew not where they were nor where was the enemy. Everything was upset for them. The bravest found that there was but one thing to do, to flee from this massacre, to go far from this cruel light, into their camp, into the night, and into the darkness."

—H. V. Fournier, Captain of Artillery, in *Revue d'Artillerie*.

SUBMARINE EXPLOSIONS

When a solid explosive is converted into its products of decomposition—entirely or partially gaseous— the gases formed cool more or less quickly, according to the character of the material surrounding the charge.

It is known that an explosion comprises two distinct effects, viz., percussion and pressure, the former chiefly depending on the product of the rate of detonation and the amount of gases generated, whilst the latter varies with the volume of the gases, the temperature of explosion and the density of charging. The percussive force is not influenced by the material surrounding the charge, but the pressure is affected thereby through reduction of temperature and consequent checking of gaseous expansion. In conjunction with the resistivity, which is not considered here, however, this heat-absorbing influence of the surrounding material on the development of the gases has hitherto stood in the way of correctly gauging their effect, and it furnishes one of the reasons why universal power gauges have proved failures.

In Bichel's pressure gauge the test charge is exploded in vacuo and the surface influence of the firing chamber is eliminated by so varying the area of the latter as to enable an "ideal" (or "theoretical zero") pressure being arrived at. This apparatus is quite suitable for measuring comparative pressures of differing explosives, but if similar comparisons are required with respect to explosives fired under water, a modified contrivance must be resorted to.

An apparatus for measuring explosions under water has been constructed by Dr. Rudolph Blochmann of Kiel, and with his assistance the writer has recently had a similar submarine power gauge constructed and a large number of experiments carried out therewith.

The diagram obtained with Dr. Blochmann's dynamometer presents two distinct maxima, one of which he ascribes to molecular undulation, the other to mass movement of the water. During a series of experiments at Schlebusch the maxima were mechanically recorded as previously noted by by Dr. Blochmann, and led to closer study of the whole matter.

It does not appear to have occurred to Dr. Blochmann to trace the phenomenon to the nature of the explosion itself. But if the theory of distinguishing between percussion and pressure is applied to the diagrammatic records, it will at once be seen that what Dr. Blochmann calls "undulation" represents the percussive force or *vis viva* of the explosion, whilst the second maximum coincides with the pressure.

The percussive force, being a function of the rate of detonation and the molecular projection, acts during such an infinitesimal space of time on the surrounding water that the latter, without being set in motion, communicates the shock directly to the piston of the dynamometer, and the first deflection is thus registered. Immediately afterwards—at a distance of one meter from the exploding charge in about 1/20th of a second—the second maximum is recorded by the gas pressure meanwhile developed. The gases form very rapidly at the outset, but soon cool and condense through contact with the water mass and ultimately escape in bubbles towards the surface, throwing up large aqueous volumes.

It is not surprising that the general mass of the water is incapable of yielding to an impulse which is transmitted at a rate rate of some four to five miles per second. The effect of the percussive force is therefore felt as a molecular vibration. The formation of the gases proceeds at the rate of detonation and, initially, within the volume occupied by the explosive charge, but this volume is increased at the same rate as the water is forced back by the gas pressure. The expansion of the gases takes a certain time, likewise their cooling and escape, and these stages of action are, doubtless, represented by the second maximum.

If we compare the diagrams obtained under water with those obtained in the vacuum firing-chamber of Bichel's pressure-gauge we find that the latter show undulations (due to the tension of the spring) which gradually grow shallower until they ultimately merge into the straight line which indicates the final pressure of the cooled gases. An initial ascending curve represents the percussive force, whilst a tapering sinusoid illustrates the gradually decreasing gas pressure. In this case, the explosion occurring in vacuo, the percussion-line merges into the pressure-line without interval. In water, on the contrary, the two effects are very distinctly defined, as the explosion takes place in a medium possessing comparatively high inertia. The water resists the instantaneons impulse of the percussive force, but yields to the less rapid action of pressure due to gas expansion and contraction. Even on the shore, close to the place of firing, the two phases of explosions under water may be distinctly felt as separate concussions. If it is true that the heights of the diagram curves correspond to the percussive force and pressure respectively, then the first maxima must of necessity vary with the different rates of detonation, and the second maxima with the different pressures. Two explosives with different rates of detonation were therefore used by way of comparison, equal weights and a No. 8 detonator being employed in each case. Two dynamometers, diagonally

TABLE I.

Explosives	Weight of charge	Gravimetric density	Rate of detonation	Ordinates of the first maximum	Pressure by constant volume	Ordinates of the second maximum
	Grammes		Meters per sec.	mm.	kilogr. per sq. cm.	mm.
Trinitrotoluol— $C_6H_2(NO_2)_3CH_3$	500	1.55	7,618	28.0	12,385	29.5
Dry guncotton— $C_{12}H_{15}(NO_2)_{15}O_{10}$	500	1.25	6,383	27.5	11,127	30.0
Ammon-carbonite: 82% Ammonium nitrate, 10% Potassium nitrate, 4% Flour, 4% Gelatinised Nitro-Glyc.	500	1.19	3,094	17.0	8,345	19.3

facing each other, and having springs of different tension were used for each experiment. The distance from the centre of gravity of the charge to the piston of each dynamometer was one meter. In Table I. the ordinates of the diagram-curves with corresponding rates of detonation will be found.

The ordinates of the first maxima are not, of course, directly proportional to the rates of detonation. Direct proportion exists only in their relation to the percussive force values, which latter depend both upon the square of the rate of detonation and the mass of decomposition products. The second curve maxima, however, show direct proportion.

That the theory of two separate and different phases of explosion should have been confirmed by subaqueous shot-firing is of no little importance for determining the practical value of explosives in general and of such explosives in particular as are used for torpedoes, mines, and shells. In the following the question will only be dealt with as far as their latter application is concerned.

As already mentioned, the velocity with which an explosive flashes into gas, when detonated, is enormous and, in the case of some of the most brisant species, attains a rate of some 9,000 meters per second. It has been shown that the effect of this kinetic energy may be illustrated by firing the charges placed on lead discs which show more or less deep cavities according to the different rates of detonation. A number of similar experiments were carried out under water. The charges used were guncotton and trinitrotoluol, each occupying a volume of 450 cubic centimeters. The cartridges were placed in an upright position in the center of 20 centimeter steel plates. No attention was paid to weight, as, in the case of shells, mines, and torpedoes, the weight of the bursting charge is of less consequence than the maximum quantity which may be packed into a given space. Higher density of charging means increase of molecular mass, and, the velocity of detonation remaining unimpaired, consequently stronger impact against the surrounding walls—in this case, water.

Trinitrotoluol can be compressed to a density of 1.7. A volume of 450 cubic centimeters will thus hold a charge weighing 765 grammes, as against 540 grammes of guncotton having a density of 1.2. To this the superior effect of the former is partly due. Owing to the involved proportion existing between given distances from the center of gravity of the charge, and the corresponding explosive effect, it is of course essential that the shape of the receptacle holding the charge should remain the same.

Bearing in mind that a drop in the rate of detonation means a less destructive effect, and in view of the fact, confirmed by the dynamometer records, that the pressure is developed *after* the percussive force, it is obviously to the latter action, the *vis viva*, of an explosive rather than to concomitant pressure that its destructive properties are mainly attributable. Correct estimates in this respect may therefore be formed by comparing the first maxima recorded in the dynamometer diagrams, that explosive which shows the largest or dinates of the first maximum being the most suitable for the purposes of contact-demolition. In shells the higher density of any one of a given number of explosives, otherwise of equal strength, results in the production of a larger number of efficient fragments, those of lesser density giving larger and fewer pieces.

Before considering in detail the absolute and comparative results obtained from the experiments under water with explosives commonly used for military purposes, it may be well to refer in brief to their chief characteristics from a military point of view. *Guncotton* is so well known that it may be passed over without further mention than that the material used for these experiments was of the kind commonly supplied, and that it had a density of 1.21.

Picric acid possesses a very high potential, but has other properties of a less satisfactory nature. Both its tendency to enter into combination with metals and salts through mere contact, forming corresponding picrates, picramates and various reduction-compounds all of which are extremely sensitive and chemically unstable, and the poisonous vapors given off by it during manufacture and melting, are causes of unavoidable trouble and risk, and unless such direct metallic contact can be obviated or rendered innocuous, the employment of this material for military purposes is practically prohibitive.

Trinitrotoluol, on the other hand, has none of the disadvantages of picric acid, and, if chemically pure, *i.e.* with a melting point of 81° to 81.5° C., it is eminently suitable for military use, especially when compressed to a density of from 1.6 to 1.70. As has been stated already, this can be accomplished without diminishing its aptitude of detonation.

Chemically pure picric acid shows almost the same absence of sensitiveness as trinitrotoluol, yet the latter has proved itself to be the least sensitive of all known explosives. The accompanying table of results obtained with falling weights demonstrates this. It is obvious that this property is of considerable importance, as it implies freedom from "prematures" and general safety of handling with respect to torpedoes and mines. With a detonator containing 2 grammes of fulminate, embedded in a priming charge of loose crystalline trinitrotoluol, the detonation of the entire compressed bursting charge is perfect.

When chemically pure, trinitrotoluol may be stored with absolute safety for any length of time. During melting and compressing no noxious vapors are given off, and the material may be handled without any evil effects to the skin and respiratory organs of the workmen. It remains unaffected by direct contact with metals, even in the presence of moisture, and is absolutely test-proof, *i.e.* it parts with some of its nitrogen only when heated by a temperature considerably higher than its melting point. Lengthy exposure to the light causes a slight discoloration of the surface but the chemical stability remains unimpaired. Trinitrotoluol is insoluble in cold water; at a temperature of 40° C. minute traces only pass into solution. If the temperature of the water is raised to 90° C. the material melts; 1 litre of water will in that case absorb 1.25 grammes of trinitrotoluol. Being practically non-hygroscopic, it requires only such care in packing and storing as is usual exercised in the treatment of valuable goods. Unlike guncotton which readily absorbs water, compressed trinitrotoluol is impermeable thereto.

The frame used for the shot-firing trials under water at first carried three dynamometers, two of which were placed on the same level as the center charge, the third being suspended vertically above it. Ultimately, however, the latter apparatus had to be dispensed with as it gave unreliable results. Owing to insufficient depth of the water this dynamometer could not be lowered deeper than two meters below the surface, which caused

Table showing comparative sensitiveness to shock caused by falling weights.

Explosives	Weight=100 gr. Drop in cm. causing		Weight=250 gr. Drop in cm. causing		Weight=500 gr. Drop in cm. causing		Weight=1 kilo. Drop in cm. causing		Weight=2 kilos Drop in cm. causing		Weight=5 kilos Drop in cm. causing		Weight=20 kilos. Drop in cm. causing	
	Expl.	No expl	Expl.	No expl	Expl.	No expl.	Expl.	No expl	Expl.	No expl	Expl.	No expl	Expl.	No expl.
Nitroglycerine	10	5	5	—	5	—	5	—	5	—	5	—	5	—
Gelatine Dyn	10	5	5	—	5	—	5	—	5	—	5	—	5	—
Dinitroglycerine	15	10	15	10	5	—	5	—	5	—	5	—	5	—
Gel. Dyn. with do.	35*	30	20	15	10	5	5	—	5	—	5	—	5	—
Trinitrotol, cryst.	+200	200	+200	200	+200	200	190*	180	100*	90	60*	50	5*	—
do. compr.	+200	200	+200	200	+200	200	+200	200	160*	150	90*	80	5*	—
Picric acid, cryst.	+200	200	+200	200	+200	200	200*	190	110*	100	60*	50	5	—
do. compr.	+200	200	+200	200	+200	200	+200	200	150*	140	90*	80	5	—
Guncotton, dry	40*	30	20*	15	10*	5	10	5	10	5	5	—	5*	—
do. with 15% water	+200	200	80*	70	20*	10	20	10	15	10	10	5	5*	—
Fulminate of Mercury	10	5	5	—	5	—	5	—	5	—	5	—	5	—

* Partial explosion. No drop given under 5 centimeters. + 200 means more than 200.

the intervening water to escape upwards more quickly than in a horizontal direction and thus to produce irregular effects. The lower dynamometers gave fairly concordant readings. As it was only intended, in the first instance, to obtain comparative results, the springs of the apparatus were not graduated. This omission, however, will have to rectified in addition to certain other modifications of construction, in order to arrive at absolute values, both as regards the indicated maxima of percussion and pressure, and the time interval between two curves. Dr. Blochmann's apparatus was however constructed so as to release and start the revolving drum at the same moment as the shots were fired, an arrangement which could but result in variable rotary speeds and, consequently, in variable indications of time interval. The diameter of the drums likewise proved to be too small. These defects are, however, easily rectified.

The tabulated results (Table II.) demonstrate that the first (percussion maximum for trinitrotoluol is about 27 per cent and the second (pressure) about 7.5 per cent higher than those registered for dry and wet guncotton.

TABLE II.

Explosives	Gravimetric density	Volume of charge	Weight of charge	Ordinates of the first maximum	Ordinates of the second maximum
		Cubic cent.	Grammes	mm.	mm.
Guncotton, dry— $C_{12}H_{15}(NO_2)_{15}O_{10}$	1.20	450	540	31.5	35.4
Do., containing 10% of water— $C_{12}H_{15}(NO_2)_{15}O_{10}$ + 10% H_2O	1.20	450	594	31.0	35.0
Picric Acid— $C_6H_2(NO_2)_3$ OH ..	1.44	450	650	31.0	30.0
Trinitrotoluol— $C_6H_2(NO_2)_3CH_3$	1.61	450	720	39.9	37.8

These results tally fairly well with values previously obtained by theoretical calculation although the densities of the two explosives were in that case different from those now used. As certain fallacies are inseparably connected with the theoretical method of gauging phenomena of explosions it was deemed desirable to check the results by practical experiments under water.

Another means used for checking the correctness of these values was by lead-block expansion (Trauzl test), the rate of detonation as well as the temperature of explosion for trinotrotoluol, picric acid and guncotton lying within sufficient close limits to render this test reliably comparative. In order, however, to ensure perfect detonation of the charge which in the case of trinitrotoluol, would require a volume of at least 50 cubic centimeters, the standard dimensions of the Trauzl lead-block (20 centimeters by 20 centimeters) had to be increased, a ball-shaped block of 40 centimeters diameter and having a 30 millimeter bore-hole of half this depth, being ultimately employed. The charges were stemmed in the usual manner prescribed for

TABLE III.

Explosives	Density	Volume of charge	Weight of charge	Net expansion
		Cubic cent	Grammes	Cubic cent
Picric Acid	1.415	49.5	70	2,390
Trinitrotoluol	0.958	49.5	47.5	1,330
	1.415	49.5	70	2,250
	1.610	49.5	80	2,700
	1.718	49.5	85	2,873
Guncotton dry	0.475	49.5	23.5	230
	1.210	49.5	60	2,145
Ditto, with 7.4% of water	1.210	49.5	60	2,081

this test. As shown in Table III., the expansions obtained for trinitrotoluol of 1.61 density were 26 per cent larger than for dry guncotton and 30 per cent larger than for wet guncotton; with a density of 1.71 the superiority of trinitrotoluol over dry guncotton was even increased to 34 per cent. These results can easily be verified by repeating the Trauzl test with lead-blocks cast as above described. The depth of the furrow struck in the metal varies with the rate of detonation of the explosive.—*Marine Rundschau.*

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FIELD ARTILLERY REARMAMENT

England.—The process of re-arming the batteries in the Aldershot command with the new quick-firing guns is being rapidly completed, and guns are now being issued to other batteries at home. Recently four batteries of 18½-pounders for the field artillery, and six of 13-pounders for the horse artillery were issued. These guns, it is stated, were intended for India, but have been retained for home use. Altogether 150 of the new guns are still required to complete the rearmament of the batteries in India, but the gun factory at Cossipore is now turning out the new guns rapidly, and India will soon be independent of the home arsenals in the matter of artillery. Up to the present twenty-five batteries of the new field guns and three of horse artillery guns have been sent out to India, and the issue of these to the troops is being carried out as rapidly as possible. The rearmament of the artillery will, it is hoped, be completed earlier than was contemplated when Mr. Arnold-Foster made his original announcement on this subject. It is a matter for regret that the War Office has not adopted the suggestion made over a year ago by certain artillery officers of high rank, that single guns should be sent to certain stations for drill purposes, in order that the gunners might be competent to use the new weapons as soon as the batteries received them.

Germany.—The German press publishes information from Augsburg to the effect that the regiment of artillery of that city (4th Bavarian) received its new rapid-fire field artillery material with long recoil carriage on February 24, 1906. The 1st and 7th Bavarian (Münich) are already equipped with this material, and the 9th regiment (Landsberg) was to have received its equipment early in March.

This information, insignificant as it may seem, does not lack value, for it shows that the rearmament of the German artillery is much more advanced that has been supposed. It is proper to note, also, that the 10th Bavarian army corps, which has its headquarters at Münich, forms part of the second line. Moreover, if certain precedents are considered in this connection (adoption of the new rifle, the lance, revolver, carrying the saber on the saddle, etc.), it will be seen that Bavaria has always followed the change. In other words, the Bavarian army has always been served last.

It may be assumed, then, with almost complete certainty that the Prussian army corps have at the present time their complete equipment of the new material.—*Belgique Militaire.*

The *Vedette* reports that the new German field gun is lighter and therefore more mobile than the French one. The surface protected by shields is larger for the German than for the French gun; further, the German gun can open fire more quickly, as it is merely necessary to detach the limber, whilst in the case of the French material, the wheels must first be anchored. The ballistic capacity of the French gun is slightly superior to the German. The above mentioned journal adds that in Germany the material will be uniform for field and horse batteries, which is not the case at present in France.

A correspondent of the *France Militaire*, writing from Strasburg, states that the three German army corps in Alsace-Lorraine have received the new field guns, of which each battery has six. In addition, the 18th Corps at Frankfort, the 8th at Coblentz, and the 13th at Stuttgart, has received three batteries for each artillery regiment, but the whole should be supplied by the middle of May. General Stoetzer and the artillery generals of the army corps have been witnessing trials of the guns, which were said to have been very successful, though later reports seem to cast some doubt upon this matter. Officers who had confidence in the new engine, remarked that it was handled with ease, and that its aim was accurate, though its mechanism might be too delicate. Perhaps the latter point may have caused the trouble reported. Shortly after the maneuvers last year the artillery received the regulations and instructions for the new gun, which have been under study and trial with dummy mechanisms and trial pieces representing the mechanism and accessories of the new gun. Hence the artillery men were somewhat familiar with the new duties when the guns actually arrived.

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SOME POINTS RELATING TO STORAGE BATTERIES

Accumulators worked regularly under normal conditions will be in a healthier condition, and give longer full service, than others subjected to protracted periods of idleness. From the fact that most battery makers are prepared to enter into contracts for upkeep at rates varying between five and ten per cent per annum, according to size, service and locality, it can be accepted that the average life of a set of plates is not less than six years if the value of renewal sections throughout be taken roughly at one-half the original cost of the storage plant, and running expenses for periodical inspections be borne in mind. These inspections are to the best interests of both user and manufacturer, and of much greater importance than is usually realized. For the sake of saving on carriage, users often obtain acid of doubtful quality from the nearest supplier, preliminary analysis being dispensed with, while water of any kind is considered suitable for making good evaporation. No battery maker would countenance such risks. Even the best soft well water undergoes changes periodically and can not be strictly relied upon; with rain-water, everything depends on the district—where houses are in the vicinity of chemical works, or of the sea, the rain-water collected is decidedly unfit for use in a battery. Only pure distilled water (not condensed steam from boilers, hot water pipes, etc.) is really safe for the purpose, and to grudge this relatively small expense is the worst possible economy in the long run. All acid should invariably be ordered from the battery firm.

Limiting my remarks to the consideration of effects, produced or absent, according to the treatment of a battery by the user, one important point is to prevent the formation of white sulphate, $PbSO_3$, as distinct from the ordinary sulphate of lead, $PbSO_4$, which is the normal compound into which peroxide on the positives and finely divided lead on the negatives are converted during the discharge of a cell within the limits indicated by the makers. Below this safe point the action of the acid on the electrodes becomes greatly intensified; continuing discharge habitually beyond it, or allowing plates in a discharged state to remain standing for any length of time in an attenuated solution, are the surest ways to produce white sulphate. When this forms between the metallic conductor and the active material, it practically insulates one from the other and lowers capacity. Being extremely difficult to reduce, and more bulky than the active material, it follows that enormous strains will be thrown on to the frames of the plates if there is insufficient free space to allow for the expansion of the active mass. If sulphating be taken in time, prolonged overcharging at half normal rate will improve matters, but on no account should such overcharges become an institution. Against doctoring the electrolyte by the addition of sulphate of potassium, sodium, or of caustic soda, user can not be warned too strongly—this only leads to different and ineradicable trouble. Should any interruption occur in the course of the initial charge of a battery from a dry condition of the plates, notably during the first twenty hours—before the specific gravity of the electrolyte has begun to rise again—the plates are particularly prone to become badly sulphated, and much trouble may result. Professor Ayrton in one of his tests has found that when the peroxide on the positives had fallen to thirty-one per cent the cell very rapidly lost its electromotive force, which he attributed partly to the layer of sulphate excluding the mass beneath from further participation in the discharge and partly to the appearance of peroxide on the negatives. Herr Liebenow, on the other hand, has conclusively proved by very simple means that the rapid drop of pressure which determines the exhaustion *pro* *tem.* of a cell on discharge is almost entirely due to the want of free acid. By continually urging acid through the pores of the negatives on to the positives, thereby reenforcing diffusion while maintaining level and density, he obtained nearly three the normal capacity from the plates. During a rapid discharge, for instance, the SO_4 contained in the active material is used up at a much quicker rate than it can be replaced from the surrounding electrolyte. Hence the fall in pressure is sharp under continuous load, also, the recuperative effect is very marked when the current is interrupted, and the deficiency is made good by diffusion.

Coming now to the abnormal rise in potential difference, toward the end of the full charge, and the fugitive high voltage given by cells immediately on breaking the charging circuit, commonly called "gas effect," this has been found to be due to the presence of unstable products, such as ozone and persulphuric acid, which only make their appearance to be decomposed at once. This high voltage unfortunately is quite short-lived, and available only when a discharge is taken immediately on switching off the charging current. With the constant current method of charging the battery, the best charging rate to adopt is at or near the normal indicated by the makers. The effect on the electrolyte, without being violent, is sufficient to promote a healthy action and uniform density, enabling reliable hydrometer and voltmeter readings to be taken, useless and harmful overcharging to be avoided. Overcharging frequently goes hand in hand with a low charging rate. Ten per cent excess in ampere-hours over previous discharges is quite enough under ordinary circumstances, the charge being pushed on to a milky state of the acid, say, once every week or fortnight, and then continued for a length of time according to the depth of cells in use. Habitual overcharging is wasteful and decidedly detrimental, tending to cause excessive formation, to increase sediment unduly and thus to shorten the useful service of the plates, besides giving rise to violent spraying with its attendant evils if a high rate be maintained. When overcharging at a low rate is practised, the case is perhaps worse, because no outward manifestation takes place; formation of spongy lead on the negative plates then becomes the trouble, bringing complication in its train.

Prior to any prolonged period of disuse it is essential to give an abundant charge to the battery, so as to provide the conducting framework of the positive with an unbroken film of peroxide, thereby reducing local action to a minimum. This film ceases to be protective if even a short discharge be taken from the cells subsequently. It is therefore best under the circumstances to disconnect the leads at the battery terminals immediately the charge has been completed. To remove the acid from the cells, after due preparation of the plates, is unquestionably the safest plan of all to adopt in such cases, but this needs care and entails some trouble; moreover, the battery cannot be made available on a surprise visit. Some of the following rough battery data may be found useful on occasion: cells in glass boxes—weight in pounds, about one-half of ampere-hours at maximum capacity; space occupied—cells erected all on one level with narrow gangways, equals about three square feet per kilowatt-hour at maximum capacity. When glass boxes are used, "bolted" connections between cells have the preference to "lead-burned" joints, as the heat of the soldering jet, unless very carefully applied, is liable to crack the glass; besides nursing, repairs are rendered much easier with the former. Bolts and nuts must, however, be encased in non-corrodible metal, so as to afford thorough protection against acid spray.

Vitrified brick laid on concrete and grouted with pitch makes a good battery-room floor, which should have a suitable slope for drainage. Protect the battery from direct sun rays, but give the attendant the benefit of good day and plenty of artificial light, especially portable lamps. Except in very much exposed localities it is scarcely necessary to heat the battery room during mild winters; low temperature merely limits the capacity for the time being, but does no harm whatever to the cells. Let the cells be arranged all on one level if possible, with gangways at least wide enough to admit passing a carboy basket along. With glass boxes double tiers are admissible, but experience is altogether against placing cells beyond easy inspection and handling; also ample head room should be allowed above the cells. For battery pressure exceeding 250 volts the modern practice of double insulation—stands from earth and cells from stands—has effected a great reduction in the number of weak cells. Coming to accessories, trays filled with sawdust or sand are better for glass boxes than lead discs, as the latter do not evenly support the weight of the element. Hydrometers should read in single degrees, on an open scale. It is best not to allow them to remain in cells, where they are liable to become sticky and grimy after a short while, rendering them unfit for taking accurate readings. A neat and safe way of using a better class portable voltmeter with central zero, the needle swinging in a horizontal plane, is to attach the instrument to a short board, the lower side of which is provided with lead contact studs. By placing this board across the equalizing bars of a cell, a slight pressure downward will secure a reliable reading, which can be marked down at once on the note pad at the side.

When current to the lamps is invariable supplied from the battery alone, overcharging of end cells can be easily avoided. Not so when the dynamo is running part of the lights while charging the battery at the same time. Without adequate supervision some end cells, then, are liable to receive considerably more than their share of charge, while, if the outside load be heavy, the body of the battery may be kept short of current, possibly have to discharge occasionally. This destroys uniformity if it has not worse effects. Larger capacity cells for regulators are occasionally used to keep down the charging rate per positive plate, or paralleling several end cells on charge by means of a suitable switch to reduce their number and the charging rate for the regulators is equally effective. Counter-electromotive-force cells in one of the supply leads is another remedy and a good one, yet rarely adopted.

In modern cells, so much free space is provided for sediment that the necessity for its removal does not arise until the plates are worn out. The removal of sediment from older-form cells is best intrusted to the makers, as they keep a staff experienced in that work, and because much damage may be done by neglecting the necessary precautions. Great care is required during the removal of the plates from the electrolyte, as the negatives oxidize quickly, heat up and shrink when exposed to the atmosthere; it is important, therefore, to prevent their becoming dry. Failure to obviate this will not only entail a subsequent full deoxidizing charge of about forty hours before the cell will give capacity again, but in shrinking the active material is liable to lose contact with the conducting frame-work and to impair seriously the capacity of the negatives. For the removal of a few defective plates only in several groups utilize the good plates of one or more of these, putting entirely new groups into the latter cells. Old and new plates mixed in the same group do not divide the work equally, and then discharge into one another after the circuit has been disconnected. Such groups invariably go to pieces in a comparatively short time.

Celluloid or kindred substances are undesirable materials to employ in connection with storage cells, whether in the form of containing-boxes, separators, or envelopes. Their behavior is uncertain; notably in proximity to the positive element the tendency of celluloid is toward decomposition, and the eventual formation of sulphate. The introduction of board diaphragm separators, acting as a complete screen between plates of opposite polarity, marks a most important step in the right direction. By rendering it impossible for any treeing to occur, scale or foreign substances to become lodged in the open spaces between plates, the liability of individual cells falling far below par is practically excluded. There is no further need to peer into cells prospecting for possible shorts; the certainty that, by reason of efficient protection of electrodes, excrescences, if any, can not develop and do mischief renders supervision very easy. To keep the cells clean, acid level and density right is really all the attendant has to do in the battery room. An additional advantage of diaphragm separators is that by holding up the voltage they raise the useful capacity of cells. This effect is readily verified by exchanging forks or glass tubes for board separators in any cell of low capacity the plates of which are, however, mechanically in good condition; after only a few weeks' regular use this cell will have redeemed its character completely—very likely will have become the strongest one in the whole set. Electrolyte, liberal in volume, and of 1.215 maximum density only is used, and as no attendant troubles from carbonization of the wood or any other causes have been experienced in the course of five years' continuous emplyment under all conditions of work, board separators have fairly passed the period of probation.

—*Electrical Review.*

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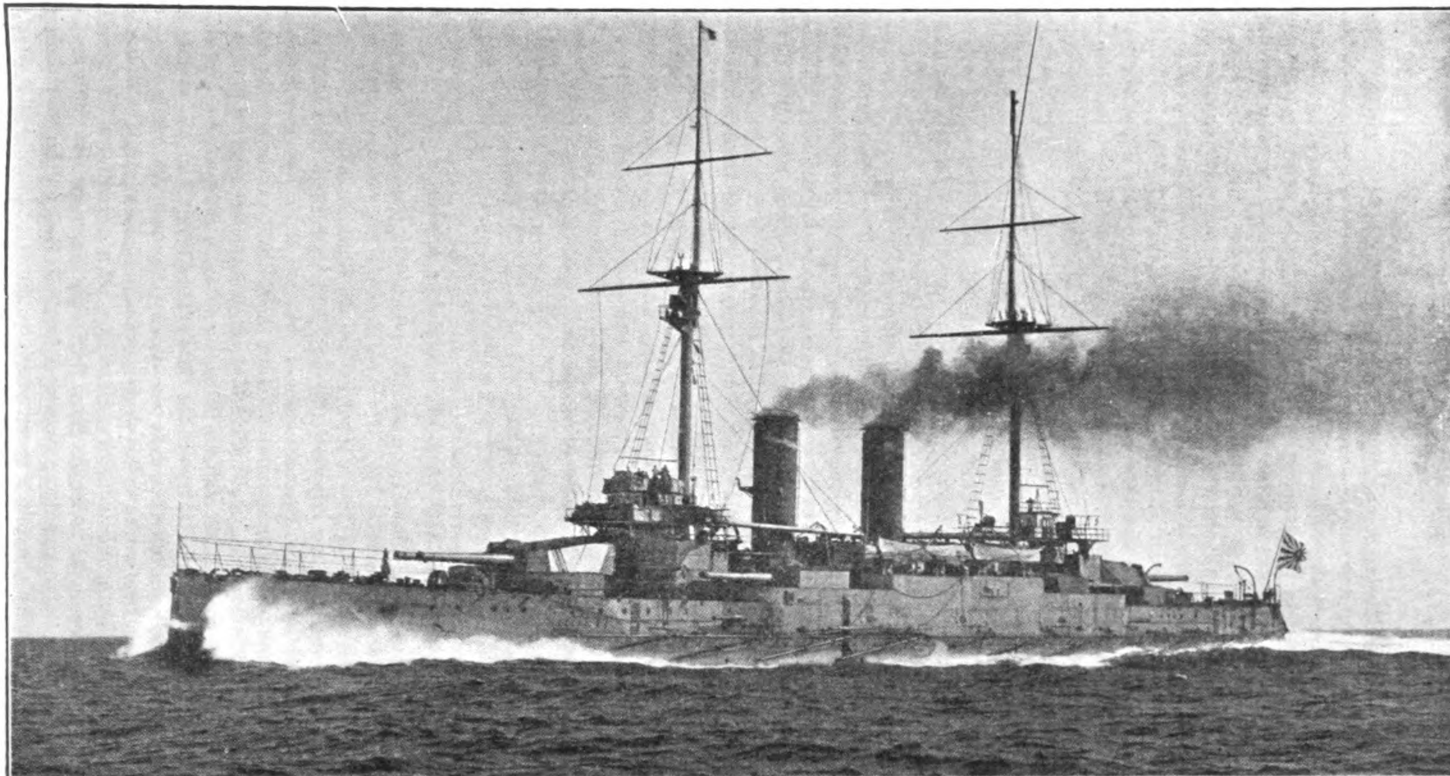
THE JAPANESE BATTLESHIP KASHIMA

The two battleships simultaneously ordered early in 1904 by the Japanese Government—one from Sir W. G. Armstrong, Whitworth, and Co., Limited, of Elswick, and now known as the Kashima, and the other from Messrs. Vickers Sons and Maxim, Limited, and called the Katori—have progressed side by side. The first named has completed her speed trials, while the second will soon go on her steam tests. Both ships will be commissioned in this country, and will sail in company to the Far East. They will form a most powerful addition to the war-worn fleet of the Mikado, representing, if not the last word in battleship design, at all events a splendid advance on even the ships of our King Edward VII. class.

The Kashima has a length between perpendiculars of 425 ft., a beam of 78 ft., and a depth, moulded, of 43 ft. 6 in.; with a mean draft of 26 ft. 7½ in., the displacement is 16,400 tons. At this displacement she carries 750 tons of fuel, but capacity is provided for 2150 tons. The machinery, was designed to give the ship a speed of 18½ knots.



JAPANESE BATTLESHIP KASHIMA

The armament, which is of most interest at the present time, is an improvement upon that in the King Edward VII. class. The vessels were ordered before the war, so that they do not embody such lessons as the operations may have suggested to the Japanese; they are rather developments of British designs. There are four 12-in. breechloading guns, two mounted in a barbette forward and two aft, while at the four corners of the citadel there are separate 10-in. guns in barbettes. Amidships on the upper deck there is a 6-in. gun on each side, and within a box battery on the main deck five 6-in. guns on each side, making twelve in all. This, it will be recognized, is a more powerful armament than in the King Edward VII. class, which have only four 12-in., four 9.2-in., and ten 6-in. guns, and moreover, each weapon of the Japanese ship is of greater power. In the later ships the Japanese have dispensed with the 6-in. gun entirely, and in addition to four 12-in. guns, have a secondary battery of 10-in. weapons. The machine guns of the Kashima include twelve 12-pounder quick-firing guns, three 3-pounders, and six Maxim guns, while for firing 18-in. torpedoes, there are five submerged torpedo tubes, which, during the trials, proved efficient when fired with the vessel steaming at 15 and 17 knots.

As to the armor, the water-line belt in the center part of the ship is 9 inches thick, tapering by easy stages to 4 inches at the bow and stern. The next strake, protecting the citadel containing the 6-in. guns, is of 6 inch thickness, and the armor for the upper deck battery is of 4 inches. The 12-in. gun barbettes are of 9-inch armor for the most part, and 5 inches where the walls are otherwise protected by bulkheads or broadside armor. The 10-in. gun barbettes are of 6 inches reduced to 2 inches behind the bulkheads. The conning-tower has 9-inch armor, and the observing-tower which is located above the conning-tower, 5-inch armor.

The triple-expansion engines have cylinders which are respectively 36 inches, 56 inches, and 63 inches in diameter, with a 48-inch stroke. Steam is supplied by twenty water-tube boilers of the latest design of the Niclausse type, the total heating surface being 42,960 square feet, while the working pressure is 430 lbs.

The trials were carried through in a remarkably short period of time. They commenced with a preliminary run and were completed in six days. In the first place, a series of progressive speed trials were made over the course, with the average results tabulated below; to these we have added speed results of 24 hours' trial, and the 8 hours' full-power trial, in order to complete the progressive speeds of the vessel.

Revolutions per Minute.	I.H.P.	Speed Knots
69.5	3030	11.136
89	6275	14.27
102	9160	16.323
110	11,400	17.204
113.6	13,000	18.
123	17,280	19.242

The results at 18 knots represent the mean performance during the 24 hours' trial at fourth-fifths full power, which is supposed to give the continuous steaming performance of the ship, while the details for the 19.242 knots are the average results attained during four runs over the measured course, while the vessel was running her full-power trial of eight hours' duration. Following upon the four hours, she continued at the same revolutions until the end of the sixth hour, when the engines were speeded up to nearly 125 revolutions, and this continued for two hours; the average speed during that period was probably 19½ knots. In any case, the speed results are exceptionally favorable; the contract required 18½ knots, with the engines indicating 15,600.

As to coal consumption, the results were thoroughly satisfactory. The gun trials were also carried out while the vessel was at sea, three rounds being fired from each of the large guns, when trained at an angle estimated to impose the most severe test upon the structure of the ship and the gun-mountings. The only effect was the usual breaking of some glass and minor fittings. It is anticipated that this vessel will leave by the end of May, so that from the date of the laying of the keel until the delivery of the ship only two years and two months will have elapsed.

—*Engineering.*

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FRENCH ARMORED CRUISER ERNEST RENAN.

On April 9th the French armored cruiser Ernest Renan, the largest and most powerful yet laid down in France, was launched at St. Nazaire.

The general dimensions and features of this armored cruiser are as follows:

Length at load water-line - -	157 m.	515 ft. 1 in.
Breadth, extreme, at load water-line -	21.36 m.	70 ft. 1 in.
Displacement on trials - -	13,644 tons.	—
Gross draft, fully loaded - -	8.18 m.	26 ft. 10 in.
Total bunkers capacity, coal - -	2,300 tons.	—
Coal carried on trials - - -	1,354 tons.	—
Trials at sea for three hours - -	23 knots.	—

The hull is of steel throughout, fitted with docking and bilge keels. It is protected at the water-line by a complete belt armor of 3.70 m. (12 feet 3 inches) in width, having a maximum thickness of 150 mm. (6 inches) for about 90 m. (296 feet) amidships, the thickness being gradually decreased to 100 mm. (4 inches), and 80 mm. (3.2 inches) at the stem and stern. The two strakes of the belt side armor extend from 1.40 m. (4.5 feet) below the water-line to 2.30 m. (7 feet 7 inches) above the same, from the lower to the upper protective decks. The heavy belt side armor strake has a maximum thickness amidships and at the water-line of 150 mm. (7 inches), and this thickness is gradually reduced to the lower edge, where it is only 129 mm. (5.2 inches), and from amidships to the ends where the thickness is 100 and 80 mm. (4 inches and 3.2 inches); the second strake is 130 mm. (5.2 inches) thick amidships, and only 80 mm. (3.2 inches) at the stem and stern. Astern the belt side armor extends only a few feet aft of the rudder, and there an athwartship armored bulkhead extends to both sides and from the lower to the upper protective decks. An armor strake extends from the stem to the fore casemates, and reaches from the top of the water-line belt to the lower edge of the gun deck, and is 56 mm. (2.2 inches) in thickness.

There are two armored athwartship bulkheads extending from the shell plating at the ends of the casemates to the 194 mm. (7.7-inch) barbettes, and 150 mm. (6 inches) thick throughout. There are two protective decks tending from the stem to the stern, the lower deck being flat amidships, but sloped at the sides throughout and at each end. It will be built of 38 mm. (1½ inch) plating throughout, with nickel steel of 46 mm. (1.84 inches) on the flat, and of 63 mm. (2½ inches) on the slopes. The upper protective deck is flat, and will be built of 38 mm. (1½ inch) double plating. The axis of the lower protective deck is about at a level of the load water line; at the side it is at 1.4 m. (4.5 feet) below it, at the level of the lower edge of the belt side armor. The side protection is completed by a cofferdam extending from the upper protective deck level to the lower protective deck level, and worked from end to end of the vesel. Behind this cofferdam there is a water-tight bulkhead worked from stem to stern; the space between the cofferdam and the water-tight bulkhead is used in its upper part as a passage for repairing breaches in the cofferdam, and in its lower part as a waterway for the water coming through the breaches. Teak backing is fitted behind all side armor. The space between the belt side armor, the water-tight bulkhead and cofferdam, and the two protective decks, is called "la tranche cellulaire de protection"; its numerous compartments are either empty, or packed with cellulose or other approved water-excluding material, or filled with coal, fresh water, &c. The ammunition passages, funnels, air pipes, &c., going through the "tranche cellulaire" are protected by an annular cofferdam extending from the lower to the upper protective decks. Above the upper protective deck is the "gaillard deck," or gun deck extending from stem to stern; above this deck is the spar deck, extending from the stem to the astern turret. On the spar deck is a large bridge.

The conning-tower is on the bridge deck, between the fore turret and the fore mast. The conning-tower and shield will have a thickness of 200 mm. (8 inches). An armored tube 890 mm. (35.6 inches) in diameter will extend from the base of the conning-tower to the protective deck and will be 125 mm. (5 inches) thick throughout.

There will be forty-two boilers of the Niclausse type, placed in water-tight compartments. There will be six funnels, each 21 m. (69 feet) above the grate level, and 6 m. (20 feet) in diameter.

The coal bunkers are to have a maximum capacity of about 2300 tons. With the ordinary load of 1354 tons the steaming radius will be at 10 knots 7500 miles, and with 2300 tons 12,000 miles. At full speed the steaming radius is to be 1026 and 1630 miles respectively with ordinary and maximum bunkerage. A certain quantity of liquid fuel will be shipped in special tanks and in the double bottom.

All the the compartments below the upper protective deck, except the coal bunkers, will be provided with forced draft ventilation, there being a number of blowers arranged for this purpose. Special attention will be given to spaces subject to habitually high temperature, such as the engine-rooms, boiler-rooms, and dynamo rooms. All the blowers, except the forced draft blowers, are to be electrically operated.

The electric plant will consist of four dynamos. The armament will consist of four 194 mm., say 7.7-inch, twelve 164 mm., say 6.5-inch breech-loading rapid-fire guns, twenty-four 47 mm., 3 pounder rapid-fire guns and three 37 mm., 1 pounder rapid-fire guns. The battery will be mounted as follows:—The 194 mm. guns in pairs in two electrically-controlled, balanced, elliptical turrets on the center line, one forward on the spar deck, the other aft on the gun deck. The 164 mm.

guns, of which eight are in electrically-controlled, balanced, elliptical turrets on the spar deck side, four on the port and four on the starboard side, two at each end of the superstructure. The 194 mm. barbettes extend from the protective deck to the spar deck for the fore barbette, and to the gun deck for the aft barbette, and consist of 160 mm. (6.4 inch) armor in front, and 120 mm. (4¾ inch) in the rear; the barbettes will not have any special framing, the connection of the armor with the decks being sufficient. The turrets will have a front plate 160 mm. (6.4 inches) thick, rear plate 120 mm. (4¾ inches) thick, and top plate 39 mm. (1.6 inch) thick, with the upper tube 80 mm. (3.2 inches) thick, and lower tube of 30 mm. (1.2 inch) in thickness.

The 164 mm. (6.5 inch) barbettes will be 140 mm. (5½ inches) thick in front. and 100 mm. (4 inches) in the rear, with the upper tube, 70 mm. (2¾ inches) thick, and the lower tube 20 mm. (.8 inches) thick; the turrets will have front plate 140 mm. (5½ inches) thick, the rear plate of 100 mm. (4 inches) and top plate plate 39 mm. (1.6 inches) thick.

The armor casemates extend from the top of the water-line belt to the lower edge of the gun deck for the forward casemates, and are 140 mm. (5½ inches) in thickness; the athwartship bulkheads at the end of these casemates extend from the shell plating to the 194 mm. (7.7-inch) barbettes, and are 164 mm. (6.6 inches) thick throughout. The casemate armor around the 164 mm. (6.5 inch) guns on the gun deck is of nickel steel, the front plate is 140 mm. (5.6 inches) in thickness; the splinter and inner plates are 60 mm. (2.4 inches) thick, the floor and top plates are 30 mm. (1.2 inch) thick.

The casemate guns are arranged to fire right ahead and right astern respectively. Two 7.7 inch guns and six 6.5 inch guns will fire right ahead or right astern, and four 7.7 inch guns and six 6.5 inch guns will fire on the broadside. There will be six 3-pounder guns on the gun deck, ten of the same size on the spar deck, and eight on the bridges. There will be two submerged torpedo tubes of 18 inches in diameter.

Magazine bulkheads adjacent to heated compartments, such as fire-rooms, engine-rooms, dynamo rooms, &c., are provided with air spaces. The shell rooms for the 7.7-inch guns are at the foot of the barbettes; the magazines and shell rooms for the 6.5-inch guns and small guns are between the main engine and fire-rooms compartments, and are so arranged that about one-half of the ammunition will be carried at each end of the ship. The ammunition will be conveyed directly by hoist from the ammunition rooms, or ammunition passages, to the deck where they are required, or as near that as possible. The hoists will be driven by electric motors; for transporting the ammunition, trolleys on rails will be provided in the handling rooms, passages, and shell rooms.

There is a lower bridge forward and aft, and a flying bridge forward. On the flying bridge forward and the lower bridge aft there are chart houses. There are steel masts forward and aft, the fore mast having an upper and lower top; there is one signal mast, also a searchlight platform forward and aft, and a crow's nest on the forward mast only. Two search-lights will be fitted forward on the gun deck, and two others on the main deck aft. The crew will be composed of 31 officers and 643 men. The vessel will, it is said, be delivered to the navy on the 5th of August, 1908.

—*The Engineer, London.*

Short Notes

For the new explosive called "Axite" it is claimed (1) that the muzzle velocity is increased by some 400 feet per second, (2) the trajectory is lower, (3) the pressure on the barrel is reduced, (4) erosion and corrosion are greatly diminished, and the life of the weapon, be it rifle or heavy gun, is increased.

Six submarine depots are to be established at convenient points around the coast, each of which is to be provided with a depot ship of high speed and a torpedo boat as a tender. The whole submarine fixed mine service on the British coasts has been disestablished during the past few months, and the equipment, taken over by the navy from the military authorities, has in large part been found unserviceable. Naval officers will in future be charged with the entire responsibility for the defense afloat of our great naval bases and national harbors.—*Page's Weekly.*

The taking over of the submarine equipment by the navy from the army has put a stop to the old division of authority which existed between the sister Services, and the Admiralty are now busily engaged in accelerating their plans for establishing six bases for submarine craft at various convenient stations on the coast line. All the preliminaries in connection with the creation of a depot at Portsmouth have been completed, and the work is now fairly in hand; a depot is being formed at Plymouth to enable the submarines to command the approach to the naval anchorage at Devonport. Another depot will be initiated before the end of the year at Dover, where a floating dock will also be stationed, and accommodation provided for dealing with minor repairs, and for storing petrol. In addition to these, three other depots are to be established, and these, in all probability, will be located on the East Coast—one being at the Nore. The intention is that eventually there shall be six thoroughly equipped naval bases for submarines, and that each shall be provided with a depot ship of high speed, with a torpedo boat as tender.—*United Service Gazette.*

The schools of submarine mining for Royal Engineers at Portsmouth, Plymouth, and Sheerness cease to exist, and schools of electric light are to be established for the corps at these stations in substitution thereof.
—*United Service Gazette.*

According to the scheme now sanctioned, a proportion of the officers R. E. in each fortress or defended port will undergo special training for work in connection with electric lights, Brennan torpedo, telephone and machinery duties. In the same way non-commissioned officers and men will undergo elementary courses in these duties, a proportion—some 50 or 60 per cent—being trained as electricians, engine-drivers, Brennan workers, instrument repairers, &c. The instruction of officers and young soldiers will be carried out at the Schools of Electric Lighting at Portsmouth and Plymouth. All young soldiers before transfer to these schools will be required to undergo a course of 10 weeks' instruction in field work with the Training Battalion R.E. Having acquired a rudimentary knowledge of field sapper's duties, they will attend a coast defense course, which will last from four to five months. During this time they will be made thoroughly acquainted with the use of ropes, chains, blocks, and tackle in the first instance, and afterwards of boats and their stores, cables, electric wires, and electric light gear, telephone work, engines, and signaling. It will be then left for the fortress sapper to elect to what particular branch he will be attached as a specialist. He can become either an electrician or an engine-driver, and he will be allowed to say for himself which he prefers. As an electrician he will have to undergo a five or six months' course; as an engine-driver a nine months' course; but it is stipulated that no man shall proceed with his training after going through the earlier stages unless he shows special aptitude for the employment.

For all specialists and for electric manipulators there will be a series of lectures and practical instruction throughout the year, designed to give higher theoretical and practical knowledge in the branches of work for which the men have been trained. An annual training of 12 days' manning of all lights is to be arranged for either in one period or two as the exigencies of the service may permit. The annual training is to coincide with the manning of fortresses by the Royal Garrison Artillery and work in conjunction with the Royal Navy.—*Army and Navy Gazette.*

Information received at Dover from an official source states that 70 torpedo craft will have their headquarters in the naval harbor as soon as the southern breakwater is completed next year.

During the gunnery trials of the new armored cruiser Duke of Edinburgh, structural weaknesses were developed in the vicinity of the base of one of the heavy guns, and the "bed" was also so seriously damaged that additional supports will have to be put in. The staff of the Gunnery School at Portsmouth have now made a thorough examination of the whole of the armament, and they are quite satisfied as to the safety of leaving the six 9.2 inch guns on the upper deck. It was, however, found that the ten 6-inch guns on the main deck were so close to the water-line as to render it impossible to fire them in a heavy seaway. The gunnery staff have considered the advisability of putting these on the upper deck, as those of her sister ship, the Warrior, are being placed. It is understood that this will be done after the maneuvers, in which the Duke of Edinburgh is to take part.

The average speed of warships is rapidly increasing, says *Cassier's Magazine.* Excluding torpedo craft, the warships built and building for the several powers in July 1, 1899, had a mean speed of 16.92 knots. This figure has become successively 17.24 in 1900, 17.49 in 1902, 18.17 in 1903, 18.39 in 1904 and 18.71 in 1905. This increase of nearly 2 knots is due largely to the construction of large numbers of large armored cruisers, most of which are capable of steaming 22 knots or over, while the building of smaller and slow ships has heavily decreased. The mean speeds of the warships of the eight greatest naval powers in 1905 were:—Great Britain, 19.82; Japan, 19.41; Italy, 18.79; Austria, 18.65; United States, 18.64; France, 18.56; Germany, 18.18, and Russia, 17.29 knots. The fastest navy is that possed by Chili, which, with only eleven ships, largely very swift cruisers, has a mean speed of 20.71 knots.

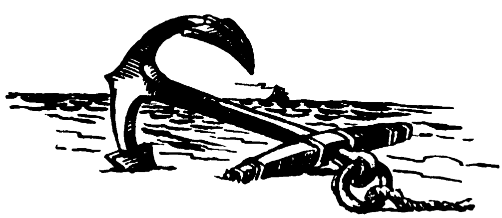
British armored cruiser, Minotaur.—The armored cruiser Minotaur will be launched on June 23. This vessel was begun January 2, 1905, at Devonport, and belongs to the class comprising the Shannon, laid down at Chatham in January 1905, and the Defence at Pembroke, February 22, 1905.

The armored cruisers of this class have the following characteristics :—14,600 tons displacement; length, 490 feet; beam 74 feet 6 inches; mean draft, 26 feet—except in the case of the Shannon, which is to draw only 25 feet, and has 1 foot more beam than her sister ships. The stern is of special design, with very long counter, and the rudder is in two parts. Forward the ship is like the Natal, with high freeboard, and this superstructure extends aft on the sides, from about 35 feet from the bow to the large turrets aft. There are two masts with range-finding tops and four funnels, arranged as in the Warrior class.

The armor protection consists of two complete belts of Krupp face-hardened steel, one above the other, both 6 inches thick amidships. The lower belt is 4 inches thick at the bow and 3 inches at the stern; the upper belt is 2 inches at its extremities. The armored deck, of Krupp non-cemented steel, is 2.5 inches on the slopes, 1.5 inches on the flat. The large turrets have 8-inch armor, and conning-tower, 12-inch.

The armament comprises four 9.2-inch, 50 caliber guns in pairs in the main turrets, ten 7.5-inch 50 caliber guns mounted singly in closed turrets five on each side, and twenty-four 3-pounders. It is probable that the majority of these latter guns will be replaced by 12-pounder guns of new design. There are three submerged torpedo tubes, two forward firing ahead, and one in the stern.

The estimated speed is 23 knots with 27,000 I.H.P., to obtained under forced draft in the case of the Shannon and Defence and under natural draft in the case of the Minotaur.—*La Yacht.*



BOOK REVIEWS

A History of Tactics. By Captain H. M. Johnstone, R. E., Ret., (Military Lecturer at Edinburgh University). 4+220p. 27 maps. 10 x 7½. London. Hugh Rees, Ltd., 124 Pall Mall, S.W. 1907. 15 s. net.

The author confesses to some diffidence relative to the rather ambitious title of his book, nevertheless, within the limits he has set, it accurately describes the nature of this work which gives the reader a clear and interesting account of the stages of the development of the methods of tactics, illustrated by a wealth of example from the time of Frederick the Great to the present day. It is not at all a book in which the aim is to argue out the correctness or incorrectness of the tactical ideas employed in different wars. Nor, on the other hand, is it a mere chronicle of what soldiers have done. Its chief aim is to present the development of methods of actual fighting both in attack and defense. The author succeeds in doing this very satisfactorily. He utilizes brief descriptions of typical battles to illustrate the tactical methods of a period, presents the opinions of noted writers of the past with reference to the art of war at these various stages, and gives pertinent comments of his own, limiting them to what is necessary to bring out the main points in the use of cavalry, artillery and infantry, and to give a clear and intelligent discussion of the evolution of tactics.

After a short introduction leading up to the time of Frederick the Great, we have the tactics of Frederick's time, with its extreme rigidity yet wonderful discipline, drill, and training that enabled him to accomplish so much over his opponents. The battles of Hohenfriedberg and his remarkable battle of Soor serve as illustrations here. The French then begin to adopt freer formations and with Mesnil-Durand's system of battalion drill we see the beginning of skirmishers. Several chapters are devoted to the French Revolution and Napoleon, examples of Napoleon's battles, and the state of tactics in Napoleon's time and after. A chapter on the British in the Peninsula (1809) is followed by a good discussion of Gettysburg and cavalry developments in the War of Secession, showing the new and novel methods of fighting brought in at that time yet which were not taken to heart by European armies until after 1870-71. Then follow the wars of 1866 and 1870, with accounts of Sadowa, Trautenau, Gravelotte, Sedan, etc., including also the second period of the Franco-German war. The Russo-Turkish war next receives careful consideration. Two excellent chapters treat of tactics as exemplified by "Small Wars" and "Desert Warfare",—campaigns in which the British army has had so much fighting to do.

Finally, the Boer war and the last great military drama, the Russo-Japanese war, are dealt with. The latter is simply sketched, to include the battle of Liaoyang, but the descriptions of the battles of the former, followed by the author's comments and the general remarks on this war, present a clear picture of the new things that were seen in the domain of tactics and of the new things that were done in consequence, with their bearing on tactical ideas. In a very interesting final chapter on "The Present Day", the author sums up to see where we stand as regards tactics, taking as a guide the most recent editions of the official text-books on Tactics and Training. He takes up the three arms combined, and also considers each separately giving the latest views on their employment.

There are 27 maps accompanying the book, illustrating the battles and movements described in the text. They are clear and simple and show the disposition of the troops at that hour which best illustrates the matter under discussion,—a critical moment being chosen, or one showing some typical action in offense or defense.

Captain Johnstone has treated his subject not only thoroughly but entertainingly. His comments are refreshing and to the point and he has arranged his facts and opinions in such a way as to make a very readable and valuable book for all officers and others interested in the Art of War.

The Battle of Mukden, with eight maps and two appendices showing composition of both armies. (A supplement to the "Militaer Wochenblatt"). To which has been added an essay: Comments on the Battle of Mukden. Authorized translation by Karl von Donat. 72p. maps. 8¾ x 6. London. Hugh Rees, Ltd. 124 Pall Mall, S.W. 1906. 6 s. net.

English readers are to be congratulated on having presented them in excellent form this admirable account of this great battle. Notice of the original was made in the September-October JOURNAL, 1905, but the English translation has been increased in value by the incorporation of Lieut.-Gen. von Caemmerer's essay "Comments on the Battle of Mukden".

The battle of Mukden was the biggest of all the fights in the Russo-Japanese war, both as regards duration and the numbers concerned. All the modern appliances for war and the latest principles of tactics have been tested in that battle; therefore the description of it by the most competent critics in the world—the German General Staff—is highly instructive and gratifying, and forms a valuable basis upon which to form a just criticism of the conduct of war. The description itself is short, only 45 pages, and throughout is confined to a terse narrative of facts, avoiding every kind of reflection; but it is by far the best that has hitherto appeared.

The eight maps at a scale of 1:168,000 present most vividly to our eyes the grand struggle of 310,000 men on either side during a battle of twelve days' duration; the characteristic features of every phase of the fight can be easily followed, and when placing side by side the various sheets, we clearly discern the progress of events from day to day and how a great international event gradually came to its final issue.

As claimed by the translator, the book forms an admirable example of how to study the outlines of a great battle and the comments materially assist the student in analysing its various features.

Guide to Military History for Military Examinations. Including Notes on the Military Geography required. Part I. Peninsular War, 1808-10; Part II. 1811-13. By Captain G. P. A. Phillips. 10+101 p. & 10+190 p. maps. 7¼ x 4¾. London. Gale & Polden, Ltd. 2, Amen Corner, Paternoster Row, E.C. 1906. 3s. each.

The increased importance given to military history in the various examinations for promotion in the English service at once led to the production of a number of manuals and text-books designed to assist the student in preparing therefor. This is avowedly the aim of this book, the author stating that his object has been to act merely as a guide through the long and difficult paths of the great works written on the subject.

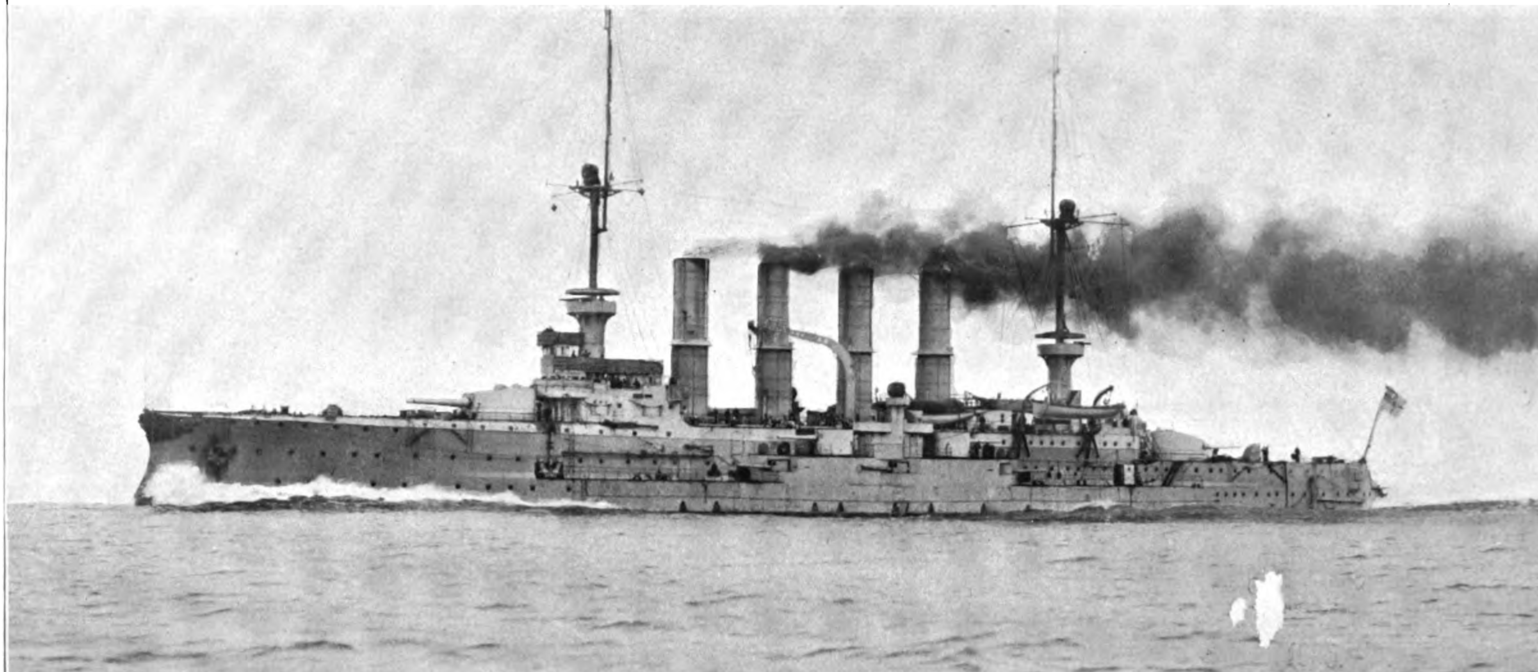
While such intentions may be wholly commendable, the resulting compilation, as a short cut to knowledge, is usually open to a number of objections. Such books undoubtedly supply a want for those imbued with the "automatic examiner" idea; for ourselves we prefer the systematic study of standard authorities. Such aid, as this book affords, facilitates ready preparation in amassing sufficient knowledge of the subject for the special purpose without devoting to it the time and analysis that the proper study of military history, for example, demands, but the important question is how much thorough knowledge of the subject is retained afterwards.

The book is extremely condensed, and it suffers in places in consequence; yet the arrangement is good for its purpose, and many of the author's observations and comments are excellent. The best feature of the work is its many excellent sketch maps. There are 13 in Part I. and 12 in Part II. They show in colors the various positions of troops, directions of troops, land features, etc., and would prove of value in any study of any of the campaigns discussed.

Manual of Bayonet Exercises and Musketry Fencing. By Captain Herschel Tupes, 1st U. S. Infantry, and Sergeant Sylvester Poole, Company D, 1st U. S. Infantry. Ed. 1. 6+111 p. 5¾ x 4. New York. John Wiley & Sons. 1906. Leather, 50 cents net.

This is a handy little book containing a very complete system of bayonet attack and defense, and furnishing many excellent explanations and suggestions regarding training in acquiring skill and dexterity in the use of this weapon. One criticism is that, perhaps, it is too elaborate. The left guard is taught as fully as the right, a number of movements formerly used are explained and many new ones are introduced. Of these some are no doubt good and worth instruction, while others are of less value. At any rate, it is doubtful whether in the service there is sufficient time for a course of such extended instruction to the average soldier, to make him the expert the authors aim at producing. For preparation for a tournament, for example, or with a class of selected, alert men, the system in its present form would undoubtedly be of great value and assistance.

After thorough preparation in the bayonet exercises, further practice in musketry fencing serves to train the eye and the muscles to cooperate quickly. Here so much of the theory and practice of this art is presented as will be found useful in developing the full value of the rifle and bayonet in hand to hand encounters.



GERMAN ARMORED CRUISER "YORCK", 9350 TONS; 19,183-I. H. P.; SPEED 21.4 KNOTS.

ARMOR PROTECTION:—Waterline belt, 4 inches Krupp amidships, three inches at ends; 6-inch K. S. side armor above belt amidships; main turrets, 6 inches K. S.; small turrets, 4 inches; battery, 4 inches. Deck, 2¾ inches.

ARMAMENT:—Four 40 cal. 8.2-inch guns in main turrets; ten 5.9-inch 40 cal; twelve 3.4-inch; ten 1.4-inch; 4 Maxims. Four submerged torpedo tubes.

—Photo by Carl Speck, Kiel.

JOURNAL

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UNITED STATES ARTILLERY

*"La guerre est un métier pour les ignorans,
et une Science pour les habiles gens."*

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THE SCREW BREECHBLOCK WITH PLASTIC GAS CHECK AND THE WEDGE BREECH-BLOCK WITH METALLIC CARTRIDGE CASES FOR ORDNANCE

BY J. CASTNER*

Translated from the German

BY MAJOR A. E. PIORKOWSKI, I.G.A.

EVER since screw and wedge breech mechanisms have been in use, their advantages and disadvantages have been weighed against each other. This controversy could continue and be repeated up to the present, because the argumentation has not always been based on real facts, and therefore lacked strength and admitted objections. The following is an attempt to argue by undeniable facts and numerical data.

HISTORICAL SURVEY OF THE DEVELOPMENT OF SCREW AND WEDGE BREECH MECHANISMS

The breechblock with *interrupted screw* was first adopted in France with the naval rifled breech-loaders, Model 1850 to 1860. The gas check was a steel disk with an elastic rim, (Fig. 1), attached to the face of the breechblock; it was later replaced by a copper ring, similar to the Broadwell ring, and seated in the chamber of the gun (Fig. 2). The French army artillery only in 1870 began trials with breech-loaders, system

*"Schiffbau", Zeitschrift fur die gesamte Industrie auf schiffbautechnischen und verwandten Gebieten, December 13, 1905.

Reffye, having interrupted screws and cartridges with obturating caps. These caps when the guns were fired stuck in the chamber, and were discarded. A *plastic gas check* made of tallow and asbestos, the invention of Capt. de Bange, in 1872, promised better results. Its first official trial in August 1873 was successful, and so the French War Department in an order of December 16th, 1873, laying down the principles for new field ordnance, also decreed the plastic gas check with movable head. The 95 mm. gun, Mod. de Lahitolle, adopted about the

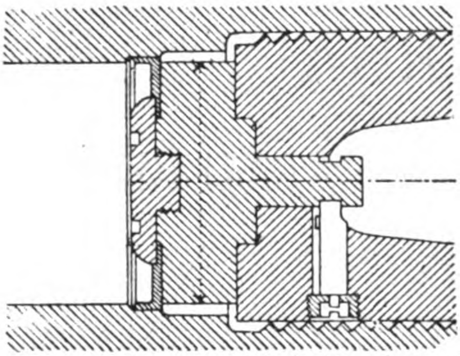


Fig. 1. Screw breechlock, French naval guns, M. 1864/66.

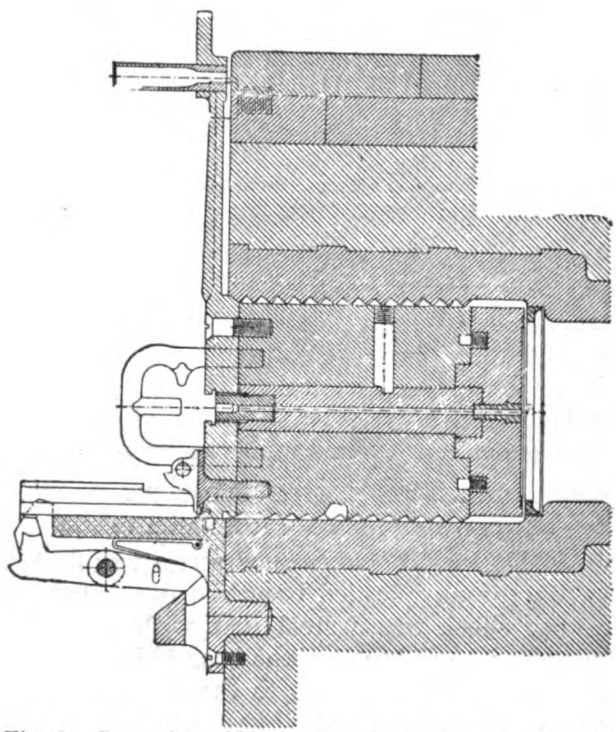


Fig. 2. Screw breechblock, French naval guns, M. 1870.

middle of 1875, therefore had a screw breechblock with plastic gas check, but had to yield the place to the 80 mm. and 90 mm. guns of De Bange Mod. 1877, adopted January 23, 1877, (Figs. 3 and 4).

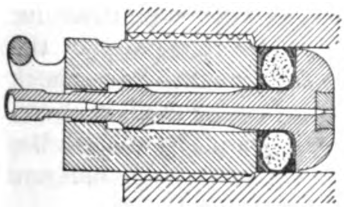


Fig. 3. Screw breechblock with de Bange plastic gas check. Longitudinal section.

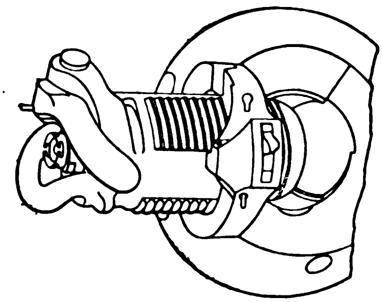


Fig. 4. De Bange screw breechblock, half-opened position.

The *wedge breech mechanism* has been developed since 1859 by Krupp. He used a steel or copper gas check in shape of a disk, which at first was put into the chamber by hand, later was seated in the face of the wedge, and finally changed into the so-called Broadwell ring (English patent of Broadwell-Karlsruhe, May 23d, 1863). Broadwell's ring was cylindrical, Krupp made the outside conical (English patent of Krupp, December 7th, 1868) and soon afterwards gave it a spherical form (Fig. 5).

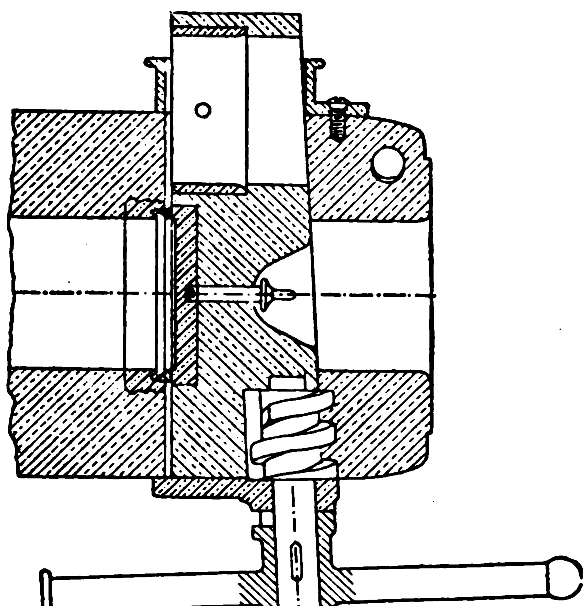


Fig 5. Horizontal wedge fermeture, Austro-Hungarian field guns, M. 1875.

In Germany since the early eighties Krupp developed his rapid-fire guns on the principle of using self-obturating *metallic cartridge cases.* The manufacture of the metallic cases by Lorenz at Karlsruhe in Baden had begun with such cases for the 37 mm. revolving gun, and gradually progressed to the largest calibers. By means of the metallic cases the gas-check question was thoroughly solved for Krupp's guns of all calibers.

In France metallic cartridge cases in connection with the screw block in the naval artillery are used only for small and medium calibers up to the 164.7 mm.

According to "La Marine francaise", November 1904, they use in the 164.7 mm. gun Mod. 1893 to 1896 a bag cartridge in front and a metallic cartridge behind it. It seems that also with the 194 mm. gun Mod. 1893 metallic cartridges are used. (Cfr. "Manuel du canonnier breveté" (Marine). Paris, 1901, page 154.)

But with the latest guns of the French navy, Mod. 1893-96 M and Mod. 1902, which have calibers from 164.7 up, the use of metallic cases has been abandoned*.

The small calibers up to 65 mm. have the dropping block mechanism, system Hotchkiss; the medium calibers divers systems of cylindrical screw blocks; the large calibers without metallic cartridges have cylindrical bracketed screw blocks with obturating ring in the chamber. *The French naval ordnance has never adopted the plastic gas check.*

The French *army ordnance* has adopted metallic cartridge cases for the 75 mm. R.F. field gun Model 1897; with several other guns, not so well known, a short metallic case, enveloping only part of the cartridge, seems to be used ("Artillerie navale et artillerie de terre" by Lorsay in "Armée et Marine" September 15th, 1904). The rest of the guns have screw blocks and plastic gas check.

In England, contrary to what was done in France, metallic cartridges were used only in naval ordnance up to 6-inch caliber, and not at all in army ordnance; recently the navy for some 6-inch guns has gone back to bag cartridges, while the army has adopted metallic cartridges for the new long recoil

* "La défense navale de la France" by Contre-Admiral Campion. Situation du matériel d'artillerie. "La Marine francaise" of November 1903, page 347. After this authority Model 1893-96 M developed from Model 1893 by elongation of the chamber (increase of powder charge and of muzzle velocity) which caused difficulties in loading. This, they say, can now be avoided by first greasing the chamber (cfr. "La Marine francaise" October 1903). It seems clear, that this will not favor the rapidity of firing; but the endeavor prevailed with Model 1893-96 M and Model 1902, to make the relation of length and diameter of chamber the smallest possible, for the sake of regularity of gas pressures.

field guns of 7.62 and 8.4 cm., whose introduction has only just begun. With the screw block without metallic case, the plastic gas check is in common use, quite recently the Welin screw with strong conical gas check.

The United States use metallic cartridges up to the 6-inch caliber; all other guns have screw blocks and plastic gas checks. As in England some 6-inch guns have gone back to the plastic gas check. The army has adopted the new field gun, Model 1902, with screw breech mechanism and metallic cartridges.

Surveying these developments of the screw and the wedge breech mechanisms the impression is gained that the cause for the persistent attacks by advocates of the screw against the wedge lies in the course of the development itself, the French as well as the English having improved their guns and breech mechanisms, so to say, on *national principles of construction.* Abandoning these in favor of a foreign design would mean a break with the past, with the existing ordnance material and the wealth of literature on the subject, and it is conceivable that such a break and the economical sacrifices it would imply are anxiously avoided. The large literature regarding the screw mechanism may, with less expert readers, easily create the opinion, that the preference given to the screw fermeture were due to the superiority of its design compared with that of the wedge fermeture, and therefore justified. It will be shown in the following that this is erroneous. It ought also to be remembered, that many authors who favor the screw block and disparage the wedge, are not really acquainted with the latter. Such opinions are worthless, as a matter of course.

We shall investigate in what manner the two kinds of breech mechanism fill their purpose, to form a reliable gas-tight bottom of the bore of the gun; and to what extent their design helps the efficiency of the gun, and guarantees safety in its use.

To this end will be considered:

I. The *strength.*

II. " *obturation.*

III. " merit of the designs in obtaining the maximum effect, that is the influence of the fermetures on
- a. the *length* of the gun,
- b. the *weight* of the gun,
- c. the *readiness* for firing.

IV. *Safety in using* the gun.

I. THE STRENGTH OF THE BREECH MECHANISM

No special proof is needed, that in regard to the strong locking of the bore the wedge is in principle preferable to the screw block, because the former is a *transverse,* the latter a *longitudinal* lock; with the screw the direction of recoil which the block shall resist, is also the direction of the movement of the screw;* while the movement of the wedge runs normal to it. Although in practice with good designs, the screw as well as the wedge, may answer the purpose of being a strong lock, theoretically and in principle the wedge is superior to the screw, as regards the strength of locking the bore.

II. THE OBTURATION

a. *The metallic cartridge cases.* Good metallic cases are known to give perfect obturation; their cylindrical part expands and presses against the bore while the bottom finds its support on the breechblock.

The advantages of metallic cartridges in themselves are indeed not denied by anyone.† The disadvantages which are ascribed to them, which will be discussed further on, do not regard their obturation, but certain qualities which have nothing to do with their obturation.

b. *The plastic gas check.* Friends of the plastic gas check point to its capacity to fit different forms of the entrance of the chamber, although this weighs very little against its shortcomings. These shortcomings shall be here discussed.

Very often the gas check after the firing sticks to the wall of the chamber. Some guns in the French coast defense therefore have a special appurtenance ("manivelle décroche-obturateur") which serves to loosen the gas check.

A similar tool has proved a necessity in the Italian siege artillery.

Freezing temperature or heat diminishes its plasticity and capacity for obturation. A frozen pad of tallow and asbestos

* R. de la Rocque, lieutenant colonel of the French naval artillery, in his book "Etude historique de la résistance des canons rayés," Paris 1885, page 246 f, mentions the following on tests with 34 cm. guns Model 1878. "Un autre canon de 34 cm de même provenance (Saint Chamond) avait été encloué, à la charge de 126 kilos, par suite de la déformation des filets; la vis avait pour ainsi dire, pénétré dans le métal de son écrou"—and further "Les filets de l'écrou de tous ces canons avaient été déformés plus ou moins gravement, dans le tir, la vis s'enfoncant dans le métal relativement mou, de la bouche à feu. The gas pressure in these trials, once had reached 3250 kg.

† In the report of the Chief of the Bureau of Ordnance to the Secretary of the Navy of the United States 1901-02 it is said: Whatever disadvantage brass cartridge cases may have, they certainly have the advantage of effectively checking the gas and obviating the sticking and jamming of breech plugs, and the German system which makes use of brass cases for guns of all calibers, even to the largest, has decided advantages over any other in these particulars.

has to be thawed before it can be used. In tropical heat and especially in *rapid fire* its plasticity decreases. It is even possible that the pad cover burns.

The gas check in firing suffers from high gas pressure. Experience in Spain has shown that the duration of the plastic body is proportionate to the relation between its original density and the gas pressure, so that a gas check, quite satisfactory at moderate pressure, may quickly be ruined at higher pressure (cfr. Kaiser, "Construction of rifled guns," Vienna, 1900, page 298).

The table on last page shows that in the United States, when 6-inch guns were fired under gas pressures above 2400 atmospheres, the pads were deformed and the breech mechanism could be worked only with difficulty.

There is no lack of official statements in the United States, on such defects of plastic gas checks. An examination of the tests made in the United States in 1900 furnishes an interesting view of the nature of the plastic pads and their defects.

1. The tests began with a semi-solid pad so constructed by hydraulic pressure (3,000 pounds per square inch) and rendered more and more so by repeated gas pressures (36,000 to 40,000 pounds per square inch), covered with canvas and inclosed between two rigid non-expanding concave disks as in Fig. 6.

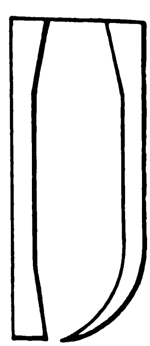


Fig. 6.
Non-expanding disks.

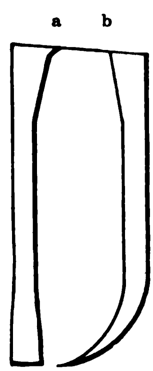


Fig. 7.
Sharp edges at a and b.

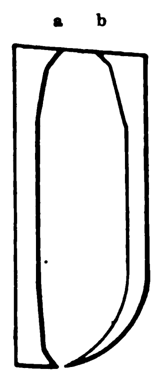


Fig. 8.
Sharp edges at a, b and c.

2. It was hoped the defects could be avoided by giving the disks sharp edges at a, b, and c, (Figs. 7 and 8), but without success.

3. Then thin copper rings were used at a and b, as in Fig. 9, and a steel split ring at c. It was expected that the pad acting as a stretcher would force the copper rings to obturate ; but this result was only reached with the smaller calibers, while with the larger ones the pad covering was burnt by the hot gases.

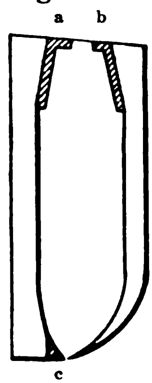


Fig. 9. Copper rings, a and b, and steel split ring, c.

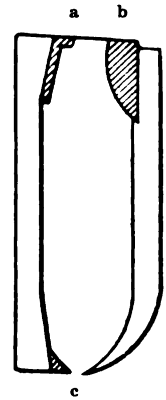


Fig. 10. a, copper ring; b, front steel split ring; c, small steel split ring.

4. Then the Gerdom gas check, as in Fig. 10, was tried, first with one split ring at b, afterwards with two at a and b, as in Fig. 11.

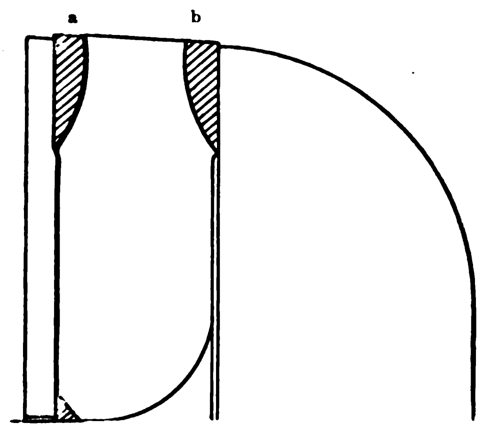


Fig. 11. a, rear ; b, front ; c, small steel split ring.

5. With the intention not to effect the obturation directly by the pad, but to use it as a stretcher between expanding disks, such disks of different shapes were tried. Dish-like steel disks, so-called Davis disks especially, worked best. Fig. 12 shows the front disk made of copper, the rear disk of steel. In Fig. 13 they are both of steel.

6. But in firing, their thin edges sometimes, instead of obturating, adhered to and cut into the pad, so these edges were broadened, but they also did not prove satisfactory.

7. Next hard cushions of guyakwood or maple were tried in place of the tallow-asbestos pad. But the wood cushions were compressed where they touched the obturator rings and open spaces formed.

8. Then a steel cushion of the same shape was tested. This expanded the split rings, the same as a pad, but after the

firing it was discovered that the diameter of the rings had slightly increased, and the middle slightly bulged out.

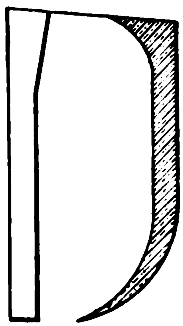


Fig. 12. Front disk of copper, rear disk of steel; both disks fit closely the gas-check seat.

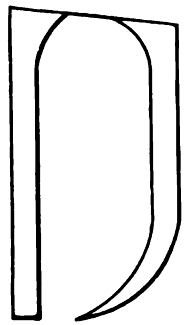


Fig. 13. Both disks of steel.

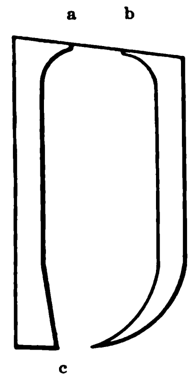


Fig. 14. Smoothed edges at a, b and c.

It resulted from these trials that the best gas check was obtained by the use of a plastic pad as a stretcher for elastic disks and steel split rings which act as obturators. Gradually *the plastic pad was more and more enveloped* by the disks and split rings, as in the Gerdom breech mechanism, Figs. 15 to 18

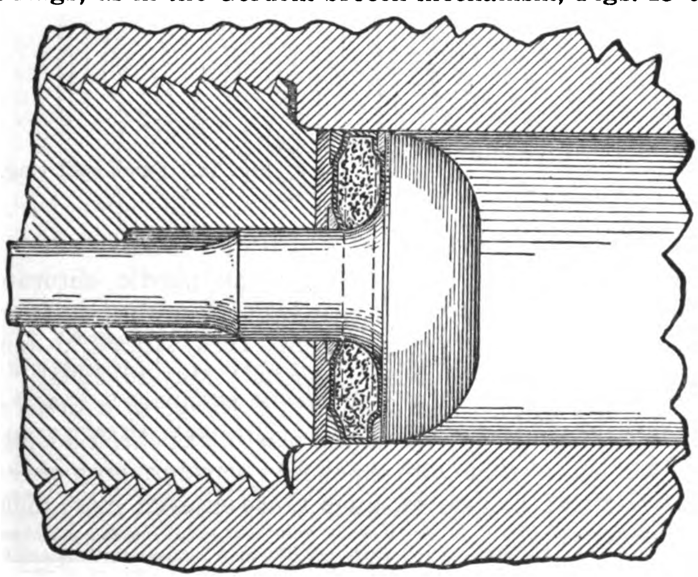


Fig. 15. Gerdom breechblock.

(U. S. Patent 539733, May 21, 1895), and further in the more recent design shown in Figs. 19 to 23. This belongs to the screw fermeture of Vickers (English Patent, Dawson, No. 2577 of February 26, 1901) and is probably the same as used in some of the guns in the United States.

The advantages claimed for this gas check at the same time point to the disadvantages to be feared in its use.

These advantages are the following:

a. *Good obturation* by the steady contact of the disks (c) Fig. 19, caused by the pad.

b. *Decreased vulnerability of the gas check* in use because of the protection of the pad by the metallic disks.

c. *Invulnerability of the pad from the powder gases* even at the split of the steel ring by the disposition of the disk under strong pressure by the mushroom head.

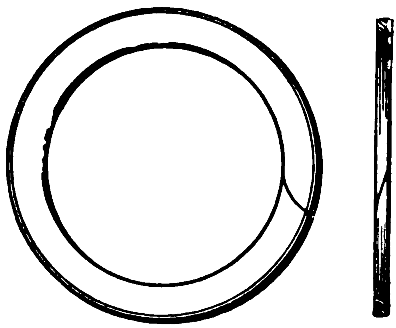


Fig. 16. Rear split ring.

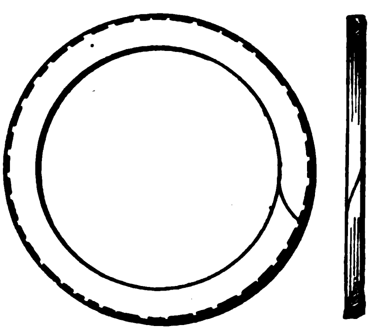


Fig. 17. Front split ring.

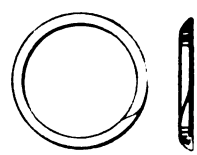


Fig. 18. Small split ring.

Recently in the United States the plastic obturator is enveloped in a fine copper-wire tissue, to protect it from the effect of the powder gases ("New York Herald", January 19, 1905, and "l'Italia militar e marina", May 16, 1905).

Professor P. R. Alger of the U. S. Navy, in a prize essay of 1903, states his opinion of the plastic gas check adopted by the U. S. Navy, that with smokeless powder, high pressures and rapid firing in modern guns there is even more difficulty than formerly.*

* He says in his "Gunnery in our Navy" (U. S. Naval Institute, Annapolis 1903, page 6), "Delay was frequently caused with our earlier guns, by the expansion and consequent sticking of the steel gas-check disk, but with the split rings now used, and with the *very powerful leverage* given by our heavy gun breech mechanism, this trouble must have disappeared. *It is the failure of the gas check, due either to the burning or cutting of the pad cover or to the softening and bulging of the pad, which is now a serious difficulty,* especially with large guns. All gas

Similar opinions have been published in other countries. The Brazilian Navy Officer, Mr. C. Heck says in the "Revista maritima brazileira" of February-March 1901, the worst fault with the plastic gas check is doubtless that after a number of rounds it inevitably becomes unserviceable and must be exchanged.

In a French hand-book of artillery it is said: "The plastic gas check is somewhat complicated and has to be changed very often, because it is used up by the softening of the plastic matter".†

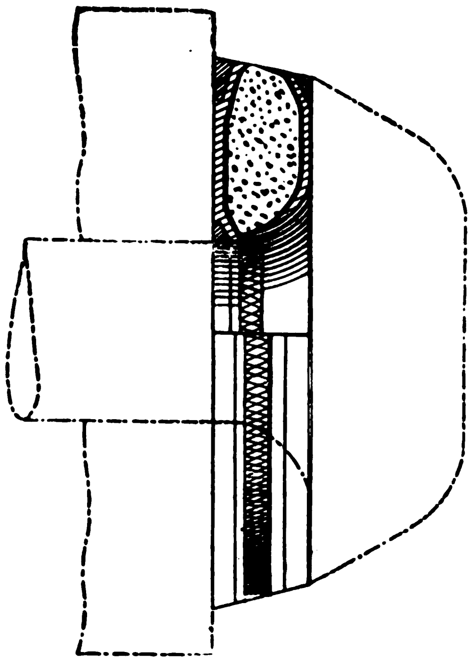
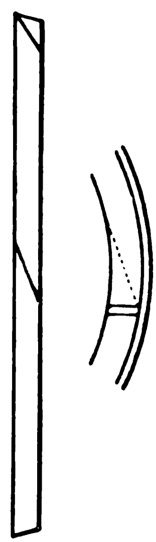


Fig. 19.
Vickers gas check.



Figs. 20 and 21.
Split ring.

In respect to the conditions in action the demand for a certain durability is certainly justified. But the obturation by the gas check suffers considerably, whenever the chamber is is not perfectly clean.

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checks require great care in manufacture,—to be of suitable material and of very exact dimensions,—and they all require to be kept clean and in proper adjustment. *With smokeless powder, high pressures, and rapid firing, the difficulty of making gas checks function properly is greater to-day than ever before, and ours need improvement*".

† Girardon, Organisation du matériel d'artillerie, Paris, 1903, page 101; and then it continues: "Ramolli par le tir, l'obturateur peut être déformé, soit par suite d'une brusquerie dans l'ouverture de la culasse, lors du retraite en arrière de la vis, soit par un choc accidentel. Quand il est trop déformé, on lui rend à peu prés su forme avec les doits, après l'avoir au besoin refroidi dans l'eau, puis on le moule dans son logement. A cet effet, on ferme la culasse et on frappe à coups de refouloir sur la tête du champignon."—This repair would now-a-days be very hard with naval guns and generally during a battle.

When remnants of the powder or the cartridge bag reach the obturating surfaces, the powder gases may flow beyond the gas check, arrive at the threads and interfere with the function of the breech mechanism, they may also damage the pad cover. English reports mention such accidents with the 6-inch gun Mark VII. and the 12-inch gun Mark IX. On these the English annual "All the World's Fighting Ships", 1901, writes:

The bare charge with pad obturation does not, from the British official records, seem to have been an unmixed advantage, though the difficulties first experienced may since their introduction have been completely overcome. The records show escape of gas over the obturators of the 6-inch Mark VII., and

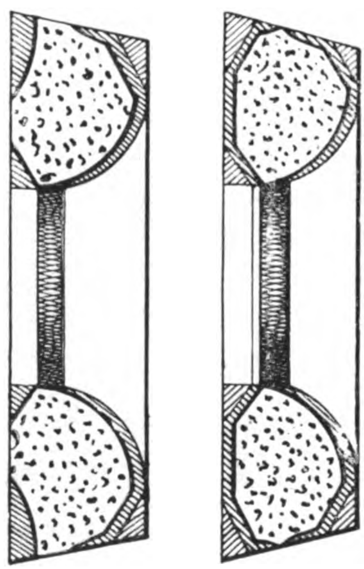


Fig. 22. Fig. 23.
Various forms of gas checks.

12-inch Mark IX. guns at proof with damage to the canvas of the pad and fusion of the tin disks, causing the breech actions to work stiffly. It seems to have been at one time doubtful if the manufacture of guns with this system of obturation should proceed, but further trials appeared to promise better results, and the manufacture is being continued. Close manufacturing limits for obturating pads were laid down, and search was to be made for a material for the disks of the obturator less liable to fusion than metallic tin, which is at present used. *This fault has of course only occurred with obturators of the steep cone form.*

The *pros* and *cons* are as follows :—*Con.*

When the pad is home in its steeply coned seating everything is all right, but on firing everything works in the opposite direction to mechanical success.

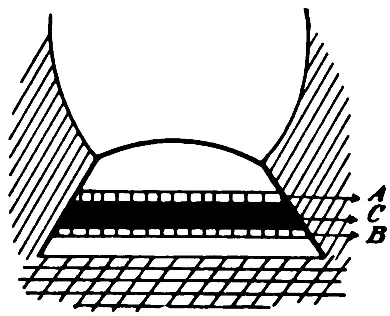


Fig. 24. Before firing.

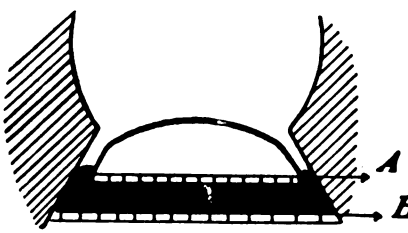


Fig. 25. After firing.

The outer tin disk A, Fig. 24, is forced by the gas pressure on the mushroom head against the asbestos pad, which is squeezed against the walls of the coned seating and seals the escape of gas; *but*, the outer tin disk is much smaller than the inner one, so it will no doubt be found that the outer disk is squeezed into the pad. Fig. 25. This leaves corners at A, Fig. 25, which will be gradually cut away by the gas, probably—unless the fit is excellent—at the very first round. This will allow gas to work round the outer tin disk, as has occurred, and will melt it, as also has occurred.

Also, even supposing everything is all correct, the following practical defects exist :—

(1) The gun has to be sponged with a saturated sponge each round. It is said that the tiniest bit of grit or dirt on the seat of the obturator immediately lets gas through.

(2) In order to be sure of getting as tight a fit as possible for the obturator, steel packing disks have to be inserted between it and the breechblock until a strong man can only just close the breech with the lever, an ordinary man cannot do it.

It is now necessary to consider the question from another standpoint.

To remedy the defects, which have at times produced the damage illustrated above, the the manufacturers have made the following changes. For the tin disks they have substituted copper for the outer, and steel or copper for the inner disks. The outer disk has also been split. The first has prevented fusing of metal; the second has greatly modified compression of the asbestos pad. Investigation has shown that much of the trouble has arisen from the steep cone obturator being loose; this is due to the neglect of fitting adjusting bands behind the outer disk whenever the breech closes too easily. . . .

Spare pads are to be served out to all guns; and these can be fitted in about two minutes. To fit the adjusting disks only takes half a minute or so. . . .

In the British naval service the steep cone system is only objected to on the score of sticking at times; but this is considered to be more than compensated for by the vastly accelerated breech action consequent upon its use. . . .

In this connection it may be observed that the Americans have regarded the steep cone system with considerable disfavor, but none the less they have adopted it. From this it may be argued that the advantages of rapidity are so great, that the existence of even grave inconveniences will not alter them.

Conclusions. It is evident from the above that while the metallic cartridge will always give perfect obturation, there are disadvantages connected with the plastic gas check which until now could not be successfully eliminated. These disadvantages are, that the plastic gas check complicates the breech mechanism and its service, that it is sensitive, not durable, and therefore not always equally efficient. These shortcomings are even more felt with modern rapid-fire guns and are admitted by those artilleries which use the interrupted screw with the plastic gas check.

DISADVANTAGES OF METALLIC CARTRIDGE CASES

The following complaints are expressed against the metallic cases:

1. Increased weight.
2. Increased necessary space.
3. Increased cost.

1. *Weight of the metallic cases.* Antagonists of the metallic cases used to call their greater weight in comparison with cartridge bags their chief disadvantage. So did, for example, Mr. A. Dawson, Ordnance Director of Vickers, in a paper on Naval Guns, read towards the end of June, 1901, before the Institution of Mechanical Engineers ("Engineering", August 2, 1901, page 148). He gave it as his opinion that with the 6-inch gun a muzzle velocity of 2900 f.s. required a powder charge of from 30 to 35 pounds and a cartridge case of the same weight as the powder charge. In reckoning an arma-

ment of 200 rounds for each 6-inch gun, from 6000 to 7000 pounds of metallic cases had to be carried, in excess of what is necessary with cartridge bags.

This argument is deceptive. Firstly, the bag cartridges have cartridge boxes for their safe storage in a ship, which are not required with metallic cases; and then two extra gas checks with their cases for every gun with plastic obturator.

Therefore 200 × 15.4 lbs. = 3080 lbs. for the zinc boxes and 90 lbs. for two extra gas checks and their cases, have to be deducted from the 6000 to 7000 lbs. weight of metallic cases, leaving only a plus of between 3000 or 4000 lbs., presuming that Mr. Dawson is right in stating the weight of a metallic case to be about 33 lbs. This may be so with English cases, but not with cases made in Germany.

In a Krupp 15 centimeter gun of 40 calibers length, for instance, the projectile weighing 90 lbs. with a muzzle velocity of 2755 f.s., the powder charge weighs 28.15 lbs. and the metallic case 19.8 lbs.

Weight of a metallic cartridge - -	49.06 lbs.
" " bag cartridge - -	29.26 "
" " " " with zinc box -	44.66 "

For 200 rounds:

Weight of 200 metallic cartridges - -	9812 lbs.
" 200 bag cartridges with zinc boxes 8932 lbs. - " 2 extra gas checks with cases 90 lbs. - -	9022 "

which leaves an additional weight to be carried with metallic cartridges of 790 lbs.

The use of metallic cartridges therefore increases the weight only by an amount of no importance on a man-of-war.

It is true that with larger guns the comparison is somewhat less favorable to the metallic cartridges, still it is not to be feared that the weight to be carried by the ship would increase considerably.

In order to demonstrate the saving in weight by substituting bag cartridges with zinc boxes for metallic cartridges, the armament of a German battleship of the "Braunschweig" class shall be computed here. Guns below 6-inch caliber are left out because for these other navies carry metallic cartridges too.

Assuming the following data for the armament:

Caliber inch	Weight of projectile lbs.	Muzzle velocity foot-seconds	No. of guns on board	No. of rounds on board for each gun	No. of rounds on board total
7″	141	2730	14	150	2100
11″	594	2750	4	80	320.

the following comparison of weights is obtained:

A	B	C	D	E	F	G	H
Caliber of guns	Weight of metallic cartridges		Zinc boxes for the bag cartridges		Extra gas ch'ks for the screw mech. and cases		Dif. in weight on board C–E–G
	each	on board	each	on board	each	on board	
inch	lbs.	lbs.	lbs.	lbs.	lbs.	(2 per gun)	lbs.
7″	28.6	60060	about 22	46200	about 66	1848	12012
11″	112.2	35904	59.4	19008	220	1760	15136
Total		95964	—	65208	—	3608	27148

= about 12 tons!

Now the question is what practical importance this difference has in a ship of 13,200 tons. Let alone that in the construction of a ship of such displacement 12 tons can hardly be considered, and is therefore without influence, a comparison for example with the consumption of coal will show its practical unimportance. The engines of the "Braunschweig" develop 16,000 H.P., and consume for this about 14 tons of coal in every hour. It is evident that if this ship changes its weight in one hour more than the amount computed above, *this weight of 12 tons is a negligible quantity.* Should, however, the influence of 12 tons be considered from a merely theoretical point of view, practical reasons will readily put up with it, because the obturation by metallic cases forms a guarantee for the faultless function of the breech mechanism during the battle, which can never be equalled with the plastic gas check.

2. *The necessary space for the cartridge cases.* In the magazine the necessary room for metallic cartridges is not greater than for bag cartridges which are stored in zinc boxes.

In transportation from the magazine to the gun the cartridges must remain in the zinc boxes, or there would be danger of explosion. After each round the zinc box must be removed from the turret or the battery the same as the metallic case. Circumstances are the same in both cases.

The use of bag cartridges makes it necessary to carry extra gas checks, which take a certain space not needed with metallic cartridges.

3. *The cost of metallic cases.* As a matter of course, the metallic cases are more expensive than the packing boxes for bag cartridges. But the difference is somewhat reduced by the fact that the metallic cases are used a number of times; and also by the cost of renewed plastic obturators and reserve pieces and for the kind of ignition necessary with bag cartridges.

Conclusions. The pretended disadvantages, examined in the foregoing, of metallic cartridges in comparison with bag cartridges are not decisive, and must give way to reasons of practical utility. With war material the question of cost is secondary where utility decides.

Although, however, metallic cases indisputably furnish better obturation, it remains to determine whether their use has a detrimental influence on loading and on handling the breech mechanism. Before entering in that discussion, it will be well to approach the following question:

What causes the advocates of the interrupted screw to disfavor metallic cartridges?

There are in the main two causes which have prevented, until now, the armies whose guns have interrupted screws from using metallic cases for their larger calibers:

1st. The difficulty of producing large metallic cases satisfying all requirements appear to have not been overcome by the industry of the countries involved.

2d. They have apparently not yet succeeded in providing the screw fermeture with an ejector, which will extract the cases by an equally simple arrangement, and with the same satisfaction as it is manifestly done with German cartridge cases and the wedge mechanism.

In France, for instance, it is to be seen from the report of the "Commission extraparlementaire d'enquête" of the Navy, in 1896, on the French Government workshops at Ruelle, that the making of metallic cartridges meets with great difficulties. It shows there (see "La Marine francaise" of July 10, 1896, pages 14 and 16) that, though the works at Bas-Meudon as far back as 1891 made metallic cases of 3-inch and 4-inch caliber for Canet and for foreign countries, yet making 164.7 mm. (6½-inch) cases in Ruelle was unsatisfactory in 1896, and among the private works only the one at Moulineau had kept pace with Ruelle.

At the Paris Exposition of 1900 there were no metallic cases of more than 6 inches caliber; Châtillon-Commentry had exhibited three cases of this size, but they had bottoms of steel inserted.

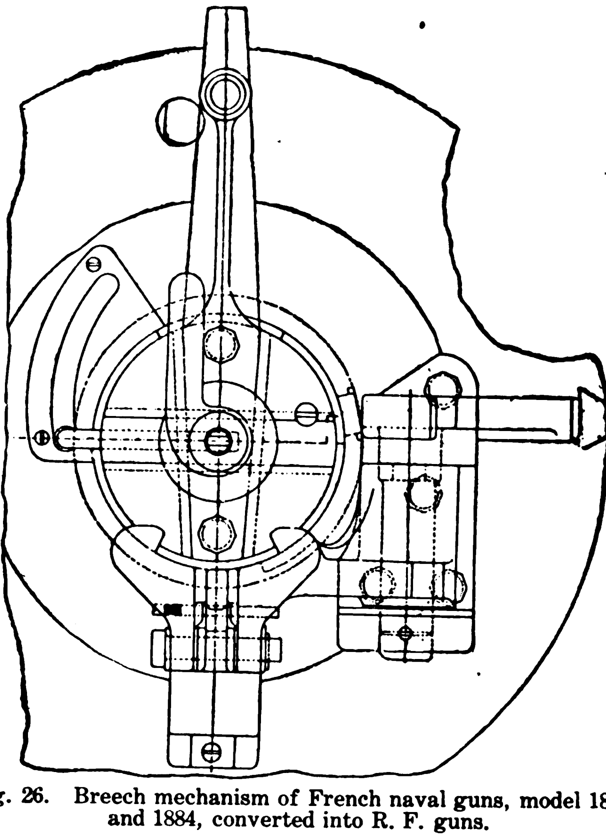


Fig. 26. Breech mechanism of French naval guns, model 1881 and 1884, converted into R. F. guns.

The ejector in the French screw mechanism can hardly function reliably; this seems clear from the drawings of these mechanisms, with their long cylindrical screws and their extractors, see for instance, Figs. 26 to 29.

Dashiell's breech mechanism (Figs. 30 and 31) in American 4-inch and 6-inch naval guns has an ejector consisting of a hooked bar parallel to the axis lodged in the screw with a very limited motion induced by a weak spring. With such an appurtenance a good extraction is hardly to be expected.

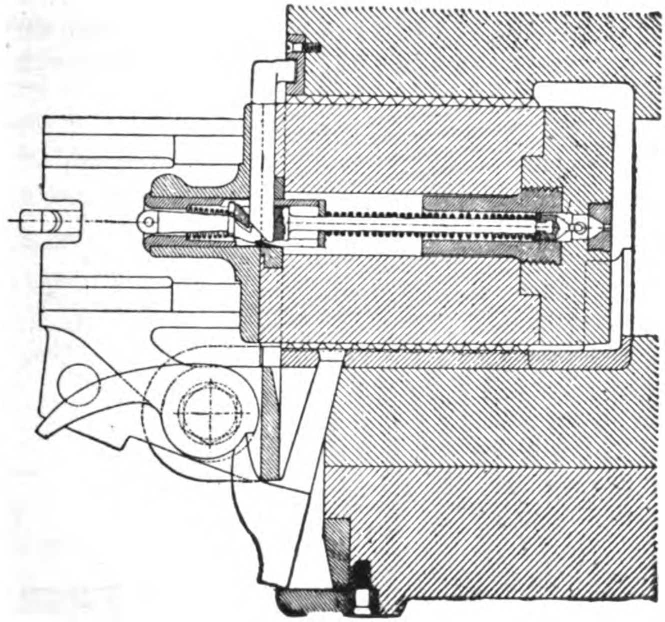
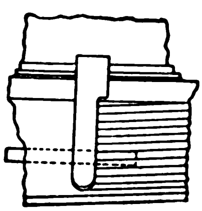
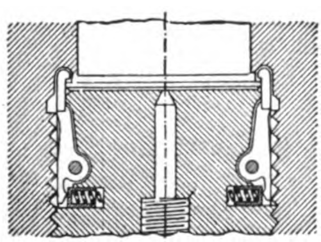


Fig. 27. Breech mechanism of French naval guns, model 1881 and 1884, converted into R. F. guns.

The English metallic cases are far from being satisfactory according to German standards, as is evident from Mr. Dawson's saying that a 6-inch case weighs 33 pounds, while a German for the same work weighs only 19.8 pounds.



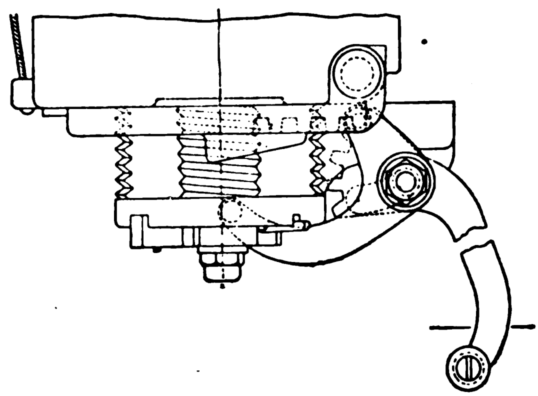


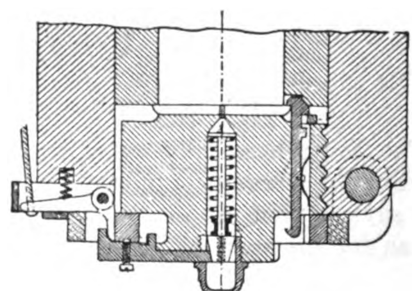
Figs. 28 and 29.
Canet breech mechanism for 14 cm. naval R. F. guns.

Some years ago English papers had much to say about defective metallic cases. "The Times" of August 17, 1895, reported that in the English naval maneuvers a case had split open at the bottom, during fire from a 6-inch gun on board the "Royal Sovereign", "apparently in consequence of faulty manufacture," and added that such splitting of cases was nothing rare.

A communication to the "Western Morning News" of January 18, 1896, says that of several thousand 6-inch cartridge cases, most of which apparently came from Woolwich, only about 400 could be used.*

In this article is found the remarkable hint that a modified manner of loading the 6-inch guns was proposed, for *a remedy!* This probably meant abandoning the metallic cartridge for a bag cartridge. It sounds curious in regard to such facts, that recently the English like to call it an advantage of the screw mechanism that it makes cartridge cases unnecessary! As if this "advantage" were not shared by *any* breech mechanism with a separate obturator.





Figs. 30 and 31. Dashiell breech mechanism for R. F. guns on cruisers of the U. S. navy.

The English cartridge cases, even those of small caliber are often *too brittle.* "Morning Post" of November 9, 1904, reports: "One of the ships of the Mediterranean fleet recently had to change a twelve-pounder gun owing to the *lining being damaged by a split cartridge case. Such occurrences are becom-*

* That article says: "There is something wrong when only 400 out of several thousand cartridges for 6-inch R.F. guns stand the official test. Most of these cartridges seem to have come from Woolwich, and the loss, from a financial view alone, is enormous. It is evident that the flaws are due to bad workmanship, but so severe is the test, that, it is contended, few cartridges can be manufactured under present conditions which can be absolutely relied upon. The remedy suggested is *that the mode of loading the 6-inch guns should be altered.* This change, however, would reduce the rapid firing to an undesirable extent. It is of first importance, however, that a thoroughly efficient supply of ammunition should be provided, and there ought to be no delay in inquiring whether our system of ammunition manufacture can be improved. If faulty cartridges are turned out in the leisurely time of peace, what may we expect in the hurry when war is at hand?"

ing more and more frequent. The brass cartridge cases are lacquered over by the makers, and until the accident has occurred any split in one is not noticeable. It is to be feared that serious notice will not be taken of such things until a disaster happens."

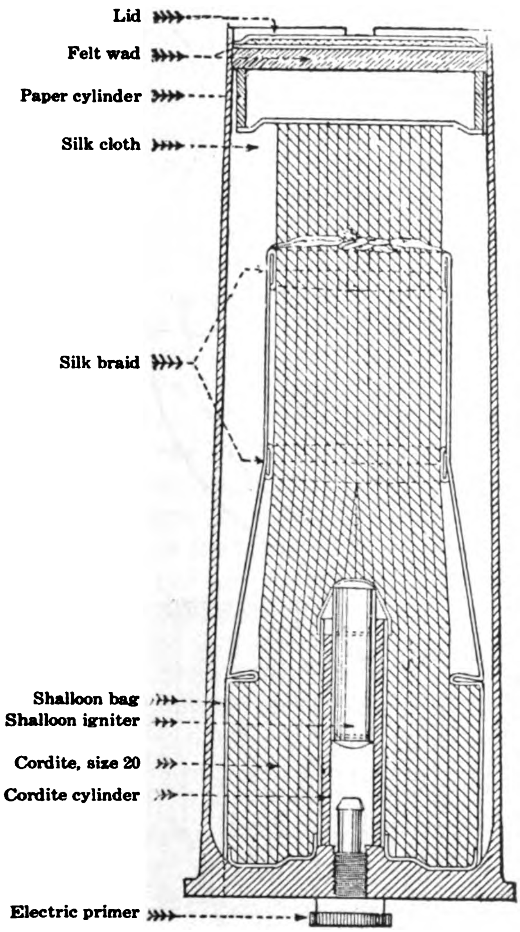


Fig. 32. Longitudinal section of an English metallic cartridge.

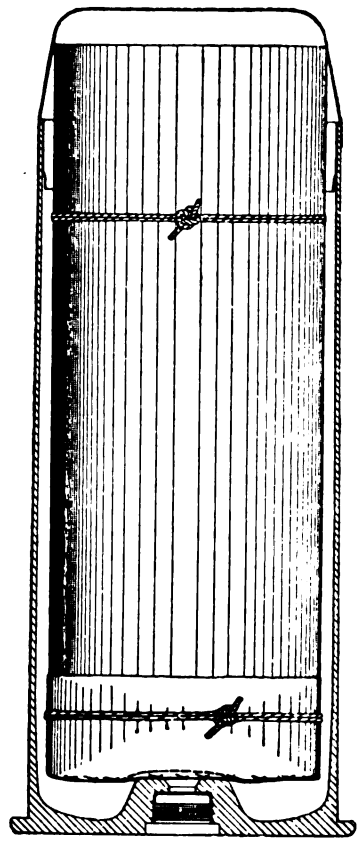
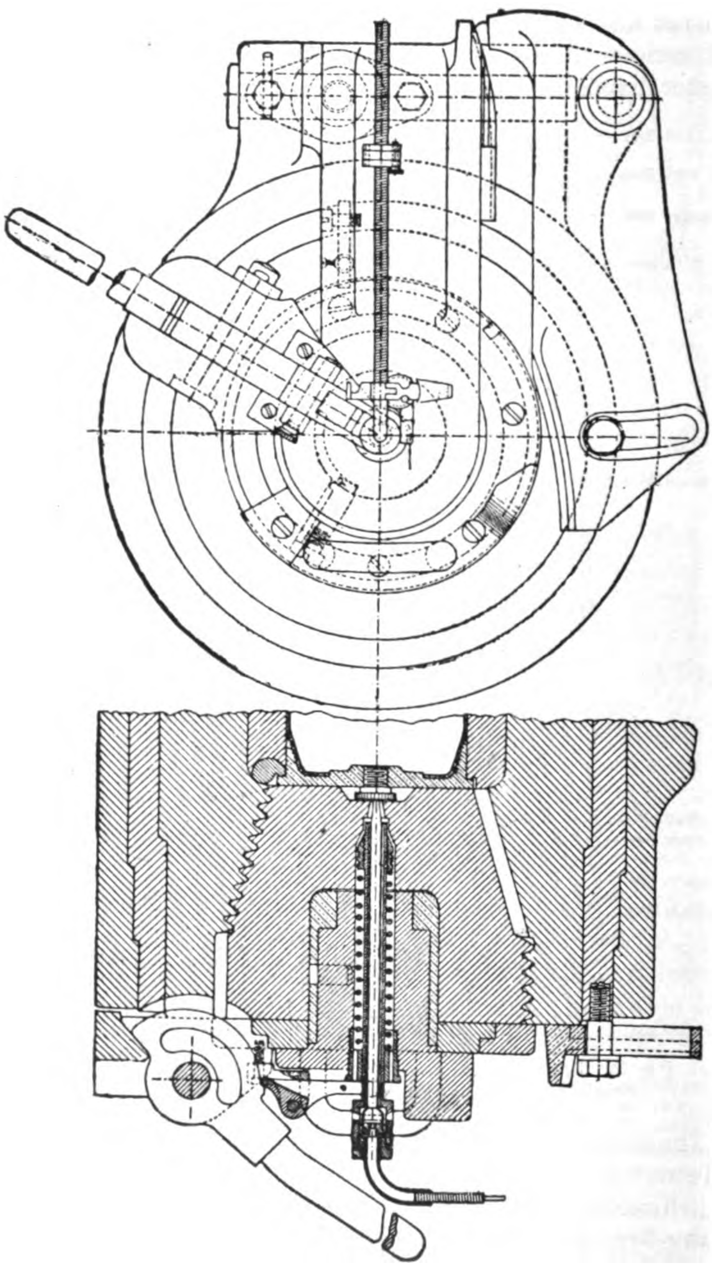


Fig. 33. Longitudinal section of a German metallic cartridge.

The accident on board the "Magnificent" on June 14, 1905, off Tetuan on the Moroccan coast shows that even at present English metallic cartridges have peculiar defects. There was a hang-fire, and when the breech was opened the cartridge exploded and was thrown backward, injuring 4 officers and 14 men, 5 of whom died soon afterwards. The explanation was



Figs. 34 and 35. Armstrong breech mechanism for 15.2 cm. naval R. F. Guns.

given, that the damaged tin plate lid of the cartridge of the 6-inch gun was loosened in loading, and the powder charge moved forward from the primer in the bottom of the cartridge case, so as to cause the hang-fire.

"The Times" of June 16, 1905, says regarding this: "A correspondent writes:—It is of interest to note, in connection with the unfortunate occurrence on board the Magnificent, that the Admiralty, in the early part of this month, notified to the Fleet the circumstance that they had had brought to their notice several cases of hang-fires which had recently occurred in 6-inch Q.F. guns. The cause of these hang-fires has been traced to the fact of the lid of the cartridge case having become corroded, and, consequently, detached during loading, thus allowing the cordite charge to move forward until it is too far from the primer for the latter to fire the igniter with certainty, although the shalloon bag has been found to be smouldering when the cartridge was withdrawn. The Admiralty therefore directed that all 6-inch Q.F. cartridge cases were to be inspected before being passed to the guns, in order to ascertain that the lids were in proper condition."

The design of an English metallic cartridge, as in use in these guns, is shown in Fig. 32. There is another disadvantage apparent from this drawing, namely, the *dangerous protruding of the primer screw from the bottom of the metallic case* (Fig. 32) in contrast with the arrangement in a German cartridge (Fig. 33) where the primer screw is even slightly sunk into the bottom of the case. It is evident that the English primer screw is liable to dangerous blows and may also be hit when the breech is closed (Figs. 34 and 35), which danger is avoided in the German design. The cover of the German metallic case at the front end is different from the tin sheet lid of the English cartridge, and precludes such a dangerous moving forward of the powder charge as caused the accident on the "Magnificent".

The difficulties exist still not alone in the manufacture of the metallic cases *in England, but also in good ejection of the cases.* This fact finds its expression, for instance, in Mr. Dawson's lecture, mentioned above, where he describes the ejector of a 3-inch fermeture, having a special wedge-shaped cam (tooth) to loosen the metallic case before the extracting fork acts. (Something like Vickers' English patent 24264 of 1897). One would think that such a complication might be avoided in the breech mechanism of so small a caliber. What the "Morning Post" says of defective metallic cases, shows their insufficient elasticity, in that they are lastingly enlarged and cling to the walls of the chamber.

Conclusions. The antipathy of the advocates of the interrupted screw against metallic cases is not the consequence of their inefficiency, but of the inability of the countries concerned to produce such cartridges which will give full satisfaction in firing, which will be sufficiently light and elastic. Also their workshops have not yet succeeded in supplying the interrupted screw mechanism with a simple and reliable ejector. The return to bag cartridges with the latest English 6-inch guns has been characterized by the press as a remedy necessitated by the poor quality of English metallic cartridges.

III. INFLUENCE OF THE BREECH MECHANISM ON THE EFFICIENCY OF THE GUN IN FIRING

a. *On the efficient lengths of barrel.*

To obtain a strict comparison between the efficient length of guns with wedge and with screw mechanism, *guns of equal actual length of both kinds, with their breech mechanism,* ought to be compared. It is often said in publications that in guns of equal length, the efficient length of barrel with a wedge mechanism is 1 to 1½ calibers shorter. This is not to the point, as certain parts of the screw mechanism protrude backward from the rear face of the gun, and, besides, this mechanism needs a certain space back of the gun for its movement and manipulation; and such space in a turret, for instance, is often very scarce. The distance the parts of the screw mechanism protrude from the rear face of modern English guns is, for example,

about 1.4 calibers with medium calibers.
1.1 " " large "

with Krupp guns
1.3 calibers with medium calibers.
0.8 " " large "

with old French guns
2.2 calibers.

With two Krupp 6-inch (15 cm.) guns L/40 C/01, designed after the same principle, one with screw, the other with wedge fermeture, the data were as follows:

α. Screw fermeture:

Length of gun from the muzzle to the rear face -	- 5960 mm (40 calibers)
Parts of fermeture protrude -	170 mm
Therefore the *full actual length* is - - -	- 6130 mm (41 calibers)
Length of rifled bore -	- 4630 mm

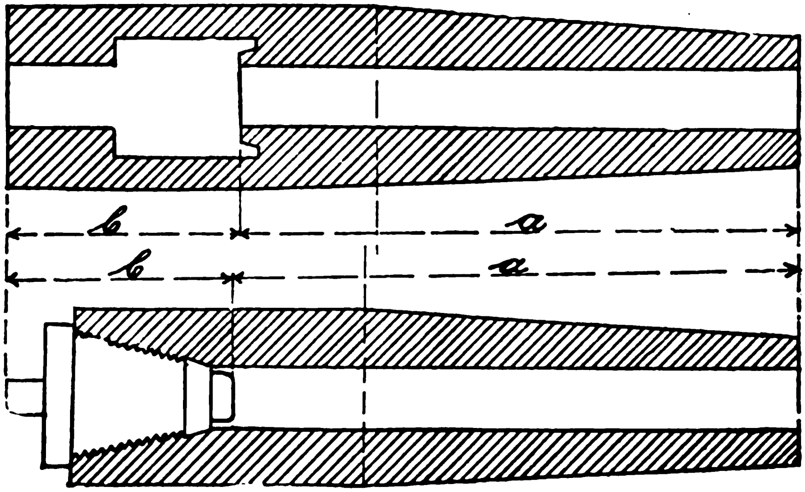
β. Wedge fermeture:

Length of gun from the muzzle to the rear face, equal to full actual length - -	- 5960 mm (40 calibers)
Length of rifled bore -	- 4398 mm

This is shorter than with the screw fermeture by 232 mm., or 1.55 calibers.

But in comparing two guns of equal length, a barrel, with wedge fermeture, of $5960 + 170 = 6130$ mm. ought to be considered. Its rifled part is $4398 + 170 = 4568$ mm. long, that is, *only* 62 mm. (= 0.5 calibers) *shorter* than that of a barrel with screw fermeture. The difference of ½ caliber in length means a difference of not more than 3 meters in muzzle velocity, which is considerably less than the variation allowed in velocity by the powder charge. *Therefore the gain in muzzle velocity with screw mechanism is without importance in practice.*

In order to show in what degree the barrels have to carry dead length it is best to compare *the relation between effective lengths and total lengths of barrels* with wedge and screw mechanisms. In this manner incontestable data are obtained for comparison of guns of both designs but of different length. The table given below shows these data for several calibers. These data demonstrate that the effective length of guns with screw mechanism is only from 0.3 to 2% greater than that of guns with wedge mechanism. In Krupp's 30.5 cm. (12-inch) guns, L/40, an increase of 2% (= about .75 caliber) in effective length of the barrel would give not above 4 m. more muzzle velocity, which is within the allowed variations for the same powder charge. It cannot, therefore, be said that there is a practical advantage obtained by the increase of the effective length of barrel in guns with screw mechanism over those with wedge mechanism.



Caliber	Breech Mechanism	Length of Gun	a + b Total length	a Length from bottom of bore to muzzle		b From bottom of bore to rear end of gun or breech mechanism		Length of gun after the manner of country
cm		cal.	mm	mm	% of a + b	mm	% of a + b	
15	Guide-shaft mechanism	L/40	5960	5536	92.9	424	7.1	German *
19			7600	7061	92.9	539	7.1	
24			9600	8916	92.9	684	7.1	
30.5			12200	11326	92.8	874	7.2	
15	Krupp's screw mechanism	L/40	6130	5707	93.1	423	6.9	German
19	English screw mechanism	L/50	10105	9526	94.3	579	5.7	English †
25.4		L/45	12050	11430	94.8	620	5.2	

* After German manner L/40 means total length from muzzle to rear face.

† After English manner L/40 means length from muzzle to bottom of bore, *i.e.*, to front of breech mechanism.

Conclusions. Although guns with screw mechanism have a somewhat greater effective length than guns of the same total length with wedge mechanism, the influence on the efficiency of the gun is so small as not to count in practice. From this argument any superiority of the screw mechanism cannot be deduced.

b. *Influence of the breech mechanism on the weight of breech block and of the barrel.*

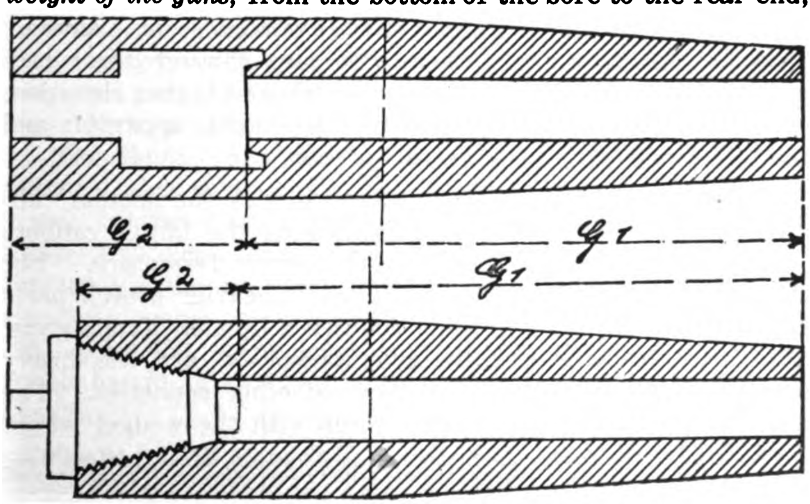
To obtain an undisputed opinion as to the influence the kind of fermeture has on the weight of barrel and breech mechanism, *guns of equal efficiency* ought to be compared. So, in the following table is given the weight of Krupp guns, ballistically equal, C/1901, with guide-shaft mechanism, and with interrupted screw and plastic obturator, swinging open without pulling back.

Gun	Guide-shaft mechanism kg	Screw mechanism kg
10.5 cm L/40	79	75
15 " "	188	190* †
17 " "	267	270* † ‡
30.5 " "	1300	930* ‡

* Weight of fermeture including loading tray.
† With these guns the loading tray is moved automatically with the breech-screw.
‡ The weights were obtained by calculation.

This table demonstrates, that *the weight for both kinds of fermeture is approximately equal up to a caliber of 17 cm., or 7 inches;* for larger calibers the screw gains the advantage, and the comparative weights for the 30.5 cm., or 12-inch caliber, are as 5 to 7. The usual saying, therefore, that the weight of a wedge block is about double the weight of a screw block, is wrong, at least for Krupp's designs of the two. Comparisons cited to prove that statement are mostly deceptive, if for no other reason, because guns of quite different power are being compared.

After all, the difference in weight of the breechblocks does not matter so much, as that in the *weight of the dead weight of the guns,* from the bottom of the bore to the rear end,



including the breechblock. In the following table, where two Krupp 15 cm. (6-inch) guns, L/40, of practically equal efficiency, are compared,

G_1 means weight of gun from muzzle to bottom of bore.
G_2 means weight of breech of gun.
G_3 means weight of breechblock and mechanism.
$G_1 + G_2 + G_3$ means weight of gun and fermeture (without attachments for the carriage).

Caliber cm	Kind of fermeture	Length calibers	G_3 kg	G_2 kg	$G_2 + G_3$ kg	$G_1 + G_2 + G_3$ kg	G_1 in % of $G_1 + G_2 + G_3$	$G_2 + G_3$ in % of $G_1 + G_2 + G_3$
15 (6-in)	Guide-shaft	L/40	188	300	488	5800	91.6	8.4
15 (6-in)	Screw	L/40	190	270	460	5800	92.07	7.93

This table demonstrates that the breech of the gun with its screw fermeture, in spite of its smaller weight, is only 0.5% lighter than breech and fermeture of the gun with wedge fermeture. This is partly due to the gun being cut open on one side and its having a smaller diameter than the gun with screw mechanism. This relation does not increase with the caliber, but it changes in favor of the wedge design, when Krupp's guns with wedge are compared with Schneider-Canet or Vickers' guns of *equal muzzle energy*, because with these guns *the available part of the gun barrel is not so well used, and they are relatively much heavier than Krupp guns.*

Besides, the greater weight of the breech of the gun with wedge fermeture is not a disadvantage in practice, but rather an advantage for the better use of the available room in turrets, because it puts trunnions whose axis runs through the center of gravity nearer to the rear end and allows a higher elevation, and more space back of the gun for the loading apparatus and ammunition hoist.*

Conclusion. The wedge fermeture with the smaller calibers is of about the same weight, with the larger calibers slightly heavier compared with the screw fermeture. But Krupp guns with wedge have not much heavier breech parts than guns with screw of other countries, because Krupp guns, the metal being used more advantageously, are less heavy when of the same efficiency as those of other countries. The small surplus of weight in the breech with the wedge, where

* See B. Weyer, "Deutsche Panzerplatter und Panzergeschuetze", Marine Rundschau, June, 1898.

it occurs, namely, in turret guns, is favorable for the service of the guns.

c. *Influence of the design of the fermeture on the readiness for firing.*

In the foregoing the qualities based on principle of the kind of fermeture, having either a longitudinal or a lateral movement, have been discussed. Next the influence of the *mechanical arrangement in the comparative designs* on the ease and rapidity of service shall be discussed, considering the wedge mechanism with metallic cartridge cases and the screw mechanism with bag cartridges.

The movement of the wedge in opening and closing the gun is in a straight line and only little longer than the diameter of the loading hole. The screw block has to make three different movements to open the gun, viz., first, loosening the screw by rotation; second, drawing it out of the gun straight backward; third, turning it sideways round a vertical bolt (French navy.) The second movement is dispensed with in modern designs with a conical screw. These designs have also been successful in combining the loosening of the screw and the turning of the screw block into one hand impulse, without, however, doing away with the original double movement, but only in summing their necessary force and sway.* *The force necessary for handling the wedge block is relatively small, because the wedge always moves horizontally.* With calibers of 6 inches and above, this force is further reduced by rollers so that even the heaviest wedge blocks can be moved by hand by one man without difficulty.

The screw blocks of the larger calibers necessitate mechanical gearing or even hydraulic or electric power. The French navy uses simple levers only up to 164.7 cm. (6½-inch) caliber. (See "Manuel du canonnier breveté").

The English are said to use simple levers up to 9½-inch caliber. But they admit, themselves, that opening of the breech is often very hard, (see "Nauticus", Berlin, 1903, page 103). A 23.4 cm. breech mechanism with hand lever of the firm of Vickers has been described by Dawson in his above mentioned paper, and pictured in "Engineering" of August 2, 1901, page 150. The lever is conspicuously long and has a double handle, above and below, which indicates hardness of handling.

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* What this leads to is shown in the U. S. 16-inch gun with its Stockett screw block, where the gun is opened by no less than 22½ turns of the hand crank.

Moving by a hand lever by one man is hardly possible above the 6-inch caliber, the less so when the loosening of the screw-block is impeded by the pad sticking to the walls of the chamber, thus necessitating an extra effort.

The mechanism of the wedge block is considerably more simple, first, because of its straight and short movement, and

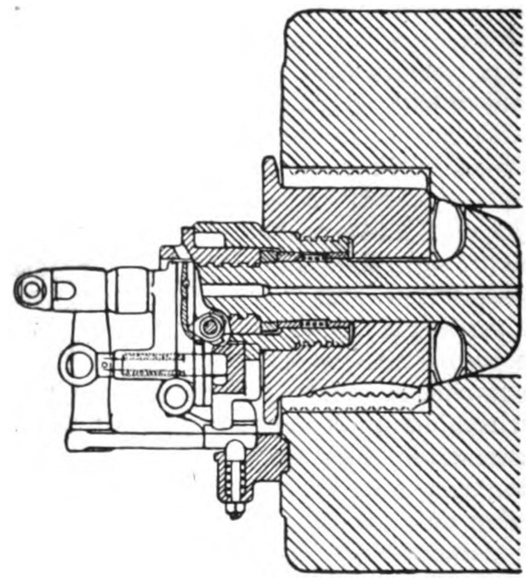
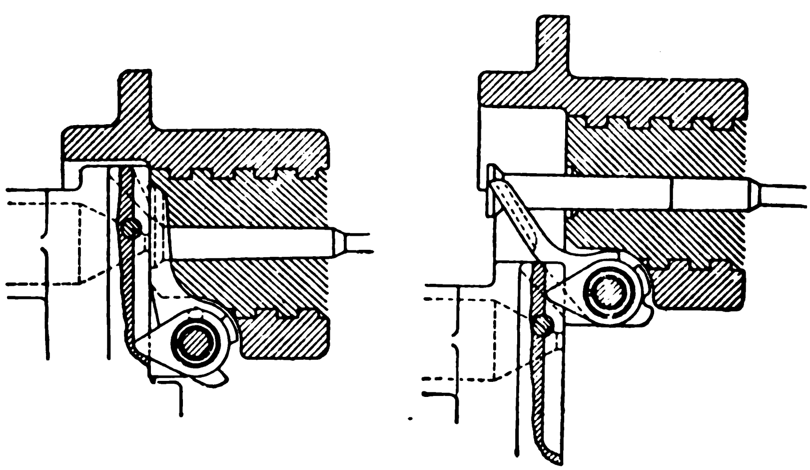


Fig. 36. Vickers' screw mechanism.



Figs. 37 and 38. Ejector of the Vickers' screw mechanism.

second, because it carries itself in the breech, while the screw block has to be supported by a frame or a bracket.

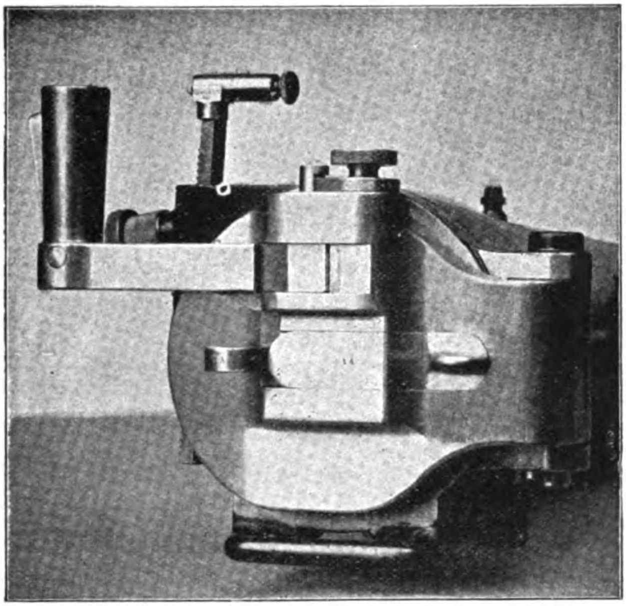


Fig. 39. Krupp's 15 cm. screw mechanism, closed.

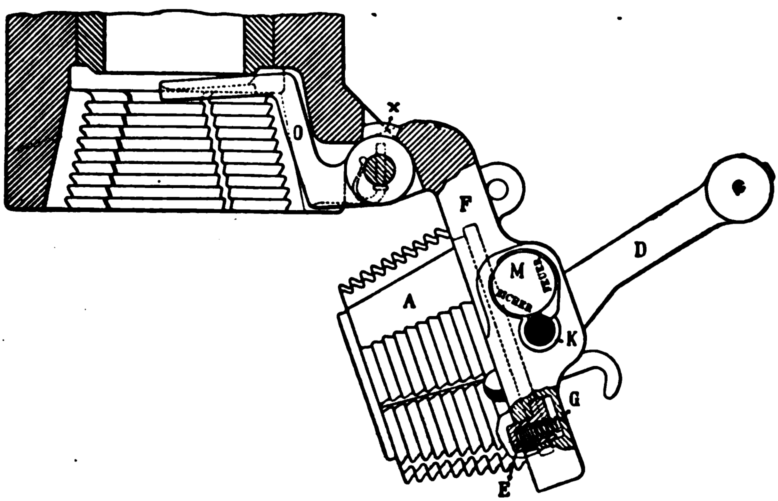


Fig. 40. Krupp's 15 cm. screw mechanism, open.

The great number of single parts in Vickers' screw mechanism is characteristic, (Figs. 36-38). In many ways it is inferior to Krupp's screw mechanism (Figs. 39-41).

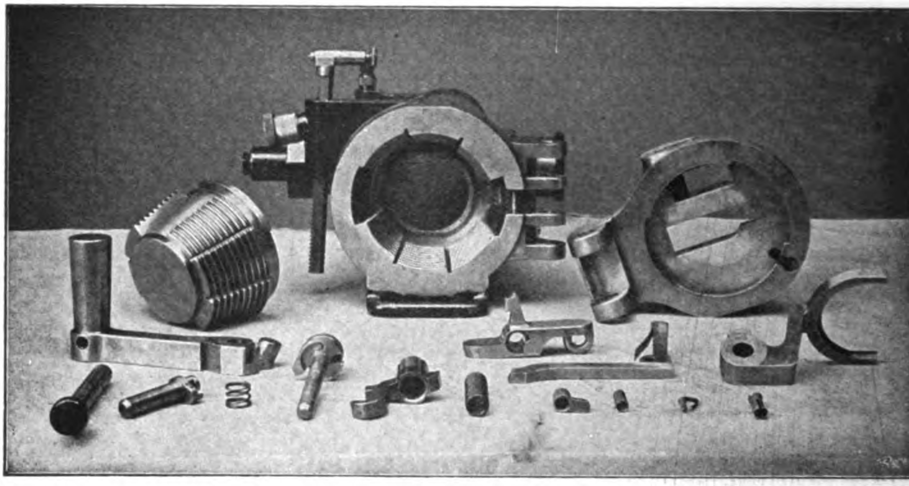


Fig. 41. Parts of the Krupp screw mechanism.

Krupp's wedge mechanism, composed of about 20 parts, is very simple (see Figs. 42-44). The turning of the guide shaft alone controls all apparatus for opening or closing the breech and cocking the firing lock. As soon as the breech is closed and the gun ready for firing, the guide shaft is free from the nut threads in the wedge hole, therefore *any disturbance in the mechanism by the action of the recoil is eliminated.*

Vickers' mechanism is of necessity of different design for the medium and large calibers, (see "Engineering", August 2d, 1901). Krupp's guide-shaft mechanism has the advantage of being *of the same design for all calibers.*

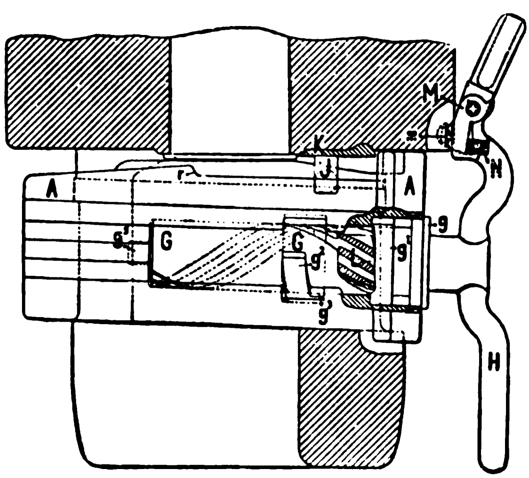


Fig. 42. Krupp's guide-shaft breech mechanism for medium and large calibers.

The use of metallic cartridges with the Krupp wedge protects the mechanism from being much soiled, *but even in case it is soiled the space between wedge and front wall of the wedge*

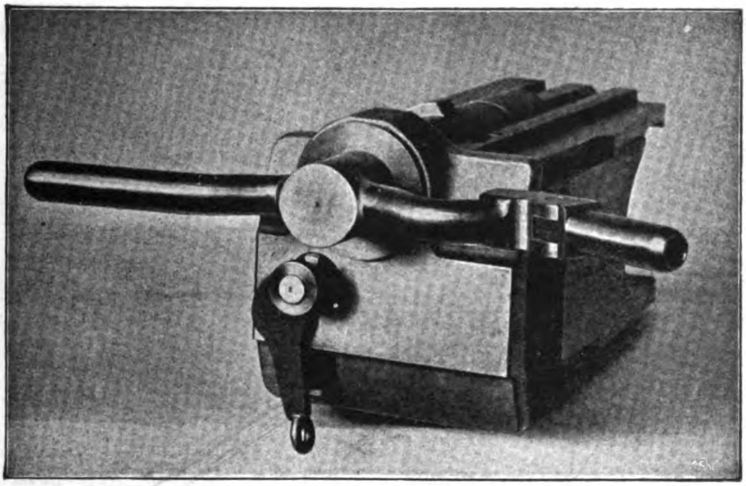


Fig. 43. Krupp's guide-shaft breechblock for medium and large calibers.

hole would guarantee its perfect functioning. All these advantages are denied the screw mechanism with plastic pad. The threads are the friction surfaces in opening and closing, and at the same time they have to take up the shock of recoil, therefore allowing very little play for the movement. Then, in case the threads become soiled, which can hardly be prevented with bag cartridges and defective obturation, the regular function of the mechanism will be interfered with, increased friction

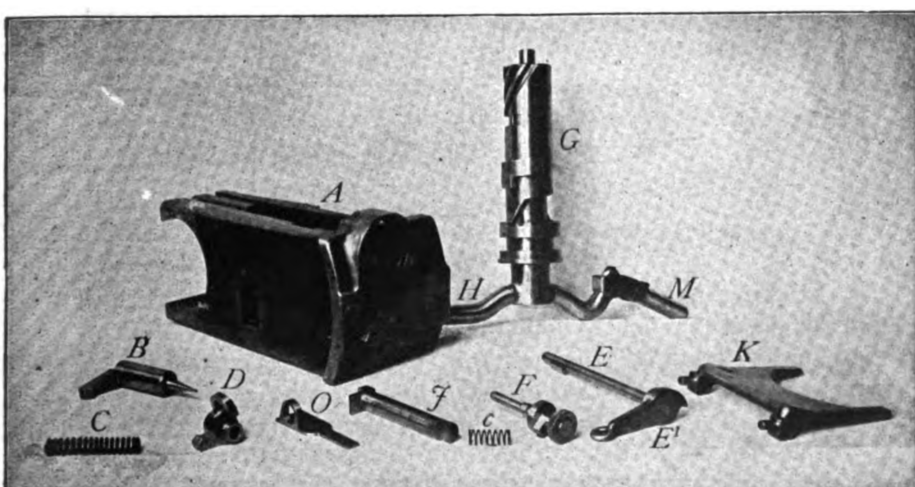
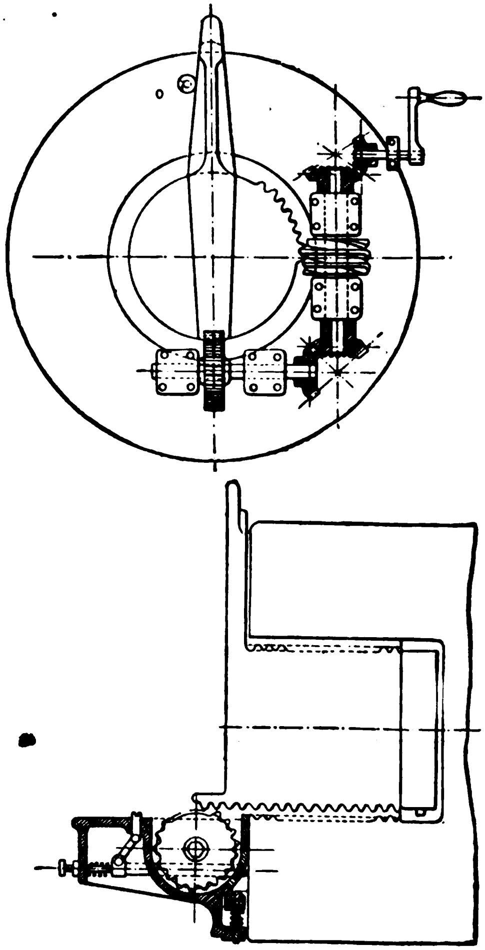


Fig. 44. Parts of the Krupp wedge breechblock for medium and large calibers.

will increase the difficulty of handling, or the screw will stick altogether and only yield to treatment in a workshop.*



Figs. 45 and 46. Screw breech mechanism, Manz system.

Sticking is very rare with a wedge mechanism, it will hardly occur except by outside action, and then relief is in most cases found by blows on the side end of the wedge. *It can be said in general that all parts of the wedge fermeture are much more accessible* than those of the screw fermeture. This

* A rather common occurrence. "La Nature" of April 29, 1905, says: "On a même été arrêté, dans la rapidité du tir, par un fait extrêmement curieux, avec certaines pièces de marine. La culasse de ces pièces, fort bien construites et trop bien ajustées, refusait, paraît-il, de se refermer dès qu'elle était encrassée par les résidus de la poudre, et, à chaque coup, il fallait procéder a un lavage complet.—Si bien qu'on apprit par l'expérience que l'ajustage d'un bon canon à tir rapide doit être laissé très large, au grand scandale des bons ouvriers de nos usines."

advantage is readily admitted even by friends of the screw mechanism; so, for example, "Text-book of Ordnance and Gunnery" says: The Krupp mechanism is very simple and not liable to get out of order. If it becomes stuck or wedged in the gun, it may be more easily removed than the screw, as it is more accessible. (See L. L. Bruff, Text-book of Ordnance and Gunnery, New York, 1902, page 277).

The ease in serving the breech mechanism is measured by the rapidity of opening and closing it, especially when many times repeated. Opening and closing Krupp's guide-shaft mechanism can be done

with the 6-inch gun 24 times per minute,
with the 9½-inch (24 cm.) 10 times per minute.

Extracting the cartridge cases does not make the handling harder, but it takes a slight extra time, so that the 6-inch guide-shaft mechanism, when extracting cartridge cases, can only be opened and closed 17 times per minute. To open and shut the guide shaft *once* takes

with the 6-inch, extracting the cartridge case, 3.53 seconds.
" " without " " " 2.5 "
" 9.5-inch " " " " 6 "

According to a French official statement* the "Fonderie de Ruelle" has been able to improve the Manz breech mechanism (see Figs. 45 and 46), which has been adopted for several modern French warships,† so that the *opening alone* can be effected

with the 12-inch gun,
in 5 seconds instead of 15 seconds as before,
with the 8-inch gun (19.4 cm),
in 3 seconds instead of 9 seconds as before.

This necessitates for one opening *and* closing, at least,

with the 12-inch gun,
10 seconds instead of 30 seconds as before,
with the 8-inch gun,
6 seconds instead of 18 seconds as before.

Professor Alger states, in his above mentioned prize essay, for the American naval guns the following times for *one opening and closing:*

* Exposé de la situation des services de la Marine. Annexe au budget de l'exercice 1905. Paris. Imprimerie nationale. Page 37.

† Manuel du canonnier breveté. Paris 1901. Page 71.

with the latest model of 12-inch gun, 9 seconds,
" " " 8 " " 9 to 10 seconds.

The rapidity of fire, however, does not depend on the rapidity of opening and closing alone, but is also influenced by the time necessary for *loading.*

The wedge block moves to one side of the gun and is handled from the side while the gun is loaded from the rear. This division of space prevents interference between the two actions, as occurs with the screw mechanism. True, with the English large caliber screw mechanism, the opening and shutting by a worm wheel arrangement is put on one side, *but the loading hole, as with all screw mechanism remains blocked until the screw has been turned aside; this in most cases consumes more time than extracting the metallic case with the wedge.*

The screw mechanism of medium and large caliber guns necessitates a *loading tray* to safeguard the nut threads in the breech. This *loading tray* can take its position only after the screw is turned aside, even if its motion is automatic.*

The complication is avoided in the wedge mechanism, where the loading hole has the function of the loading tray. Besides, the loading hole being cut open on one side facilitates the introduction by hand of the head of the projectile, which cannot be done in the screw mechanism. And the hand, when putting in the cartridges of the small and medium calibers, must be withdrawn before it is caught and injured by the screw turning to close; such an accident is impossible with the wedge, which would only shove the hand out of the loading hole without catching it.

The *rigidity of the metallic cartridges* offers the advantage of convenient handling and easy introduction into the chamber. Bag cartridges lack stiffness, and therefore, in the United States Navy, for example, strips of linen are wound around them to stiffen them.

Metallic cartridges have been criticised because of their greater weight and length, and it has been ignored that their weight is only a fraction of that of the projectile, which has to be introduced as well. When this is done, the metallic cartridge is put in by one movement, while the bag cartridges divided into several parts, necessitate as many movements of the rammer. The metallic cartridges are longer, but there is also

* With the 6-inch Bofors fermeture, adopted in the United States Army, the elastic loading tray remains in the gun, and protects the two lower sections of the threads as soon as the screw has turned (Horney, Gun Construction in the United States, Plate IX. and X.), but the merit of this design is doubtful because of its complication.

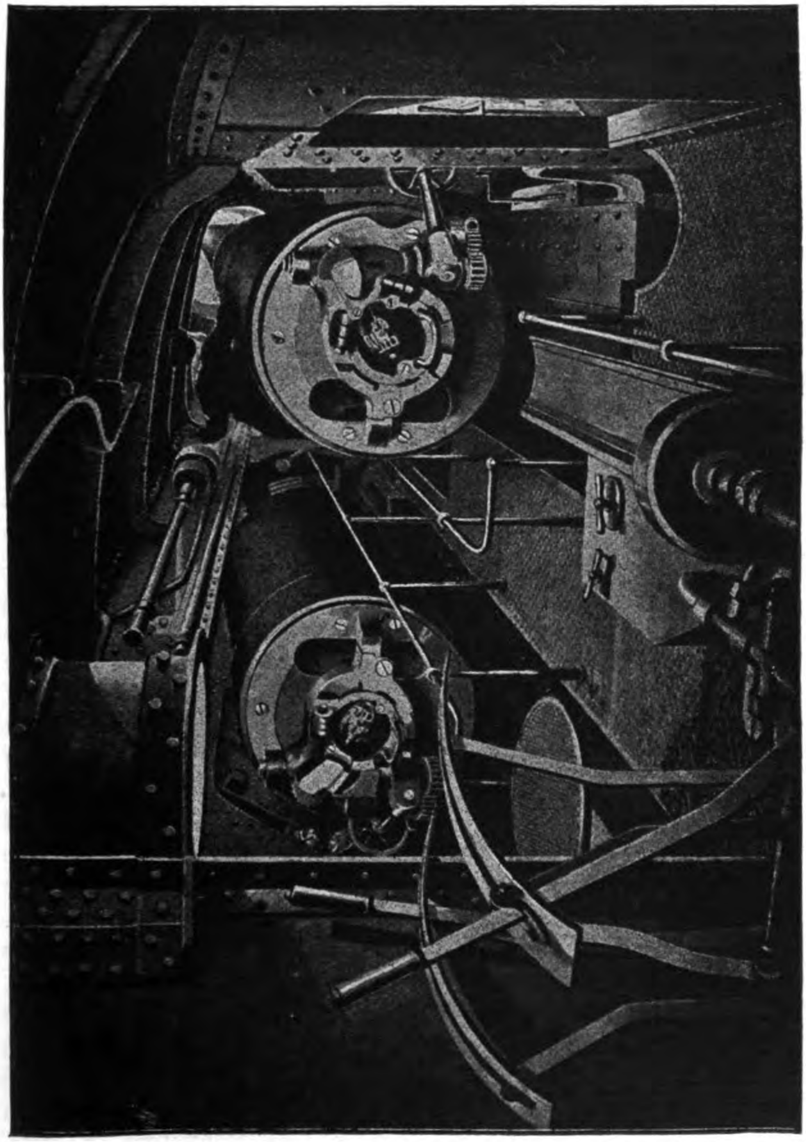


Fig. 47. View of the interior of a turret for two 12-inch guns on ships of the British "Majestic" class.

more room back of the gun, because the breech part is shorter, and there are no parts of the mechanism protruding to the rear. Consequently, loading can undoubtedly be quicker with the wedge and metallic cartridges than with the screw and bag cartridges.

The wedge for the same reasons *closes more quickly* than the screw ; for its travel is shorter and its movement needs less effort. With the screw and conical pad pressing the pad into its seat makes closing harder.

The *firing* arrangement is considerably simpler and the ignition surer with wedge and metallic cartridges. The metallic cartridge being inserted, the gun is ready to be fired, as the cartridge carries the primer in its bottom. With bag cartridges it is necessary to use an extra primer or firing cartridge for every round. The obturation of the vent-hole by such a firing cartridge made of brass is imperfect when the gas pressure exceeds 2800 atmospheres—40,000 pounds per square inch, because the front end of the firing cartridge will melt and burn. The powder gases then penetrating into the vent-hole then will clog it and force a cessation of the fire until the vent-hole is cleaned.*

The use of firing cartridges also calls for a mechanical ejector for the cartridge cases (see Figs. 36 and 38), which being smaller is more vulnerable than an extractor for the metallic cases of cartridges with a wedge mechanism. So if the extractor is said to be a disadvantage with metallic cartridges, this is more so with the ejector for the firing cartridges with bag cartridges.

In some instances with bag cartridges electric firing and percussion firing are combined, which complicates not only the mechanical arrangement but also the firing itself. The electric firing may be so arranged that the current will be effective only after the breech is locked, but safety so gained is sometimes lost again by other arrangements; for instance, in the English heavy naval guns by the so-called "auxiliary current" which allows firing independent of the breech mechanism. Using this auxiliary electric firing before the breech screw was fully locked caused the severe accident on board the English battleship "Mars" on February 14, 1902. (See Appendix I, No. 57).

* In the weekly "Uberall", 1903, No. 12, pages 222 and 223, pictures show the "Firing of a 24 cm. Gun in a Fort of Algiers" and "Firing Practice of a Flying Battery at Algiers," where the characteristic escape of powder gases is clearly visible. See also "Armée et Marine" of February 20, 1905, page 77.

The numerous drawings of different screw mechanisms in publications and letters patent prove the *complication in the firing locks* for bag cartridges in France, England and the United States. As an example, see Vickers' English patent No. 10606, of 1896, and the drawings in the addendum to "Treatise on Service Ordnance", London, 1898. This complication of the firing mechanism explains the numerous *misfires*, of which English and American artillerists complain.

"Morning Post" of November 9, 1904, referring to English firing cartridges, says: "Owing to the large number of misfires in electric circuits lately, the question of percussion firing daily becomes more important. The Admiralty recently adopted and issued a new pattern percussion tube, Mark VI., which, owing to its faulty construction, had to be withdrawn almost immediately, the Mark IV. being substituted. Now several Mark II. tubes have been found in the Mark IV. boxes, and as they are no good for modern guns they always misfire." And Professor Ph. R. Alger, of the United States Navy, states in his prize essay mentioned above, "it is the firing mechanism, more than any other feature of our ordnance material, that causes delay in firing service." Also the official reports in the United States confirm the considerable defects in the electric and percussion primers with screw fermetures and plastic obturators.

According to these reports, when in 1902 the 6-inch Bofors gun was tried, Bofors percussion tubes were used with 106 rounds, and their obturation was very unsatisfactory. The ejection of the tubes was very hard owing to the clogging of the vent-hole, partly because the ejector became loosened. The Bofors electric primer was used only with three rounds, and every time the powder gases escaped in quantity, so as to make the firing mechanism unserviceable, although the gas pressure was only 39,000 pounds per square inch. Percussion primers of the Frankford Arsenal when used in the same gun, were somewhat better, but still it sometimes happened that brass melted from the tube stuck to the seat of the primer so that the next primer could not be insertcd.

Among 30 rounds fired with electric primers of Frankford Arsenal, two-thirds obturated well or tolerably well, 3 caused misfires, 6 showed some escape of gas, 3 damaging escape of gas.

Also at another series of trials in the United States in April, 1903, the firing lock could not stand the greater gas pressures. In 8-inch and 12-inch guns gas escaped to the rear, and there was serious danger with gas pressures from 35,000 pounds per square inch upwards. From 45,000 pounds upwards the firing lock was destroyed and parts of it thrown out to the rear.

It has been shown in the above, that with a wedge mechanism and metallic cartridges, readiness for firing is superior to that with the screw mechanism and bag cartridges. It may be concluded from this that *the rapidity too of firing must be greater with wedge mechanism.* The following table gives some comparative data on this.

Gun	English data* rounds per minute	French data† rounds per minute	Krupp's data rounds per minute
30.5 cm. (12-inch)	0.91	1.2 or 1.5‡	1
28 "	—	—	1 to 2
27.4 "	—	1.5	—
25.4 cm. (10-inch)	0.69	—	—
24 "	—	1	2 to 3
23.4 cm. (9-inch)	2.5	—	—
21 "	—	—	3 to 4
19.4 "	—	1 or 2‡	—
19.0 "	—	—	3 to 4
17 "	—	—	4 to 5
16.47 "	—	4 or 5§	—
16 "	—	—	5 to 6
15.2 cm. (6-inch M. VII.)	5.88	—	—
15.2 " (6-inch)	5.03	—	—
15 "	—	—	5 to 6

* After Brassey's "Naval Annual, 1904," page 36. Average data per gun and minute at the record firing of the Mediterranean fleet in 1903 (Americans point to these data as standard; see "Gunnery in our Navy," prize essay by Ph. R. Alger, page 4.)

† After Armée et Marine, January 17, 1904, page 63. These data ought hardly to be taken as averages. They are not probably even reliable, as the article by P. de Gondi, from which they are taken, rather partially follows the tendency to show the superiority of the French naval artillery. The data have been calculated from the following in the French paper: Rapidity of fire with the

305	mm.	gun	6	rounds	in	5	minutes	on board	"Bouvet"
274.4	"	"	3	"	"	2	"	"	"
240	"	"	1	"	"	1	"	"	"Furieux"
194	"	"	1	"	"	1	"	"	"Marseillaise"
164	"	"	4	"	"	1	"	"	"

‡ After "La Marine francaise" of November 15, 1904, page 352.

§ For Model 1891, after "Carnet de l'officier de Marine," 1898, page 68.

Exceptional feats, so often praised in the papers, ought not to stand for averages. It would be easy enough to outdo such "individual shootings", as they are called in England, with German guns under similar conditions, but in Germany no importance is attached to such champion feats; rapidity without accuracy of firing is considered without value.

The following table gives the result of a few series actually fired with Krupp's guns with wedge mechanism and metallic cartridges, and guns with screw mechanism and bag cartridges:

Date.	Gun.	Number of rounds.	Time in seconds.	No. of rounds per minute.
A. guns with wedge mechanism.				
29/5/1899.	15 cm. L/40	10	102	5.8
9/2/1895.	R. F.	10	8	7.4
B. guns with screw mechanism and plastic obturator.				
14/8/1903.	15 cm. L/40	5	45	6.7
25/1/1904.	R. F.	5	52	5.8

In reading the two tables above it ought to be remembered that in testing the rapidity of fire, time in England and France is often reckoned from the command "Ready", but in Germany always from the command "Load".

The data in the table for Krupp rapidities of fire have been gathered with the gun in a *horizontal position. When the gun with a wedge mechanism is elevated, the rapidity is not reduced, but in large calibers even slightly increased,* as the following table shows, because the breech being lowered the man handling the wedge can use his own weight to better advantage.

The following data are the result of a test made on Krupp's proving ground Meppen on May 30, 1899, for opening and closing the guide-shaft mechanism without using metallic cartridges:

Gun.	Elevation.	Opening and Closing.	Time.
15 cm. R. F. Gun L/40	none 15°	10 times 10 "	15 seconds 15 "
21 cm. R. F. Gun L/35	none 11°	6 times 6 "	15 seconds 15 "
24 cm. R. F. Gun L/40	none 9.5°	6 times 6 "	16 seconds 15 "
30.5 cm. R. F. Gun L/40	none 8°	4 times 5 "	15 seconds 16 "

On the other hand the service of the screw mechanism grows harder with increasing the elevation, because the breechblock drops when opening and has to be lifted when closing. When the gun is depressed the breechblock has to be lifted in opening, and drops when closing. For example, with a 15 cm. Krupp screw mechanism the man in handling the mechanism has to use energy as follows:

at 1°	elevation	11 mkg	= 79	foot-pounds
2°	"	16 "	= 115	"
3°	"	20 "	= 144	"
5°	"	26 "	= 187	"
10°	"	40 "	= 288	"

Such additional effort of course reduces the rapidity of fire.

The French screw mechanism, system Manz, (for 274.4 and 305 mm. guns) at 10° elevation needs two men for its service (Manuel du cannonier breveté, Paris, 1901, page 71.)

With regard to the difficulty of handling, the French naval guns of large caliber are loaded with the gun depressed, so that the projectile is rammed by its own weight; but this makes the *opening* of the breech harder.*

Conclusions. The superior simplicity of mechanism of the wedge block, and in consequence the diminished sensitiveness to the effects of soiling and rough handling, lend to this construction a higher value for fighting use than the screw block possesses, whichi s adopted at present in the three leading countries, France, England and the United States.

The vulnerability of the screw threads and many defects of the plastic obturator form a constant source of disturbances in the service of the screw mechanism, which will not occur with the wedge mechanism and metallic cartridges.

It is also to be admitted in favor of the wedge that its handling is easier, especially with the larger calibers, than that of the screw. The greater the elevation of the gun, the more this advantage is felt.

The wedge running sideways, leaves all the space behind the gun for the loading service, while the screw must use this space for its movements and therefore interfere with rapid loading.

* Armée et Marine, September 15, 1904, says on page 846: "Par tradition, en effet, cette dernière (the French Naval Artillery) s'en tient à la vis-culasse à filets interrompus. Si, pour les gros calibres, on compare ce système de fermeture à celui imaginé par Krupp, on voit: d'un côté, lenteur dans les mouvement et difficulté de traction en arrière d'une masse pesante dont l'inclinaison négative (nécessité pour le chargement de la pièce) s'oppose à l'effet produit; de l'autre, légèreté d'un bloc dont le centre de gravité se meut dans un plan horizontal, rapidité extrême de manoeuvre.

The sum of these advantages of the wedge leads to the conclusion, that when metallic cartridges are used it offers a superior readiness for firing than the screw mechanism with bag cartridges.

IV. SAFETY IN USING THE GUN

While with guns with wedge block accidents in service have always been rare and for a number of years have hardly happened any more, numerous accidents with guns with screw mechanism up to the present have been published by the press. And there is room for the assumption that the number of accidents actually occurring is still greater, because for good reasons some of them are withheld from publication. Appendix I., gives the accidents with screw mechanisms since 1882, which have been reported by the papers.

It is conspicuous that many accidents can be traced to the *gun being fired before the screw block was locked.* Such accidents were numerous in France some years ago and typically called "déculassements." But this kind of accident is not limited to France, but spreads all over the domain of the screw block, as shown by the Appendix. Accident No. 38, occurring on July 15, 1897 on the Russian armor-clad "Sissoi Velicky" with a 12-in. gun, may be pointed out as a specially characteristic example. The importance attributed to accidents of this kind in the United States Navy is shown by an order of Secretary Morton, suggested by the Chief of Bureau of Ordnance, and published in the "Army and Navy Register" of February 4, 1905.

"The Department desires to call the attention of the officers and crews of ships carrying five- and six-inch guns having mechanism of the Vickers' Sons & Maxim type to the possible danger of firing these guns, as at present fitted, with the breech block swung home but not rotated. This could only happen in a case where the rotating stud was broken as sometimes happens if the plugman were to rotate the hammer of the lock by hand in order to raise the wedge and allow the operating lever to pass it. Officers and crews of guns are strictly cautioned against touching the hammer at target practice for any such purpose. If the hammer is found to be in the way, the firing will at once be discontinued until the apparent jamming is investigated. Safety devices and stronger studs will be fitted to these blocks as soon as possible by the Bureau of Ordnance; but, in the meantime, a luminous white line one inch wide across the upper part of the breech face on a vertical radius, continuously when the breech is properly closed, and a red sector on the breechblock, invisible only when the breech is properly closed, will be painted on the guns referred to, as a visual signal of danger."

It has been mentioned above that with the wedge block the hand of the loading man in the breech is simply shoved aside by the wedge when in the excitement of action the breech is closed too soon; his hand cannot be caught and injured. *With the screw mechanism*, which will not allow cutting open part of the breech, *prematurely turning the screw block in* (which with the present tendency to fire in record time may easily happen) *would generally cause serious injury to the hand not yet withdrawn from the gun.* It is evident that being conscious of such danger the loading cannoneer may neglect to put the cartridge far enough into the chamber, and then the screw rapidly moving in will jam the cartridge. Even with metallic cartridges under such circumstances the danger will not be less, the *screw will violently strike the rear of the cartridge case and the primer*, especially when the primer protrudes towards the rear as it does in the English cartridges. Excepting certain recent designs, *the firing pin then faces the primer*, and if for any reason (viz., when its end is bent or broken) the firing pin stands out from the front face of the screw, it may cause a premature firing. A characteristic example of this is the accident with a 6-inch gun at Bofors on February 25, 1902, No. 56 in Appendix I. Such occurrences are impossible with the wedge mechanism. In case the cartridge is not fully put in place, the wedge when closing will by means of its beveled end (Fig. 42) gradually press it home. It is an error, therefore, to say that the wedge would shear off a cartridge that was not fully inserted. The firing pin in the wedge can only face the primer in the cartridge when fully locked; therefore, a premature firing by the firing pin, as with a screw block, is impossible with the wedge.*

*The following is a report taken from "Le Temps," Paris, April 22, 1906, on the latest disastrous accident on board the French Schoolship "Couronne" at Toulon. It furnishes another proof of the dangers in using a screw breech mechanism. The latest news gives the number of killed as 4, the number of wounded as 22.

The accident is remarkable and characteristic; in its cause: the point of the firing pin hitting the primer and igniting the charge before the screw was rotated and locked; in its effect: the screw block being shot backward and doing great damage. Neither could have happened with a Krupp wedge.

"La 'Couronne,' navire-école de canonnage, était hier le théâtre d'un terrible accident d'artillerie.

"La culasse d'un canon de 164 millimètres avait été projetée en arrière par suite d'un enflammement prématuré de la charge; elle était allée frapper le canon de l'autre bord et ses débris avaient fait de nombreuses victimes; sur le pont gissaient des blessés et des morts.

"Le grand nombre des blessés s'explique par le fait que la culasse projetée en arrière s'est

But should from any other cause a premature firing take place, everything in the design of the wedge mechanism will add to prevent such serious consequences as will happen with the screw, because the wedge cannot be shot out of the gun, as is usual with the screw which opens in the direction of the bore. (See accident on the "Sissoi Velicky" No. 38, Appendix I.) Such occurrences have their source in the principle of the screw mechanism and could only be avoided by unfailing safety devices. But such have not yet been invented, see, for example, accident No. 58, Appendix I.

The danger of the screw being blown out grows as the gas pressure increases. It is quite probable that in continued firing the plastic pad will not withstand 2800 atmospheres (39,000 lbs. per square inch). Very little in known about tests of screw fermetures above 3600 atmospheres (50,000 lbs. per square inch).*

In comparison with this it is to be stated that Krupp wedge blocks have been tested with gas pressures up to 6000 atmospheres (84,000 lbs. per square inch) without the wedge being jammed, or there being any other irregularity.

Another source for a long succession of accidents is the use of bag cartridges with screw block and plastic pad, because in case the chamber is not thoroughly cleaned smouldering parts from the cartridge bag (in most cases silk) may remain and ignite the next cartridge before the breech is locked. Appendix II. is a list of accidents of this nature, among which the one on the U. S. S. "Missouri" (No. 16) was of especially grave consequences.

The many occurrences of this kind have led to a number of

fragmentée en de nombreux éclats après son choc sur le canon opposé ; ces éclats ont formé mitraille et ont balayé le pont et la dunette, chaque fragment de métal faisant l'effet d'un projectile.

"Le passage de la culasse a laissé des traces profondes partout ou les débris ont porté.

"Une enquête va être ouverte pour rechercher les causes de l'accident, enquête difficile, car la culasse a été brisée ; jusqu'ici il est admis que la catastrophe est due a ce que la charge de poudre a pris feu avant la fermeture de la culasse ; on s'expliquerait ce fait de la manière suivante : la pointe du percuteur faisant saillie serait venue frapper l'étoupille au moment ou l'on ramenait la culasse pour la fermer."

* In French naval guns Model 1893-93 the gas pressure was increased and is said "to allow 3000 kilos per square centimeter without danger to the resistance of the material" ("La défense navale de la France" by Contre-admiral Campion in "La Marine francaise" of November 1904, page 346).

According to an official report of 1903 the United States Ordnance Department tested a 6-in. Bofors gun, which has screw block and plastic obturation, also, with 5 rounds which had "excessive charges", and the gas pressure were not higher than 36,000, 38,500, 42,000, 42,500 and 49,700 lbs. per square inch.

At another test with an 8.in. gun on April 10, 1902, the firing lock was blown out by a gas pressure of 45,000 lbs. per square inch.

preventive measures. So, for example, the "Army and Navy Journal of April 23, 1904, page 897, says:

"With guns that open at the breech it has been customary to wash out the powder chamber with a stream of water from a hose, but in the later types of guns, where the powder chambers are contracted at both ends so that the water would be retained in them in considerable quantity, this is hardly practicable. Hence, although some navies, the Japanese in particular, still continue to wash out their guns, others content themselves with a fan-blast of air, and where fast record firing is going on there is a strong tendency to omit any cleansing at all."

Sir Andrew Noble of the Armstrong firm, in a paper read in 1899 before the Institution of Naval Architects, desires the gun elevated to 4 or 5 degrees so that the water for washing it may flow out. In the U. S. Navy an arrangement for *blowing air through the bore* after firing has been adopted since the "Missouri" accident.*

Considering what doubtful light the words regarding the tendency to omit cleansing during record firing throw on the safety of gun crews on board American warships, these words also prove that those measures for cleaning the bore after each round are preventing a real rapid firing. That is a reason why Vickers tries to obtain the same object without a special apparatus, by *studding the head of the rammer with bristles* (See "Engineering," January 15, 1904, page 76, Fig. 19). Such rammers are in use on the battleship "Triumph" built originally for Chile, but then taken into the British navy. That they will answer their purpose, remains doubtful.

After the "Missouri" disaster it was proposed to make the cartridge bags of *tissue woven of smokeless powder*. But there would be the new danger of the cartridge easily catching fire when not protected by a metallic case. It would be especially dangerous for the ammunition held ready in a turret, when a flare-back occurs, as shown by what happened on the British battleship "Venerable" October 7, 1904.†

* According to the "Army and Navy Journal" of April 4, 1904, the apparatus designed by the Bureau of Ordnance provides an air pressure of 200 lbs. per sq. inch, and the "Army and Navy Register" of July 2, 1904, says that this device shall be used with all guns in the Naval Service from 8-inch up.

† The Mediterranean Fleet. A disaster narrowly averted. Letters received from the Mediterranean Squadron at Argostoli, dated the 7th inst. state that the battleship "Venerable" narrowly escaped destruction a few days previously and it was only by a miracle that a terrible disaster was averted. The "Venerable" is the flagship of Rear-Admiral Reginald N. Custance, C.V.O., C.M.G., and is a vessel of 15,000 tons displacement and 15,000 indicated horse-power. She

Conclusions. The defects of the screw mechanism with plastic obtuation in contrast with the wedge mechanism with metallic cartridge cases appear most conspicuous in discussing the safety of the gun crew. They are defects which, like the premature firing before the breech is fully locked, are connected in principle with the device of a screw block, and, like the premature ignition of the powder charge by smouldering remnants of the cartridge bag, connected in principle with the use of loose bag cartridges. It is hardly to be expected that all these defects can be overcome by improved designs. A guarantee for the safety of the crew must be the first consideration with weapons of war, and the wedge mechanism with metallic cratridge cases gives this guarantee thoroughly.

RESUME

It has been the purpose in the foregoing pages to examine and compare the advantages and disadvantages of the mechanism with plastic pad and bag cartridge, and the wedge mechanism with metallic cartridge cases, on the ground of actual experience and numerical data. This has been accomplished. It has been shown that the general use of the metallic cases with the screw block met with unsurmountable difficulties and the plastic pad and bag cartridge had to take the place of the self-obturating metallic cartridge, although essential disadvantages had to be accepted in the bargain. It is claimed in favor of the screw mechanism, that it allows a somewhat longer rifled bore and a somewhat smaller weight of the breech; but it has been proven that these advantages are without value in practice, and that the heavier breech of guns with wedge block has even certain advantages.

The higher mechanical simplicity of the wedge mechanism, its easier handling and in consequence its reliable safety gives it a fitness for fighting use, far superior to that of the screw mechanism.

The question, well justified by the results of such comparison, why the advocates of the screw mechanism with plastic pad and bag cartridges will not surrender in favor of the

was engaged in long-range firing with the other ships of the Mediterranean squadron and after a round had been fired the breech was opened for the reception of another charge, when a back-flash occurred. The man who was working No. 3 gun was severely scorched, and the second charge which had been got ready to be placed in the gun was completely enveloped in the flame. Had this charge caught fire the flare might have communicated to the open magazine below with results that that would have been appalling. Fortunately the mischief was confined to the immediate vicinity of the gun. The injured man is progressing favorably.—*Naval and Military Record*, October 20, 1904.

wedge mechanism with metallic cartridge cases, must be answered by the statement that historical evolution and national tradition, as well as certain unconquered difficulties of manufacture favor the retention of the screw mechanism.

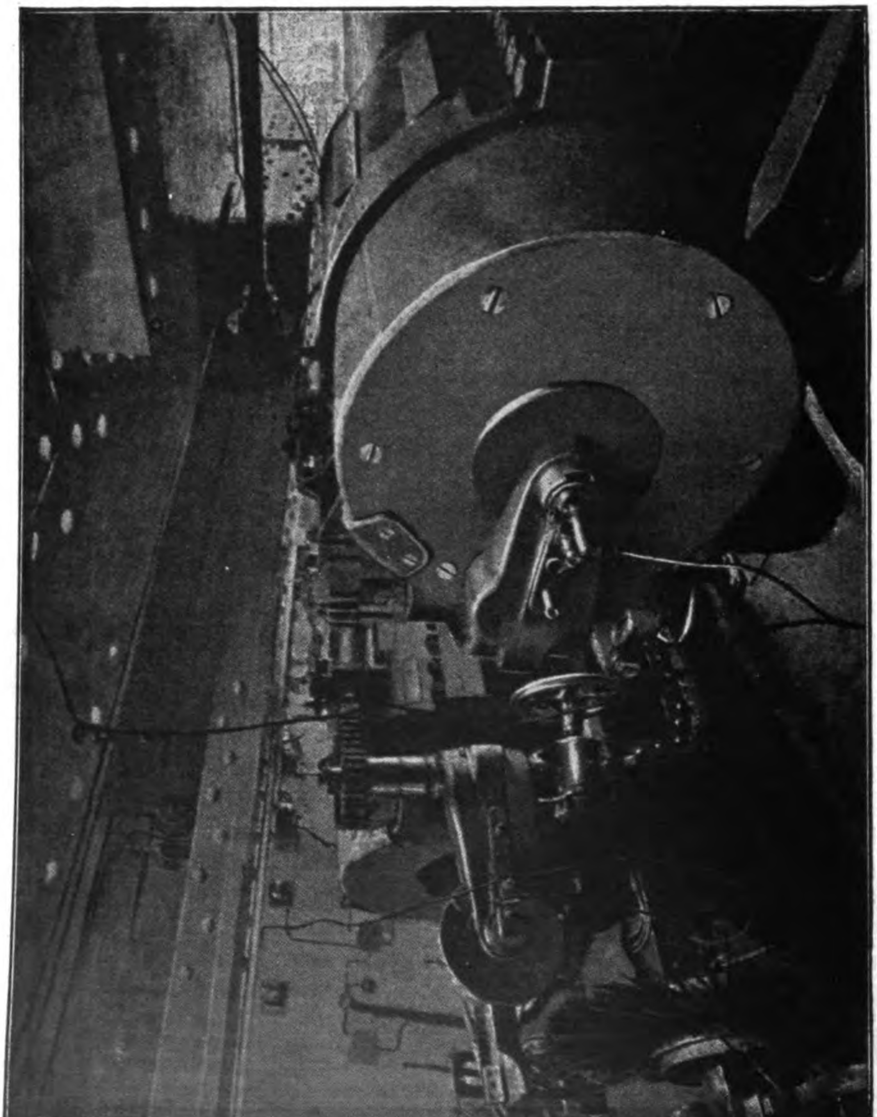


Fig. 48. The 10-inch Vickers guns of the British battleship "Triumph." (Engineering of 15. 1. 04.)
In the corner to the left is seen the head of rammer with bristles.

TABLE I.

Extract from a Report on Guns with Screw Breechblocks on Barbette and Disappearing Carriages, in 1902, in the United States of America.

No. of rounds	Total time between first and last shot of series m. secs.	M. V. f. s.	Pressure ft. lbs.	Manner of operation of breech screw	Firing mechanism	Remarks
Firing at Fort H. G. Wright, with 6-inch B. L. rifle on disappearing carriage No. 24, Model 1898, July 30, 1902.						
10	5 31.5	2650	31,600	Single motion breech mechanism operated by a lever.	Electric	Two defective primers caused a delay of 1 minute 20 seconds; 15½ seconds were lost in traversing and 10 seconds in locking.
With 6-inch B. L. rifle on disappearing carriage No. 26, Model 1898, August 12, 1902.						
10	3 24.8	2650	31,600	Single motion breech mechanism worked by a lever.	Electric	Lost 25 seconds due to defective primer.
With 10-inch B. L. rifle on disappearing carriage No. 54, Model 1898, August 12, 1902.						
30	27 35.3	2250	36,500	Breech mechanism operated by one revolving crank.	—	Toward the end of test *the breechblock worked hard.* Due to the sticking of breechblock and primers, 80 seconds were lost.
With 10-inch B. L. rifle on disappearing carriage No. 54, Model 1898, July 29, 1902.						
10 then 16	14 45.6	2300	36,000	By one revolving crank.	—	*The mushroom head and pad were found so much deformed* after the first round *that the breech could not be closed.* A new pad was put in. After the 11th round of the second series it was *almost impossible* to remove the breechblock; *after the 16th round the breechblock could not be closed,* and the series had to be discontinued.

Table I.—Continued.

No. of rounds	Total time between first and last shot of series		M. V.	Pressure	Manner of operation of breech screw	Firing mechanism	Remarks
	m.	secs.	f. s.	ft. lbs.			
Firing tests at Sandy Hook Proving Ground with 10-inch B. L. rifle on barbette carriage No. 6, Model 1893. Date not given.							
30	57	27.2	2250	34,460	By two revolving cranks.	—	The breechblock jammed when loading for the first shot, and a new latch had to be put on. *The block worked slightly hard during the first 15 shots, and quite hard during the last 15.*
Firing at Fort H. G. Wright with 12-inch B. L. rifle on disappearing carriages Nos. 22 and 21, Model 1897, July 30, 1902.							
3	2	36	2250	34,500	—	—	*The breechblock worked hard during the firing,* and jammed badly in closing it after the last shot.
With 12-inch B. L. rifle on disappearing carriage No. 21, Model 1897, August, 12, 1902.							
10	9	18.6	2250	34,500	—	—	Lost 36 seconds *due to sticking of gas-check pad.* Breechblock worked very hard during last three shots. *Gas-check pad was in bad shape at end of firing.*

Correction: Page 209, 3d par., 2d line, should read, "when guns above 6 inches in caliber were fired," etc.

APPENDIX I.

Accidents in firing guns with screw mechanism, as far as published (in chronological order).

Accidents caused by smouldering remnants of cartridge bags are listed in Appendix II.

No.	Country	Date and place of accident	Occurrence

No.	Country	Date and place of accident	Occurrence	Consequence

No.	Country	Date and place of accident	Occurrence	Consequences
12	United States	February 19, 1904 on board the "Boston"	At firing practice with a 6-inch gun there occurred a premature explosion of the cartridge probably ignited by smouldering remnants of cartridge bag.	1 man killed 2 men injured
13	England	March 29, 1904	At firing practice of the 120th Field Battery a 3.2-inch blank cartridge exploded in the gun, probably ignition was caused by smouldering remnants of cartridge bag.	2 men injured
14	United States	Spring of 1904 on board the "Kentucky."	In consequence of repeated flare-backs of smouldering remnants from preceding round a device was adopted to blow air through the bore after opening the breech.	

PERFORATION FORMULAS

By Captain ALSTON HAMILTON, Artillery Corps

ANYONE who has examined the records of proof firings of armor piercing projectiles will have noticed that the perforations are, to some extent, dependent on the relative merits of the *particular* projectile and plate used in a particular round. He will therefore realize that extreme nicety as to striking velocities is not only unnecessary but out of place and misleading. To obtain the striking velocity to within 10 f.s. is amply approximate.

Another fact is that any formula which does not take into account the thickness of the plate in determining its figure of merit is lacking.

The writer proposes to give formulas for the perforation of Krupp cemented and Harveyized plates by projectiles capped and uncapped, which will be both accurate and simple. He has been greatly aided in the preparation of this article by the able discussion of perforations by Captain Tresidder, C. M. G., in Brassey's "Naval Annual" for 1905; and (especially in regard to perforations at oblique impact), by photographs, data and opinions furnished by John F. Meigs, Esq., Engineer of Ordnance of the Bethlehem Steel Company.

In Captain Tresidder's discussion tables of perforation are given for both capped and uncapped projectiles. Those for uncapped projectiles have been adopted in their entirety as representing the best data. Those for capped projectiles have been accepted as true for a thickness of one caliber only. For two calibers the writer has relied on the results of firings by Messrs. Vickers, Sons and Maxim, Ltd.; which firings were sufficiently numerous to have great weight.

The conclusions of the firm were reprinted from the "Engineer" by the JOURNAL, and will be found on page 58 of the January-February, 1906, number; and, as there stated, the conclusions are based on "actual penetrations obtained with lower velocities".

They are as follows:

Gun	Weight of Projectile	Striking Velocity	Thickness in inches Perforated
12-inch	850 lbs.	2850 f.s.	24.3
9.2 "	380 "	3048 "	20.0
6 "	100 "	3060 "	12.25

These give the following figures of merit relatively to wrought iron for the thicknesses given:

12-inch gun	-	2.0
9.2 " "	- -	2.054
6 " "	-	2.142

Using a figure of merit 2.00 for 1 caliber as given by Captain Tresidder, the figures of merit for 2 calibers become by linear interpolation:

for 12-inch gun	-	2.00
9.2 " "	- -	2.046
6 " "	-	2.137

These conditions are satisfied by a figure of merit

$$F=2\left\{1+.0014\,(13-d)^2\left(\frac{t}{d}-1\right)\right\}$$

This, introduced into Tresidder's formula for wrought iron, gives the following formula for K.C. plates by capped A.P. projectiles, impact normal:

$$\left(\frac{t}{d}\right)^2 F^2=\frac{w}{d^3}\,v^2\log^{-1}[0.55694-10].$$

Designating the first member by P, we have, taking the logarithms of both members,

$$9.443+\log P=\log w+\log v^2-\log d^3,$$

or

$$\log P+\log d^3+9.443=\log w+\log v^2.$$

Log P is given in Table I. for values of $\tau=\frac{t}{d}$ (= perforation in calibers) from ½ to 3 calibers, at intervals of one-tenth of a caliber, and for values of d from 4 inches up, at intervals of 2 inches.

In Table II. values of log v^2 are given for values from 1000 to 3600.

In Table III. are given the logarithms of numbers from 1000 to 3000 by tens. Table IV. gives the necessary logarithms of secants.

Three place logarithms are used and are ample for the purpose for reasons above given.

Illustrations of the use of this formula will be given a little further on.

OBLIQUE IMPACT

Concerning oblique impact of capped projectiles against face-hardened armor, it has been recognized for some time that the cap materially assists in turning the projectile in toward the normal. It is evident by the composition of moments that any projectile that "bites" properly will necessarily turn in towards the normal. It is also perfectly evident that under such conditions the stress on the projectile has a transverse component unequally distributed along its length and that a bending moment is set up. This becomes so pronounced at 45° with the normal as to wreck the projectile even against a normal thickness of $\frac{3}{4}$ of a caliber. Mr. Meigs informs me that in the case of 6-inch capped A. P. projectiles against $4\frac{1}{2}$-inch inclined armor, twenty-one shots were fired and that all that perforated, with two exceptions, turned in to within about 15° of the normal. He further shows that 1682 f.s. was the critical striking velocity.

To show how he reached this conclusion it will again be necessary to refer to Captain Tresidder's article.

Capt. Tresidder very logically states that "treating the obliquely presented plate as one normally presented but thicker in inverse proportion to the cosine of the angle of obliquity, is a method generally admitted to be without claim to scientific accuracy. It deals only with the increased distance the perforating projectile would have to traverse in the obstructing medium, supposing its course were in no degree deflected from the straight line. The same objection applies to (what is not quite the same thing) resolving the velocity into its components normal and parallel to the plate, and considering only the former and the plate normally presented to it."

He proposes the following method: "Giving the usual meanings to t, D, W and v, let C represent the F. M. of the material for its oblique thickness against the given attack and θ the number of degrees of obliquity from the normal, then

$$v = \cos\frac{\theta}{2}\sqrt[3]{\frac{C^2\, t^2\, D \times \log^{-1} 8.8410}{W \cos^2\theta}} \quad \text{''}$$

That is to say he uses the figure of merit of the oblique thickness and assumes the return toward the normal of the projectile to be half the angle of obliquity.

Now, as stated above, the cap decidedly increases the return toward the normal; and taking the return as $\frac{2}{8}\theta$, Mr. Meigs obtained the velocity 1682 as the critical velocity for perforation of the plate under the conditions, using Captain Tresidder's data as to figures of merit.

Concerning this, Mr. Meigs states that "with two exceptions all the projectiles striking the plate at the latter velocity and above, perforated them, and the one projectile which had a lower velocity, 1587 f.s., failed to do so." The value obtained by Captain Tresidder was 1752 f.s.

For capped projectiles at oblique impact, I propose the following formula.

$$\log P_\theta + \log d^3 + 9.443 = \log w + \log v_\theta{}^2$$

in which P_θ is found with $\left(\frac{t}{d}\sec\theta\right) = \tau_\theta$ as argument and $v_\theta = v \sec \frac{2}{8}\theta$.

ILLUSTRATION

1. At what striking velocity will the 10-inch gun, w = 600, perforate 15 inches K. C. armor, using capped A.P. projectile.

a. At normal impact.

b. At 30° obliquity.

(a)	(b)
$\tau_\theta = 1.5$	$\tau_\theta = 1.5 \times 1.15 = 1.73$
$d = 10$	$d = 10$
$\log P = .358$ (Table 1)	$\log P = .485$
$\log d^3 = 3.000$	3.000
Const log = 9.443	9.443
colog w = 7.222	7.222
$\log v^3 = 10.023$	$\log v^3 = 10.150$
v = 2193 f.s	$\log v = 3.383$
	a. c. $\log \sec \frac{2}{8}\theta = 9.988$
	$\log v = 3.371$
	v = 2350

For Harveyized armor against capped projectiles, the formula becomes

$$\log P_\theta + \log d^3 + 9.193 = \log w + \log v_\theta{}^2.$$

The data furnished the writer by Mr. Meigs consisted of photographs and data sheets, and the amount was sufficiently voluminous and varied to show that the cap is a distinct asset in any case where perforation is desired by A. P. projectiles against face-hardened armor whether the impact be oblique or normal and whether the velocity be above or below 1800 f.s.; and this view is also that of Mr. Meigs.

Using the values of the figures of merit for Krupp and Harveyized steel attacked by uncapped projectiles, the expression for the figure of merit may be expressed as a function of the thickness in inches. In the case of Krupp armor:

$$F = 2.7\left\{1 - \frac{1}{5}\left(1 - \frac{t}{6}\right)^{2/3}\right\}$$

Introducing this into Tresidder's formula for wrought iron we have

$$t_\theta^2 F^2 = \frac{w}{d} v_\theta^3 \ [0.296-10]$$

or designating $t_\theta^2 F^2$ by P' we have

$$\log P' + 9.704 + \log d = \log w + \log v_\theta^3$$

in which $\log P'$ is found with $t_\theta = t \sec \theta$ as argument; and $v_\theta = v \sec \frac{1}{2} \theta$.

For Harveyized plates against uncapped projectiles

$$\log P' + 9.454 + \log d = \log w + \log v_\theta^3$$

Table V. gives the values of $\log P'$ with t_θ as argument.

ILLUSTRATION.

Find the normal thickness of K.C. plate which a 6-inch A.P. projectile uncapped will perforate with 2000 f.s. striking velocity the projectile weighing 100 lbs. (a) The impact being normal; (b) inclined at 35°.

(a)	(b)
$\log v^3 = 9.903$	$\log v^3 = 9.903$
$\log w = 2.000$	$3 \log \sec \frac{1}{2}\theta = .063$
a.c. $\log d = 9.222-10$	$\log w = 2.000$
a.c. const $\log = 0.296-10$	a.c. $\log d = 9.222-10$
$\log P' = 1.421$	a.c. const $\log = 0.296-10$
$t = 5.38$	$\log P' = 1.484$
	$t_\theta = 5.66$
	$\log \sec \theta = 0.087$
	$t = t_\theta \cos \theta = 4.64$ in.

The advantages claimed for this method are:

(1) The general expression for the figure of merit.

(2) The brevity of both direct and inverse solutions.

(3) Elimination of multiplication of error in table for log v^3, by abridging the logarithm of the cube instead of taking three times the abridged logarithm.

(4) The determination of the form of the expression for the relation between the elements of perforation so that future developments should merely change the constant logarithm in the first member.

No attempt has been made to deduce *analytically* a perforation formula, because of the lack of homogeneity in face-hardened armor; and because in the words of a Spanish contemporary, "the projectile which is the vehicle of the energy intended for perforation is not unfrequently itself destroyed by that very energy." With wrought iron, however, the analytical problem is capable of solution, as has been shown to the world by Major Weaver of the United States Artillery.

No apology is made for the empirical character of the formulas deduced in this paper, as no other practicable course was apparent.

The writer desires to repeat his acknowledgment of indebtedness to the discussion of Captain Tresidder; and of his deep obligation to Mr. John F. Meigs, whose interest in the matter contributed in great measure to any merit that may be found in this paper.

TABLE I.

Values of $\log P = \log w + \log v_e{}^3 - \log d^3 - 9.443$ with τ and d as arguments.

τ = thickness of plate in calibers, in line of impact.
d = caliber in inches.

τ	d: 4	5	6	7	8	9	10	11	12
	−10								
0.5	9.346	357	366	375	382	387	393	396	398
0.6	.496	505	513	520	526	531	534	537	539
0.7	.637	644	649	654	659	662	665	667	669
0.8	.768	773	776	780	783	785	787	789	790
0.9	.889	892	893	895	896	897	898	899	900
1.0	0.000	000	000	000	000	000	000	000	000
1.1	.088	086	085	083	082	081	080	080	079
1.2	.173	168	165	162	159	157	156	155	154
1.3	.253	246	241	237	233	230	227	225	224
1.4	.328	319	312	306	302	298	295	293	291
1.5	0.400	390	381	374	367	362	358	355	353
1.6	.464	446	440	432	425	419	414	411	408
1.7	.526	507	498	489	480	473	468	464	460
1.8	.585	566	555	543	533	526	520	515	511
1.9	.642	624	609	595	584	576	569	563	558
2.0	0.696	677	660	645	632	621	613	607	604
2.1	.746	726	707	690	676	664	654	649	646
2.2	.795	773	752	737	718	704	695	690	686
2.3	.842	819	796	776	760	746	735	729	725
2.4	.888	863	839	817	800	785	773	766	762
2.5	0.932	905	881	859	840	825	812	803	798
2.6	.973	945	920	895	876	859	846	836	830
2.7	1.013	984	957	931	911	894	879	869	862
2.8	1.053	1.021	994	968	946	926	912	901	894
2.9	1.093	1.060	1.031	1.002	980	961	945	936	925
3.0	1.132	1.098	1.066	1.038	1.013	992	976	959	957

TABLE II.

Values of log v^3 with v as argument.

	00	10	20	30	40	50	60	70	80	90
1000	9.000	013	026	038	051	063	076	088	100	112
1100	.124	133	148	159	171	182	193	205	216	227
1200	.238	248	259	270	280	290	301	311	322	332
1300	.342	352	362	371	381	390	400	410	419	429
1400	.438	447	456	465	474	483	492	501	510	519
1500	.528	537	546	554	563	571	580	588	596	604
1600	.612	620	628	636	644	652	660	668	676	684
1700	.691	699	707	714	722	729	737	744	752	759
1800	.766	773	780	787	794	801	808	815	822	829
1900	.836	843	849	856	863	869	876	883	889	896
2000	.903	909	916	922	929	935	942	948	955	961
2100	.967	973	979	985	991	997	*003	*009	*015	*021
2200	10.027	033	039	045	051	057	063	069	075	080
2300	.085	091	097	102	106	113	118	124	130	135
2400	.141	146	151	157	162	167	173	178	183	189
2500	.194	199	205	210	215	220	225	230	235	240
2600	.245	250	255	260	265	270	275	280	285	290
2700	.294	299	304	308	313	318	322	327	332	336
2800	.341	346	350	355	359	364	369	373	378	383
2900	.387	392	396	401	405	409	414	418	423	427
3000	.431	436	440	444	449	453	457	462	466	470
3100	.474	479	483	487	491	495	499	503	507	511
3200	.515	519	523	527	531	535	540	544	548	552
3300	.556	560	564	568	571	575	579	583	586	590
3400	.594	598	602	606	609	613	617	621	624	628
3500	.632	636	640	644	647	651	655	659	662	666
3600	.669	673	676	680	683	686	690	694	698	702

TABLE III.

Logarithms of numbers from 20 to 300. Mantissas to three places.

	0	1	2	3	4	5	6	7	8	9
2	.301	322	342	362	380	398	415	431	447	462
3	.477	491	505	519	531	544	556	568	580	591
4	.602	613	623	633	643	653	663	672	681	690
5	.699	708	716	724	732	740	748	756	763	771
6	.778	785	792	799	806	813	820	826	833	839
7	.845	851	857	863	869	875	881	886	892	898
8	.903	908	914	919	924	929	934	940	944	949
9	.954	959	964	968	973	978	982	987	991	996
10	.000	004	009	013	017	021	025	029	033	037
11	.041	045	049	053	057	061	064	068	072	076
12	.079	083	086	090	093	097	100	104	107	111
13	.114	117	121	124	127	130	134	137	140	143
14	.146	149	152	155	158	161	164	167	170	173
15	.176	179	182	185	188	190	193	196	199	201
16	.204	207	210	212	215	217	220	223	225	228
17	.230	233	236	238	241	243	246	248	250	253
18	.255	258	260	262	265	267	270	272	274	276
19	.279	281	283	286	288	290	292	294	297	299
20	.301	303	305	307	310	312	314	316	318	320
21	.322	324	326	328	330	332	334	336	338	340
22	.342	344	346	348	350	352	354	356	358	360
23	.362	364	365	367	369	371	373	375	377	378
24	.380	382	384	386	387	389	391	393	394	396
25	.398	400	401	403	405	407	408	410	412	413
26	.415	417	418	420	422	423	425	426	428	430
27	.431	433	435	436	438	439	441	442	444	446
28	.447	449	450	452	453	455	456	458	459	461
29	.462	464	465	467	468	470	471	473	474	476
30	.477	479	480	481	483	484	486	487	489	490

TABLE IV.

$\theta°$	log cos θ	D	log sec θ	D	log sec $\frac{1}{2}\theta$	D	log sec $\frac{2}{3}\theta$	D
5	9.998	5	0.002	5	0.000	2	0.001	2
10	9.993	8	.007	8	.002	2	.003	4
15	9.985	12	.015	12	.004	3	.007	5
20	9.973	16	.027	16	.007	3	.012	7
25	9.957	20	.043	20	.010	5	.019	8
30	9.937	24	.063	24	.015	6	.027	10
35	9.913	29	.087	29	.021	6	.037	12
40	9.884	34	.116	34	.027	7	.049	13
45	9.850		.150		.034		.062	

TABLE V.

For Uncapped Projectiles.
Values of log P′ with t_0 as argument.

t (in)	0	1	2	3	4	5	6	7	8	9
4	1.087	117	143	168	193	218	243	266	288	313
5	337	361	383	405	427	450	472	492	513	530
6	546	560	573	586	598	608	618	628	637	646
7	655	663	671	680	688	696	705	712	719	726
8	735	744	753	762	771	780	788	796	804	812
9	820	828	836	844	852	860	868	876	884	892
10	900	908	916	924	932	939	946	953	960	967
11	974	981	988	995	*002	*009	*016	*023	*029	*035
12	2.041	048	054	060	067	073	079	086	092	099
13	105	111	117	122	128	134	140	145	151	157
14	163	169	175	180	186	191	197	202	208	213
15	219	225	230	236	241	246	251	256	261	266
16	271	276	281	286	291	296	301	306	311	316
17	320	325	330	334	339	343	348	352	357	361
18	366	370	375	379	383	388	392	397	401	406
19	410	414	419	423	427	432	436	440	445	449
20	453	457	461	465	469	473	477	481	485	489
21	493	497	500	504	508	512	516	520	524	527
22	531	535	538	542	546	549	553	556	560	564
23	568	571	575	579	582	586	589	593	596	600
24	604	607	611	614	617	621	624	628	631	634

UNITED STATES FIELD ARTILLERY HARNESS

By Lieutenant EDGAR H. YULE, Artillery Corps

MEMBERS of the service are glad to see that due to the rapid advance of the United States field artillery material, we now have a field piece that is equal, if not superior to, those of the European armies.

In this advancement there appears to have been an oversight in the matter of improving the locomotive part, *i. e.* keeping the harness abreast of the latest ideas in equine equipment, in regard to eliminating a useless waste of energy.

The following is a report I submitted and some correspondence on my investigations of, and experiments with, field artillery harness.

I have been on duty with the 9th Battery Field Artillery from December 28th, 1902, up to the present time.

During that period I have never been quite satisfied with the arrangement of the line of draft (traces from the singletree to the lead-horses' collar) of the present artillery harness. It is not straight.

When all six horses are pulling their proportionate amount of load, there is an unnecessary downward pull on the wheel-horses' necks. This, in addition to the weight of the collar, pole, and pole-yoke, puts at times an enormous load on the necks of the wheelers.

During the two years that I was stationed at Pasay Garrison, Manila, P. I., with the 9th Battery F. A., I seldom noticed a swing or lead-horse with a sore neck. All the wheel-horses were so affected or bore scars on their abused necks.

Upon my arrival at the Presidio of San Francisco, Cal., I looked over the horses that the 9th battery took charge of (the old 5th battery animals) and found that almost all of the wheel-horses bore marks of bad necks.

During the last six months' stay of the battery in the Philippines, by order, it took two fifteen-mile practice marches each month. While on these marches, I paid particular attention to the wheel-horses while going up grades, over soft ground, and crossing bridges.

I noticed that if the wheelers pulled their share, they raised the line of draft several inches above the straight line drawn from the singletree to the collar of the lead-horse.

The constant tendency of the wheelers was to lag a little so that the trace-tugs on their collars were almost perpendicular. This would lessen the downward pull on the collar.

The wheel-horses are the heaviest of the six and very naturally the largest and tallest. This fact causes the line of draft to be drawn still further out of the straight line that it should occupy; or, in other words, the true line of draft.

It frequently happens that when the wheel-horse lags back until he is not pulling a pound and the trace-tug is perpendicular, the line of draft is still too high at this point and there is a downward pull on the wheelers' necks.

I took the average of several measurements of the height of the trace-plate of the wheel-horses' collar of the 9th battery F. A. at Pasay Garrison, Manila, P. I. and found that it was 16.5 inches higher than the singletree.

The trace-tug is 9.75 inches long; length of wheel-trace and rear connections 78.5 inches; distance from singletree to trace-plate 88.25 inches. Therefore, the height of the point where the swing-trace joins to the wheel-trace is:—

$85.25 : 16.5 :: 78.5 : x = 14.67$ inches higher than the singletree.

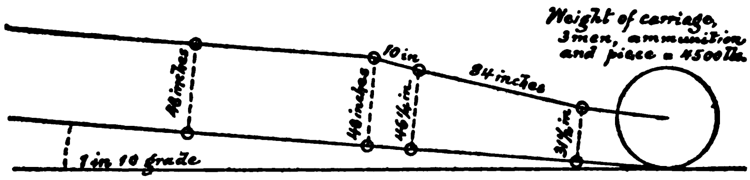
At this point, the height of the true line of draft above the singletree is as follows:—

Distance from singletree to trace-plate of lead-horse 337.75 inches. Height of trace-plate of lead-horse above singletree 16.5 inches. Length of wheel-trace and rear connections 78.5 inches.

$$337.75 : 16.5 :: 78.5 : x = 3.83 \text{ inches.}$$

Therefore, the line of draft is pulled out of its true line, $14.67 - 3.83 = 10.84$ inches. This is assuming that the trace-plate of the collar of the lead-horse is the same height as that of the wheeler. Usually, it is lower, thus making the error in draft still greater.

I took the following average measurements of several sections of the 9th battery F. A. at Pasay Garrison, Manila, P. I., from the harness and horses in use at the time. All in their regular positions:—



These do not conform exactly with the Ordnance Department measurements on account of stretched leather traces, pole not level, and doubling of trace chains.

I assumed the weight of the carriage to be 4500 lbs. (conservative estimate for piece, limber, ammunition, and three men on limber) and assumed a 1 in 10 grade.

From the above, I found that the best authorities on road traction give 200 lbs. per ton as the maximum pull on ordinary earth roads. On grades, the additional traction is equal to 20 lbs. per ton, per per cent of grade, making 200 lbs. per ton on the assumed 1 in 10 grade, altogether 400 lbs. per ton, or a total pull of 900 lbs.

A horse is supposed to exert a pull equal to his weight, with ease, for ten hours a day. This pull then of 900 lbs. gives 150 lbs. per horse, which would be, theoretically, the work of a 1500 lb. horse.

The force pulling down on the collar of the wheel-horse then would be the vertical component of the 300 lb. pull of the horses ahead of him.

On the assumed 1 in 10 bridge approach, just as the wheel-horse's collar reached the change from 1 in 10 to level grade this vertical component amounts to about 57 lbs. On a straight 1 in 10 grade it is about 36 lbs.

These results are, of course, based upon data obtained from experiments, but are sufficiently exact for all practical purposes.

In starting the load and on rough roads this downward pull would be doubled or even trebled, while on the level it would not be over 15 or 20 lbs.

When a battery passes over deep sand going up hill, with all of the horses exerting their full strength, this downward pull becomes so great that the wheelers are simply dragged to earth. I have seen them give away under the strain by crouching or kneeling; or, in other words, progressing by a stumbling gait.

In addition to sore necks, the wheel-horses become broken down in front by carrying this load on the fore legs.

From a perusal of the text-books prescribed by the War Department for the use and guidance of mounted troops, I find the following:—

"HORSES, SADDLES, AND BRIDLES", CARTER

Page 208. "The serious disadvantages of heavy and cumbersome packs is fully recognized by the authorities in every army, and the problem of devising means whereby the weight may be reduced without decreasing the efficiency of the trooper (applicable as well to artillery soldiers and horses*) is one always open for consideration and experiment."

Page 111. "While speed is gained for short distances by adjusting the load forward, it will not do for service because of the rapid breaking down which occurs in the fore legs."

Page 114. "One reason exists for throwing the balance of the horse somewhat to the rear, which alone mades it expedient to do so. This is the necessity for preventing the fore feet and legs from becoming prematurely ruined. It is not a matter of theory merely, but a well known result of actual experience, that horses carrying weights upon their backs become broken down in front, as a rule, long before they suffer any deterioration of the hind legs. The date of breaking down is much hastened by saddling far forward (in case of artillery downward pull on collar also*) over the withers, and by an improper use of the stirrups."

Page 160-1. " Taking a pound out of the amount carried in the horse's mouth may not seem to be a very important matter at first glance, but when it is considered that a first-class handicapper may, by adding or taking off a pound here or there, entirely upset all calculations as to the result of a race between animals of equal form, it must been seen that a pound more or less, particularly at the end of his neck, makes a great difference to the horse."

Page 221. "Weight of cavalry kit. The weight of the average kit and equipments complete is about ninety pounds."

The entire trend of the above extracts is to get weight off of the fore legs of the horse, a few ounces in the bit of the horse being of great moment.

Yet, all of our artillery wheel-horses are carrying on their fore legs, in addition to what a cavalry horse does, a fifteen pound collar, pole-yoke, strain from pole, and a downward pull from the lead and swing-horses of 15 to 20 lbs. on the level, to

* The writer.

35 to 57 lbs. on a 1 in 10 grade; and finally, on soft ground up grade an enormous weight which aggregates hundreds of lbs.

There is small wonder that a large percentage of wheel-horses have sore necks and are broken down in front.

"HAND BOOK FOR LIGHT ARTILLERY", DYER

Page 157. "Harness weights: wheel, near, 71 lbs. 15 ozs. Wheel, off, 69 lbs. 2 ozs."

Page 173-74. "The loin-straps should be adjusted so that the wheel-traces, when in draft, will be straight and without downward pull on the loops that support them."

"The loin-straps of swing and lead-horses should raise the traces about six inches above the stifle-joint when in draft. In this position the line of the traces from front to rear will be straight, and the loops of the loin-straps will support the traces without drawing them up.

The traces should be adjusted so that the line of traction will be unbroken from the singletree to the collar of the leaders, and this rule will regulate, in some measure, the length of the loin-straps, the matching of the horses, the arrangement of the pairs as wheel, swing, and lead pair; this should be such as to make the waste of force as small as possible."

The above description by Dyer seems to overlook the fact that the wheel-horses are bound, by the necessity of the case, to be the largest and their trace-plates the highest. Also, that the singletree is the lowest point of the line of draft.

Thus, we have the lowest and highest points of the line of draft very close together, with the necks of the wheelers as a sort of fulcrum over which the lead and swing-horses pull.

The average distance of the highest point above the true line of draft, found from my several measurements of different hitched teams, as mentioned before, is 10.84 inches. This error in the line of draft causes an enormous loss of energy.

The weight of the harness of the wheelers is almost as much as the entire kit carried by a cavalry horse.

From the above discussion, it is evident that the artillery horse is required to carry much more weight than the cavalry horse and, this in addition to his first duty of drawing the carriage.

In movement of troops the first and all important thing is to cover the maximum distance with the minimum loss of energy.

To accomplish this end, I have devised a line of draft and have had it in successful use in the 9th battery F. A., since June 3d, 1905, which eliminates the downward pull on the wheelers' necks.

It is simple, requires but very little more material than the present harness, and, does not change any parts.

The battery has operated over the steep and rugged hills of the Presidio of San Francisco; gone through deep sand; taken 15-mile practice marches; and the device has worked satisfactorily.

I gave it an exhaustive test in counter-marching, reversing, etc., at a trot and gallop and found it to work perfectly.

The description of the device is as follows:— (Particulars can be easily seen in the accompanying photographs).

Take two regulation wheel-traces (leather or steel cable) join them together at the rear ends by a cockeye passed through the two D rings in such a manner that the traces will be close together but not rub. This cockeye is plainly seen in photograph 2. It is made of $\frac{3}{8}$-in. best quality Norway iron, 11 in., long and bent as shown in the photograph. In case of leather traces put a strip of leather around rear end of each to prevent wearing on each other, as seen in photograph 2.

The trace that is attached to the wheel-horse to remain intact. Lengthen the other trace eight and one-half inches, by inserting more links in the front chain; (in case of adoption, lengthen the body of the trace instead). This makes it long enough to bring the toggle directly underneath the trace-plate of the wheeler's collar.

Take a breast strap, or similar strap, leave one breast strap hook on it; engage the hook in the breast-strap ring of the trace-plate (there is room for it); put a double eye-loop, similar to the one on the trace-tug, on the strap and buckle it up; engage the toggle of the longest trace in this eye-loop. This strap should be adjustable in order that the lower trace can be brought into the true line of draft for different height horses. It should be about thirty or thirty-two inches long.

Make a double loop on the loin-strap. The lower loop about six or eight inches long. Eight inches will give an adjustment of sixteen inches separation at the front end of the traces. Then one adjustment of the loin-strap would do for both traces.

From the above, it is readily seen that to put the device in in use, it is not necessary to manufacture any different material nor to change any now in use except to lengthen one trace, manufacture a *double cockeye* which I have made, and put a double loop on the loin-strap. In case of adoption, there should be another ring put on the trace-plate.

In order to give the device a practical test, it is not necessary to lengthen the lower trace. Simply arrange the harness as shown in photograph 2. In Plate II. both traces are the same length, (regulation traces), the only difference being that the supporting strap slants backward instead of being vertical. This is not so good as the other, however, as it strikes the horse's fore leg too much.

The large dray and transfer companies have solved this problem of getting the weight off of the horses necks by having the pole held up either by a spring or patent hounds. The doubletrees for the lead-horses are put on the end of the pole.

The wheel-horses' breechings are independent of their collars. This gives the wheelers complete freedom of movement and absolutely no weight but that of the collar, on the necks. This arrangement is impracticable in artillery. Therefore, the next best thing is the double-trace.

A careful study of the English and French breechings, convinces me that the one now in use in the U. S. Artillery, is the better.

The advantages of this double-trace, are:—

I. There is no downward pull on the wheeler's necks from the leaders.

II. It allows the wheeler to exert more of an upward pull on the carriage when it drops into a rut, low place, or sinks into soft ground, *i.e.* the same lifting force that is given in working on the rear of a wheel by the cannoneers No. 1 and 2 in "By hand to the front."

III. Elimination of the jerk on the wheelers' necks in going down grade or across ditches, if the lead and swing-horses go into draft—as they are bound to, and often do—after they have crossed a ditch, recovered themselves and the wheelers are still in the ditch and generally not in draft. By the lead and swing-horses having an independent line of draft they come into it, keep the carriage moving at a critical moment, after they have crossed and fully recovered themselves. The wheelers are not interfered with as they are crossing the bad place, have freedom of movement in coming up the bank and come into draft gradually after having recovered themselves from holding the carriage back and getting through the ditch.

IV. Elimination of see-saw motion on the wheelers' necks from the lead and swing-horses not keeping in step. This is considerable when all are in draft, as they should be.

V. The wheelers have complete freedom of motion at all times, especially when going at a gallop.

VI. The wheelers are not held down with a load on their necks from the pull of the horses in front of them.

VII. It lowers the traces of the swing-horses so that their collars do not slip upward, when in draft, and choke them.

VIII. Everything presented in this paper, and many other things that could be mentioned by a further study of the subject.

I am fully convinced that this device in an improvement on the present field artillery harness, and therefore request that it be given a trial in the two Provisional Regiments of Field Artillery recently organized.

I took a copy of the above report, a 3.2-inch field piece, and the harness to Headquarters Pacific Division, San Francisco, Cal., for the officers to inspect. A discussion arose as to the weight I had assumed for the load drawn by a six-horse team of artillery horses. In defense of my assumption, I wrote the following letter:

Presidio of San Francisco,
San Francisco, Cal., Aug. 11, 1905.

Col. Stephen P. Jocelyn,
San Francisco, Cal.,

Sir:

I beg leave to write to you, informally, about the harness that I had down at the Division Headquarters last week.

During the reading of my report there, a discussion arose about the weight of the load that the six horses were required to pull. I had assumed that the weight was 4500 pounds. The officers were inclined to think that that was too much.

The next day, after weekly inspection, I weighed the gun that I had down town for the officers to see. I unhitched the horses, and mounted three men on the limber chest. I took the three men that happened to be with the gun. The gun was weighed on the scales on which the forage of the Post is weighed. Then I figured the weight of ammunition and powder that would be in the limber in case that the battery was equipped for service. Following are the weights:

3822 lbs. weight of gun and carriage with three men mounted.
567 lbs. weight of 42 shell and shrapnel, each 13.5 lbs.
34.5 lbs. weight of three canister that are on the trail of the piece, each 11 lbs. 8 ozs.
43.5 lbs. weight of 45 rounds of powder, each 15.5 ozs.

4467.0 lbs. Total

That is the weight of each of the guns in the two batteries that I have been with during the last three years.

Now this weight is still greater at times. When a battery is prepared for action, there are two more men mounted on the axle seats, which increases the weight about three hundred pounds.

In wet weather when the gun and carriage gets water-soaked they will become still heavier.

So you can see my assumption of 4500 lbs. was, as I stated, conservative.

The last two days the field artillery battalion has gone out to drill here with the two men mounted on the axle seats. To-day we went up the beach toward Fort Point (through deep sand) then up a steep hill, a distance of fully a mile. Part of the distance up the hill was covered at a trot. Of course, at present, we have no ammunition in the limbers. But if it had been service conditions all of the pieces would have weighed nearly 4800 lbs. each.

When on marches, it is customary for the men to be allowed to ride on the axle seats to smoke. This is done in order to safe-guard the ammunition in the chests. So you see a good share of the time on the march there is this weight of almost 4800 lbs. to be drawn by the piece horses.

The above is not theory, but facts, as they exist.

I have been unable to obtain weight of the new equipment but suspect that it has been considerably lightened, as I remember of having read of the wheels being lightened.

Hoping that this will sustain me in the article, I am,

Very respectfully,

EDGAR H. YULE,

1st Lieutenant, Artillery Corps.

On September 4th, 1905, the First Battalion Field Artillery left Presidio of San Francisco, Cal., on its annual practice march. I had command of the 9th battery, and previous to starting had the wheel-horses of the four pieces equipped with the double-traces. I changed neither any horses nor drivers to favor the device but let it stand on its own merits.

Upon arrival in camp, after a 225-mile march, I checked up the sore necks of the wheelers and found :

Wheelers of pieces : one sore, two scalds.

Wheelers of caissons, battery and forage wagons : three sore, nine scalds, and two chafed.

That is, there were three-eights of the double-trace and seven-tenths of the others with worsted necks.

Coming back the same distance, I had :

Wheelers of pieces : one small boil (not deep seated sore, but a pimple), one scald, and one bruised.

Wheelers of caissons, battery and forage wagons : one small boil, (pimple) six scalded, and two bruised.

That is, there were three-eighths of the double-trace and nine-twentieths of the others worsted.

The wheelers of the pieces were at a disadvantage during the march on account of there being no brakes on the piece carriages.

It will be noticed that there was a smaller percentage of sore necks in the twenty caisson wheelers returning than going out. The results of the double-trace were so satisfactory going out that some of the caisson drivers asked permission to have double-traces. I was naturally pleased at this, and had all of my spare traces utilized, and fitted up five caisson wheelers with the double-trace, on the return trip.

Some of the wheel-horses of the caissons were occasionally changed with the swing-horses.

Four of the piece wheelers worked in their places the entire six weeks that we were on the march and in the field; two nearly all the time, and the remaining two the same as the caisson wheelers were.

The results obtained prompt me to publish them.

I received the following letter, on October 20, upon our return from the march :

War Department,
The Military Secretary's Office,
Washington, September 14, 1905.

1st Lieutenant, Edgar H. Yule, Artillery Corps,
Presidio of San Francisco, Cal.
(Through Headquarters, Department of California.)

Sir :

In response to your letter of July 15th, last, in which you submit a description, with photographs, of a modification of the present harness for wheel-horses of field batteries devised by you, I have the honor to inform you that the professional zeal displayed by you in devising a modification of the present harness for wheel-horses of field artillery is commended by the Acting Chief of Staff, but that another device practically accomplishing the same purpose, without so great an addition to the weight of the harness is now under trial and is preferable to the scheme proposed by you.

Very respectfully,

BENJAMIN ALVORD.
Military Secretary. (S.W.D.)

In reference to the above letter, in regard to the device not being desirable on account of its weight, I beg leave to say: As shown in the photographs it is too heavy. It was gotten up with the material at hand. *But the theory of the double-trace is feasible and an improvement.*

The supporting strap and metal connections in front can be reduced more than two-thirds in size and weight and still be strong enough. It is subjected to no stress except an occasional jerk and in coming on a level from an incline, viz: going on to a bridge. A bridle rein strap is strong enough.

The trace proper can be lightened. The upper one now having but one horse working on it can be reduced two-thirds in weight. The lower one having but two horses working on it can be reduced one-third.

The new wire-rope wheel trace weighs 2 lbs. 14 oz. and the former leather trace 3 lbs. 12 oz.

Put on two wire-rope traces with the above mentioned percentage of reductions and you have a double-trace weighing 14 oz. less than the old leather one and the same weight as the present single wire-rope trace. Therefore, considering the vast advantage the wheelers have, as shown in the eight "advantages" given above, I am quite sure that the device is superior to any other that can be put in use, or to the present harness.

Another added advantage to the eight above mentioned is, *that there is no need of the detachable trace-chains*, thus reducing the weight of each trace 1 lb. 2 oz.

I have never been able to see the utility of these chains for the present harness, except to be constantly getting lost and delaying getting hitched in, and there is certainly no need for them with the double-trace. (Some battery commanders remove the rear trace-chains of the wheel-traces. This is the case in the accompanying photographs.)

They are intended to adjust the length of the traces for different sized horses, viz:—Drill Regulations Field Artillery, 1905. (Provisional page 96.) "The length of the traces must depend in a great measure on the size of the horse and his stride. For the wheel team, the rule is to allow about fourteen inches from the singletree to hindquarters, and for swing and lead teams, about one yard from head to point of buttocks when in draft. The traces should be adjusted so that the line of traction will be straight from the singletree to the collars of the leaders," (last sentence impossible with present single trace).

A moment's thought will make it clear that if the wheel-traces are to be adjusted for different sized horses, the pole will also have to be adjusted, in length, as it is far more important that the collars be in such a position that the pole-yoke will be held at the proper angle in relation to the pole-yoke stop, than that the horse's hindquarters be a trifle of a few inches farther from or nearer to the singletree.

The only adjustments for the longitudinal stresses made necessary by different sized horses are the breeching and a slight change of the breast strap to keep the pole at the proper height. And in the case of small horses care must be taken or the latter will be gotten too short and bring all the hold-back on the horse's neck instead of the breeching.

These chains become worn so that they become unhooked very easily. Men resort to all sorts of schemes to make them secure, even to tying knots in them.

On account of these chains (in the Philippines, where the leather traces stretched unduly) it was necessary to strap the pole-yoke to the pole to prevent the latter from dropping out of the former. Finally, the chains were discarded on the wheel horses.

With the new wire-rope trace, where the liability to stretch is reduced to a minimum, there is no necessity for them to be adjusted.

The collar should always bear the same relation to the end of the pole. The difference caused by the height of different sized horses is so small that it can be easily corrected by the breast straps simply to keep the pole at the proper height.

In photograph No. 3 a line AB is drawn from the end of the doubletree A, to the trace-plate of the collar B; another, BC, from the trace-plate B, slanting down and forward to the pole-yoke stop, C, on the end of the pole; and one from C to

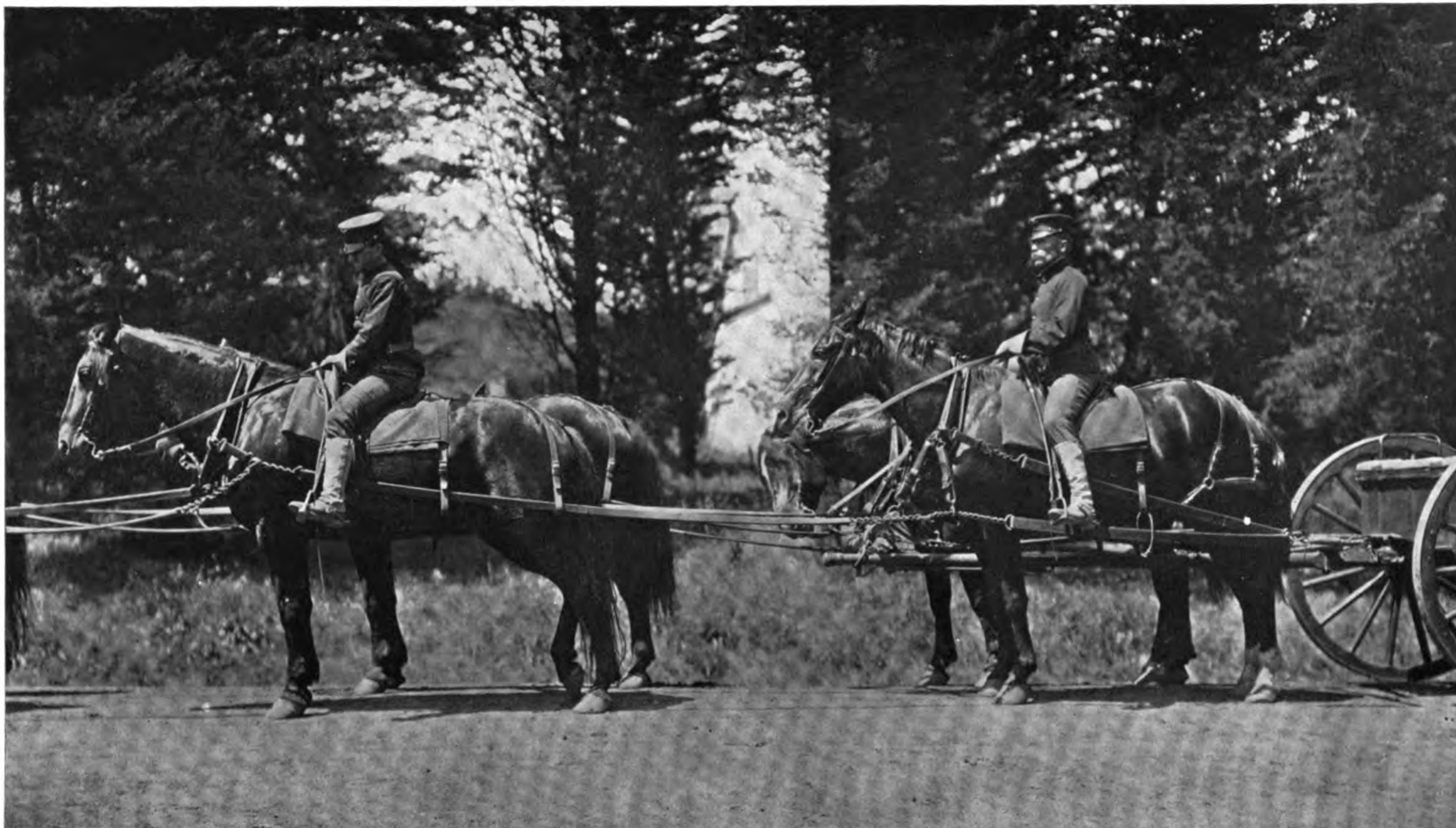


PLATE I.—YULE'S IMPROVED ARTILLERY HARNESS.

PLATE II.—YULE'S IMPROVED ARTILLERY HARNESS.

PLATE III.—YULE'S IMPROVED ARTILLERY HARNESS.

A, making a triangle. It will be seen that angle B is a little more than a right angle. Extend B horizontally forward to B′. B′ is a right angle. B would be a little beyond B′ at B″ if the horse had been standing well in draft at the instant the photograph was taken. Angle AB″C should equal angle ACB″.

With these two angles equal you have an isosceles triangle in which the trace and connections are one side, *i. e.* AB″. The other side is the line AC; *i. e.* in reality, the length of the pole from the doubletree bolt to the neck-yoke stop.

Now this isosceles triangle is lying on the side AC, which is practically horizontal and in most cases C is slightly higher than A. Therefore, the angle B″ will always be farther to the rear than angle C. That is to say: No matter how large or small the horse the isosceles triangle simply has a longer or shorter base, B″C, caused by adjusting the breast strap, and the collar will approach or recede from the pole-yoke stop and the angles B″ and C remain equal. The collar never gets forward of the pole-yoke stop nor too far to the rear of it.

Thus far I have used only my own measurements and a graphic representation.

I will now take some Ordnance Department measurements of the new field artillery material and show that this isosceles triangle now exists; but all of its advantages are lost by the provisions of the drill regulations which permit the driver to adjust the length of his trace with the new trace-chain when he imagines that something is wrong, instead of using the proper remedy; *i. e.* the breast strap and side straps of the breeching.

The new pole from the doubletree bolt to the pole-yoke stop is 102.687 inches. (Blue print 3-inch field limber, model 1902, R.I.A.)

The new steel wire trace with connections from end of doubletree to trace-plate of collar is:

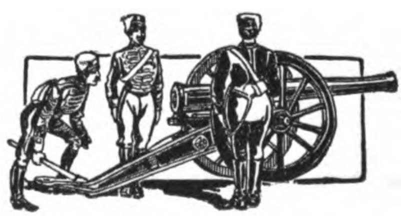
8.25 inches doubletree to end of whippletree hook.
11.625 inches rear chain.
9.75 inches Mogul spring.
58. inches trace.
5. inches front chain.
9.75 inches tug.

102.375 inches equals AB″ (blue print, artillery harness traces R.I.A. 1904.) The pole equals AC. The trace and connections equals AB″ of the established triangle, and is only .312 of an inch shorter than AC.

I do not know whether the Ordnance Department intended this triangle to be or not. Nevertheless, it does exist when the harness is properly adjusted. Therefore, the rear chain should be discarded and the trace lengthened.

With the non-stretching trace, the length needs no more adjusting than the piston rod of an engine for a varying steam pressure.

With the double-trace the wheel horse is independent of the others. On all kinds of roads he performs his functions without hinderance; and at the end of a long march his driver can feel that the animal's great strength has been utilized to the best advantage, and that with a minimum loss of energy.



DESCRIPTIVE CARDS FOR PUBLIC ANIMALS

BY LIEUTENANT F. B. HENNESSY, ARTILLERY CORPS.

THE following plates represent a loose-leaf system of descriptive cards for public animals, which has been submitted for the consideration of the proper authorities :—

The present system of keeping records of Public Animals in the book issued for that purpose by the Quartermaster's Department is rather crude and unsatisfactory.

Under the present system when public animals are transferred an abbreviated description of each animal is sent to the receiving officer by the Quartermaster.

Many mistakes occur in this description due to the fact that the civilian clerks who make out the list, or who copy it from time to time, do not understand the meaning of the abbreviations, and as a result, make mistakes in the different letters; or still worse, slur over the letters, so that they are illegible, and mean nothing to the receiving officer, thus necessitating a complete test of identification by the receiving officer.

Of the 162 horses in one of the organizations stationed at this post, there is hardly a single animal that could be positively identified if the official identification sheet received with the animal were the only source of information.

Many of the descriptions read, for example, "Bay, Black Points, 15½ hands high, age 8." This is too meagre to be accurate, as in one organization there may be some twenty animals that are "Bay, Black Points, 15½ hands high, age 8."

With the loose-leaf system herewith submitted, if faithfully adhered to, it would be practically impossible to confuse any two animals, for there are no two animals so *perfectly* matched as to color, peculiar marks, age, exact *weight*, height, sex, hoof number, and the side that the mane is carried upon, as to prevent positive identification by this diagram system.

Some of the data contained in Quartermaster's Book of Public Animals are omitted in this system and other data added for the following reasons :—

The *naming* of horses is a sentimental fad of doubtful value in our modern army, for the reason that the ordinary soldier gives a pet name to his own horse and rarely calls him "General Washington" or "General Hunt," or any other official name. If a recruit is told to secure a certain bay horse named "Russel," he is very liable to return with a bay horse called "Ping-Pong" or "Budweiser," or any other bay horse; whereas, if he is ordered to bring bay horse "Hoof No. 63," he can bring back only that certain horse, as "63" should be legibly branded on hoof of off hind foot and renewed once or twice annually, depending upon the climate.

It is also unnecessary to enter the name of the rider or driver of an animal, as in the present day of few re-enlistments the riders and drivers are so often changed, due to the exigencies of the service, that a descriptive book would be littered with a lot of useless information if it were attempted to preserve a complete list of names of riders and drivers of an animal throughout the twelve to eighteen years of service of an ordinary public animal.

The heights of animals should be expressed in inches instead of by the antiquated method of "hands high," as all men understand what is meant by "62.3 inches high," whereas many never do understand what "15½ hands" means. In connection with the subject of heights, it should be insisted upon that the measuring rod be placed parallel to the vertical axis of the front leg, touching outside quarter of shoe.

The remark "how employed" is also superfluous, at least in a battery of field artillery, as it is a general principle that an artillery horse should be interchangeable, either as a saddle or draft animal, near or off horse, if of a properly trained and selected type.

The "weight" is entered because it is a good means of identification when there are two bay horses, for example, that are very similar in markings, etc., but differ considerably in size and *weight*.

A table of "weights" has been entered in order to furnish statistics in the future, by means of which the proper weight and type of animal may be definitely selected for different kinds of work which public animals must perform, as Cavalry, Horse Artillery, Field Artillery, Siege Artillery, or for heavy draft purposes. It is a very simple matter to weigh animals once per annum, as scales are often available at Quartermaster Depot at most posts; and any great falling off of weight will be a positive indication that any certain animal is unfitted for the work to which it has been put.

The item "sex" is given as a means of identification, because in time of war mares are bought for government use in the Cavalry, Artillery, etc.; and, again, because the Quartermaster's Department may use this same form for transportation of mules, bell mares of pack trains, etc., in time of peace.

The item "purchased where," is also given to furnish statistics as to the locality from which the best type of animals come for the different kinds of work, as the great majority of animals are foaled and raised in the immediate vicinity of the of the place where purchased from the contractor.

No horse should be bought for heavy army use until he has attained the age of six years. At this age a horse has acquired its full growth, and therefore when measured for size of shoe, bit and collar, upon receipt by an organization, the sizes then taken will practically remain constant throughout the animal's service; with the possible exception of the collar measurement, due to the fact that the great majority of horses when purchased for the government are too sleek and fat. Hence the permanent size of collar should be determined only after the animal has served long enough with his organization to become thoroughly fit and in a hardened condition.

One point necessary to remember in connection with this measurement for size of collar for an artillery horse, is that the collar finally selected should be extended to its greatest dimensions at the time of measurement, in order that it may be made smaller after the horses become thin and worn down in time of campaign.

All of the above enumerated data may prove valuable should Congress ever permit the army to operate a horse-breeding establishment of its own, as in that happy event we would have reliable statistics by means of which a judicious selection of different types of animals could be made for the different kinds of work.

As soon as an animal ceases to belong to an organization either by death, condemnation and sale, or by transfer, his descriptive list should be removed from the "active list," and either kept by the organization as a retained paper, or, better still, forwarded to the Quartermaster-General for permanent file.

The price at which an animal is finally sold is entered in order to show the total cost to the government of each animal.

The "cause" of condemnation is entered in order to show the most frequent diseases and disabilities to which animals are subject in the different branches of the service, and in time to provide remedial measures for same if possible.

If any such scheme as the above is finally adopted for public animals, it is thought that the diagrams of horse should be printed in *red* ink in order that black ink may be used for notation purposes, etc.

DESCRIPTIVE LIST OF PUBLIC ANIMALS 120TH BATTERY F. A. HORSE

DESCRIPTIVE LIST OF PUBLIC ANIMALS ...TH BATTERY F. A. HORSE

A CONTRIBUTION TO INTERIOR BALLISTICS

By Colonel JAMES M. INGALLS, U. S. A., Retired

CHAPTER III.

SECOND APPLICATION.

Experiments with cordite. For a second comparison of theory with observation, we will take the first of the Noble firings given on page 153 with cordite of 0.4 inch diameter. The weight of charge was 27.5 lbs., density of loading 0.55, weight of projectile 100 lbs., log $z_0 = 0.42178$ and log $a^2 = 0.07084$. For convenience of reference the values of x, v, log X_0, log X_1 and log X_2 which will be necessary in the discussion, are collected in the following table. The logarithms of the functions was taken from the table of these functions, using second differences when necessary, that is, when these differences exceed 0.00008.

u	x	v	log X_0	log X_1	log X_2
ft. 16.6	6.2853	f. s. 2794	0.82110	0.50606	—10 9.68496
21.6	8.1784	2940	0.86213	0.57994	9.71799
34.1	12.9112	3166	0.93117	0.69774	9.76657
46.6	17.6446	3284	0.97710	0.77150	9.79440

The pressure functions for u = 16.6 ft. are log $X_3 = 9.53338$, log $X_4 = 1.00926$ and log $X_5 = 1.96122$. These will probably be needed during the discussion.

The *form* characteristics of cordite are (Chapter I., page 192) $\alpha = 2$, $\lambda = -\frac{1}{2}$ and $\mu = 0$. These substituted in the expressions for M, N and N′ (page 36) give

$$M = \frac{2\bar{v}^2}{X_1}, \quad N = \frac{1}{2X_0} \quad \text{and } N' = 0;$$

and these in equations (40), (47) and (50) reduce them to

$$\frac{y}{\omega} = \frac{2}{X_0} X_0 \left\{ 1 - N X_0 \right\}$$

$$v^2 = M X_1 \left\{1 - N X_0\right\}$$

$$p = M' X_3 \left\{1 - N X_4\right\}$$

Also for this particular gun and charge equation (74) becomes

$$p_m = [8.17490-10]\, M \left\{1 - [0.48444]\, N\right\}$$

by means of which the maximum pressure may be computed when M and N have been satisfactorily determined by two independent velocity equations. Or, M and N may be found when but *one* velocity has been measured, by combining the the velocity equation with that for the maximum pressure, assuming this latter to be the crusher-gauge pressure or some known function of it.

In this example the values of M and N are best determined by means of equations (a), page 150. The data selected from the above table are the following:

$v_1 = 2794$ f.s., $v_2 = 3166$ f.s., $\log X_0' = 0.82110$, $\log X_0'' = 0.93117$, $\log X_1' = 0.50606$ and $\log X_1'' = 0.69774$. With these data we easily find

$$\log M = 6.59155$$
$$\log M' = 4.91005$$
$$\log N = 8.75465$$

The expressions for velocity and pressure for this shot are therefore

$$v^2 = [6.59155] X_1 \left\{1 - [8.75465-10] X_0\right\}$$

and

$$p = [4.91005]\, X_3 \left\{1 - [8.75465-10]\, X_4\right\}$$

By this last formula the maximum pressure is found to be 48276 lbs. The crusher-gauge pressures ranged from 44800 to 49280 lbs. The first formula gives for $u = 21.6$ ft. a velocity of 2950 f.s. which is 10 f.s. more than the chronograph velocity.

At the point where the powder is all burned we have

$$\overline{X_0} = \frac{1}{2N}$$

Therefore

$$\log \overline{X_0} = 0.94432;$$

and from the table of the X functions, by interpolation, using only first differences, we find

$$\overline{x} = 14.11,$$

$$\log \overline{X_1} = 0.71921,$$

$$\log \overline{X_2} = 9.77488.$$

Therefore $\overline{u} = 14.11 \times 2.6411 = 37.266$ ft.

The charge was therefore all burned in the gun.

$\overline{v}$ can now be computed by the velocity equation already deduced. It is easier however to compute $\overline{v}$ by this equation

$$\overline{v}^2 = \tfrac{1}{2} M \overline{X_1}$$

by which we find

$$\overline{v} = 3198 \text{ f.s.}$$

We also have

$$V_1^2 = \tfrac{1}{2} M \overline{X_0}$$

$$\therefore \quad \log V_1^2 = 7.23484$$

$$\therefore \quad V_1 = 4144 \text{ f.s.}$$

Also from (65′) we get

$$\log P' = 5.07622 \qquad \therefore \quad P' = 119180 \text{ lbs.}$$

We can now write the expressions for the velocity and pressure *after* the powder is all burned, which are the following:

$$V^2 = [7.23484] X_2$$

and

$$P = \frac{[5.07622]}{(1+x)^{\frac{4}{3}}}$$

From the first of these equations we get at the muzzle, where $u = 46.6$ ft., and $\log X_2 = 9.79440$,

$$V = 3271 \text{ f.s.}$$

The computed muzzle velocity is therefore 13 f.s. less than the measured velocity. The following is a summary of the differences between the computed and measured velocities which have been obtained:

Travel of projectile:	16.6 ft.,	21.6 ft.,	34.1 ft.,	46.6 ft.
Differences:	0	+10	0	—13

These differences refer to Sir Andrew Noble's velocity curve. But a careful study of this curve will show that the computed and *chronoscope* velocities are almost exactly the same.

It is stated in Chapter II. that the trinomial expression for the velocity applies only while the powder is burning. This may be illustrated numerically by means of the binomial formula for the velocity deduced above for this example, which gives at the muzzle,

$$V = 3260.5 \text{ f.s.}$$

This is considerably too small; and it is evident that for a travel of the projectile in the bore, imagined prolonged, until

$$X_0 = \frac{1}{N}$$

the velocity by this formula would be zero, and therefore y, the weight of powder burned, would also be zero. If we differentiate the equation

$$\frac{y}{\bar{\omega}} = \frac{2}{\overline{X_0}} X_0 \left\{1 - N X_0\right\}$$

it will be seen that y is a maximum and equal to $\bar{\omega}$ when

$$X_0 = \frac{1}{2N} = \overline{X_0}$$

that is, at the point where the powder is all burned.

Similarly it will be found by differentiating the trinomial expression for y given on page 154, for ballistite, that y is a maximum and equal to $\bar{\omega}$ when

$$X_0 = \frac{1}{N} = \overline{X_0}$$

and that the velocity would become zero by the trinomial formula when

$$X_0 = \tfrac{1}{2}(3 + \sqrt{21})\ \overline{X_0}$$

It follows from these results that the muzzle velocity cannot always be used for determining M and N,—only as before stated, when the powder is all burned at, or near, the muzzle.

The expression for the weight of powder burned in this example is

$$y = [4.20449-10]\ \frac{v^2}{X_2}$$

It only remains to compute the characteristics f and τ for this form of cordite to solve completely the problems pertaining to this round. These are found to be

$$f = 2247.4 \text{ lbs.}$$

$$\tau = 0.50486 \text{ sec.}$$

and

$$\text{Vel. of burning } \frac{0.2}{0.50486} = 0.39615 \text{ inches per second.}$$

This is almost exactly the velocity of burning of gunpowder in free air. It will be seen that the "force" of cordite is less than that of ballistite and that the velocity of burning is considerably greater. Whether or not these deductions are correct the writer has no means of knowing.

If all the preceding work has been correctly performed the two velocities v and V and the corresponding pressures p and P should agree when

$$\overline{x} = 14.11$$

The following calculations verify this:

$\log N = 8.75465$	$\log V_1^2 = 7.23484$
$\log \overline{X_0} = 0.94432$	$\log \overline{X_2} = 9.77488$
$\log 0.50000 = \overline{9.69897}$	$\log V^2 = \overline{7.00972}$
$0.50000 = \overline{9.69897}$	
$\log \overline{X_1} = 0.71921$	
$\log u = 6.59155$	
$\log v^2 = \overline{7.00973}$	
$\log N = 8.75465$	$\log P' = 5.07622$
$\log X_4 = 1.15293$	$\text{a.c. } \log (1 + \overline{x}) = 8.82074$
$0.80832 = \overline{9.90758}$	(Divide by 3) 9.60691
$0.19168 = \overline{9.28258}$	$\log P = \overline{3.50387}$
$\log X_3 = 9.31125$	
$\log M' = 4.91005$	
$\log p = \overline{3.50388}$	
$p = 3190.7$ lbs.	

We will now give a few examples illustrative of the formulas developed in Chapter II., and which can be solved by the data of this one round we have been discussing.

Example 1. What thickness of layer was burned from the the grains of powder when the projectile had traveled 16.6 ft.?

Combining equations (32) and (39) gives

$$l = \frac{l_0}{\overline{X_0}} X_0$$

That is, the thickness of layer burned from the surface of a grain of powder of any shape whatever, in the bore of a gun, varies directly as the function X_0. In this example, applying the known values of l_0, $\overline{X_0}$ and X_0 we find

$$l = 0.1506 \text{ in. Ans.}$$

Example 2. What was the velocity of combustion of the grains at the point of maximum pressure?

Equation (23) gives

$$\text{Velocity of combustion} = \frac{l_0}{\tau}\left(\frac{p}{p_0}\right)^{\frac{1}{2}}$$

On page 282 we found the maximum pressure to be 48276 lbs. per square inch. The atmospheric pressure is 14.6967 lbs. per square inch (page 44), while the value of l_0/τ is 0.39615. Applying these numbers we find, at the point of maximum pressure,

$$\text{Velocity of combustion} = 22.7 \text{ inches per sec.}$$

At this rate of burning the charge would be consumed in about the nine-thousandth part of a second.

Example 3. What must be the diameter of the grains of this powder in order that the charge of 27.5 lbs. should all be burned when the projectile has traveled 16.6 ft.?

Equation (62) may be written

$$\tau = A\overline{X_0}$$

where for the conditions of this example, A is constant.

Designate the thickness of web which makes

$$\overline{u} = 16.6 \text{ ft.}$$

by $2l'$, and distinguish the other corresponding symbols by primes. We then have

$$\tau' = A\overline{X_0}'$$

whence by division

$$\frac{\tau'}{\tau} = \frac{\overline{X_0}'}{\overline{X_0}} = \frac{2l_0'}{2l_0}$$

Therefore

$$2l_0' = 2l_0\frac{\overline{X_0}'}{\overline{X_0}} = 0.295 \text{ in. Ans.}$$

From (17) and (32) we have

$$S' = S\frac{\overline{X_0}}{\overline{X_0}'}$$

where S and S′ are the initial surfaces of one pound of each of the two grains under consideration. Therefore

$$S' = 1.356\ S$$

That is, the initial surface of one pound (or the whole charge) of the smaller grains is 1.356 times that of the larger grains.

Example 4. Suppose the cordite of this "second application" to be moulded into ribbons of the same density, and of the following dimensions:

Thickness	0."4
Width	2."0
Length	8."0

Determine the equations of velocity and pressure.

For these dimensions we have (Chapter I., page 190)

$$\alpha = 1.25, \qquad \lambda = -0.208, \qquad \mu = 0.008.$$

By equation (17) it will be found that the entire initial surface of the charge of the new grains is five-eighths of that of the real charge, and therefore the maximum pressure, which evidently depends upon the burning surface, will be less with the new grains than with the old. The characteristics τ and f will remain unchanged in the new grains as will also a^2, z_0, the X functions, $\overline{v^2}$, V_1^2, and P′. As has already been illustrated, we find for these new grains,

$$\log M = 6.38743$$
$$\log M' = 4.70593$$
$$\log N = 8.37374-10$$
$$\log N' = 6.01445-10$$

The formulas for velocity and pressure for this new form of grain, while the powder is burning, are then

$$v^2 = [6.38743] M_1 \left\{ 1 - [8.37374-10] X_0 + [6.01445-10] X_0^2 \right\}$$

and

$$p = [4.70593] M_3 \left\{ 1 - [8.37374-10] X_4 + [6.01445-10] X_5 \right\}$$

The expressions for weight of charge burned, and for velocity and pressure after the powder was all burned, are the same as those already deduced for the cylindrical form of cordite. This follows from the fact that the thickness of web, and mean pressure for the travel $\overline{u}$, are the same for both forms of grain. These equations are

$$y = [4.20449-10] \frac{v^2}{X_2}$$

$$V^2 = [7.23484] X_3$$

$$P = \frac{[5.07622]}{(1+x)^{\frac{4}{3}}}$$

The following table gives the velocities, pressures and weights of powder burned corresponding to the travels of projectile in the second column, for the two forms of grain which have been considered, the weight of charge in both cases being the same, namely, 27.5 lbs. The formulas belonging to the ordinary cylindrical form of grain will be designated by (A). Those referring to the ribbon form by (B).

The figures in this table are reproduced graphically on the accompanying plate, where the velocity, pressure and powder curves are shown for each form of grain.*

Table of velocities and pressures in a 6-inch gun, weight of charge 27.5 lbs., weight of projectile 100 lbs., for two forms of grain, namely, (A) cylindrical; (B) in ribbon form.

x	u	Velocity		Pressure		Powder burned	
		(A)	(B)	(A)	(B)	(A)	(B)
	ft.	f.s.	f.s.	lbs. □″	lbs. □″	lbs.	lbs.
0.0	0.000	0.00	0.00	0.00	0.00	0.00	0.00
0.2	0.528	564.99	458.86	43929	29584	8.669	5.718
0.4	1.056	876.56	720.16	48183	33587	11.597	7.828
0.6	1.585	1109.1	919.33	47558	34089	13.584	9.333
0.8	2.113	1295.2	1081.6	45569	33381	15.097	10.528
1.0	2.641	1449.8	1218.6	42895	32220	16.315	11.527
1.5	3.962	1747.9	1489.7	36632	28926	18.589	13.503
2.0	5.282	1967.2	1696.1	31386	25922	20.209	15.024
2.5	6.603	2138.0	1862.3	27158	23390	21.442	16.269
3.0	7.923	2276.1	2005.6	23738	21278	22.419	17.326
4.0	10.564	2488.0	2223.2	18600	18001	23.873	19.062
5.0	13.205	2644.2	2397.2	14975	15600	24.898	20.465
6.2853	16.600	2794.0	2576.0	11642	13324	25.822	21.947
8.1784	21.600	2950.0	2780.3	8329	10977	26.677	23.697
12.9112	34.100	3166.0	3131.0	3840	7559	27.475	26.871
14.1100	37.266	3198.0	3198.0	3191	7091	27.500	27.500
17.6446	46.600	3271.0	3271.0	2411	2411	——	——

Example 5. Suppose the powder chamber of the 6-inch gun in question to be so enlarged that the density of loading remains the same (0.55), while the charge is increased to 34 lbs. of the powder described in Example 4. Determine the circumstances of motion.

The computations necessary for the solution of this example are the following:

$$\log a^2 = 0.07084$$
$$\text{Const. } \log = 0.46789$$
$$\log \bar{\omega} = 1.53148$$
$$\text{a.c. } \log c^2 = 8.44370$$
$$\log z_0 = 0.51391 \qquad \therefore \quad z_0 = 3.2652 \text{ ft.}$$

* The writer is indebted to Major Lissak, in charge of the Department of Ordnance and Gunnery at West Point, for these beautiful and instructive curves.

$$
\begin{aligned}
\text{Const. log} &= 1.43994 \\
\log c^2 &= 1.55630 \\
\log r &= 9.71218 \\
\text{a.c. } \log a &= 9.96458 \\
\text{a.c. } \log \sqrt{w\tilde{\omega}} &= 8.23426 \\
\hline
\log \overline{X_0} &= 0.90726
\end{aligned}
$$

$$
\begin{aligned}
\text{Const. log} &= 4.44383 \\
\log f &= 3.35534 \\
\log \tilde{\omega}/w &= 9.53148 \\
\hline
\log V_1^2 &= 7.33065 \\
\log \alpha &= 0.09691 \\
\text{a.c. } \log \overline{X_0} &= 9.09274 \\
\hline
\log M &= 6.52030 \\
\text{Const. log} &= 7.82867 \\
\log w/a^2\,\tilde{\omega} &= 0.39768 \\
\hline
\log M' &= 4.74665
\end{aligned}
$$

$$
\begin{aligned}
\log \lambda &= 9.31806 \\
\log \overline{X_0} &= 0.90726 \\
\hline
\log N &= 8.41080
\end{aligned}
$$

$$
\begin{aligned}
\log \mu &= 7.90309 \\
\log \overline{X_0}^2 &= 1.81452 \\
\hline
\log N' &= 6.08857
\end{aligned}
$$

We therefore have for these new conditions the following expressions for velocity and pressure:

$$v^2 = [6.52030]X_1 \left\{1 - [8.41080-10]X_0 + [6.08857-10]X_0^2\right\}$$

$$p = [4.74665]X_3 \left\{1 - [8.41080-10]X_4 + [6.08857-10]X_5\right\}$$

Maximum pressure. As heretofore we will assume the maximum pressure to occur when $x = 0.45$, which will give it within one or two per cent.,—near enough for the purpose we have in view.

$$
\begin{aligned}
\log N' &= 6.08857 \\
\log X_5 &= 0.93587 \\
\hline
\text{(add unity)} \quad 1.00106 \quad &= 7.02444
\end{aligned}
$$

$$
\begin{aligned}
\log N &= 8.41080 \\
\log X_4 &= 0.48444 \\
\hline
0.07857 \quad &= 8.89524 \\
\hline
\log 0.92249 \quad &= 9.96496 \\
\log X_3 &= 9.85640 \\
\log M' &= 4.74665 \\
\hline
\log p_m &= 4.56801 \qquad \therefore \quad p_m = 36984
\end{aligned}
$$

Velocity and pressure when $u = 16.6$ feet.

$$\begin{aligned} \log u &= 1.22011 \\ \log z_0 &= 0.51391 \\ \hline \log x &= 0.70620 \qquad \therefore \quad x = 5.0839 \end{aligned}$$

For this value of x we find by interpolation from the table, employing second differences,

$\log X_0 = 0.78736$, $\log X_1 = 0.44271$, $\log X_2 = 9.65774$,
$\log X_3 = 9.58628$, $\log X_4 = 0.97010$, $\log X_5 = 1.88569$.

$$\begin{array}{lll} & & \log N' = 6.08857 \\ & & \log X_5 = 1.88569 \\ \hline \text{(add unity)} & 1.00942 & \quad\;\; = 7.97426 \\ & & \log N = 8.41080 \\ & & \log X_4 = 0.97010 \\ \hline & 0.24038 & \quad\;\; = 9.38090 \\ \hline & \log 0.76904 & \quad\;\; = 9.88595 \\ & & \log X_3 = 9.58628 \\ & & \log M' = 4.74665 \\ \hline & & \log p = 4.21888 \qquad \therefore \quad p = 16553 \text{ lbs.} \end{array}$$

$$\begin{array}{lll} & & \log N' = 6.08857 \\ & & \log X_0^2 = 1.57472 \\ \hline \text{(add unity)} & 1.00461 & \quad\;\; = 7.66329 \\ & & \log N = 8.41080 \\ & & \log X_0 = 0.78736 \\ \hline & 0.15782 & \quad\;\; = 9.19816 \\ \hline & \log 0.84679 & \quad\;\; = 9.92778 \\ & & \log X_1 = 0.44271 \\ & & \log M = 6.52030 \\ \hline & & \log v^2 = 6.89079 \\ & & \log v = 3.44539 \qquad \therefore \quad v = 2789 \end{array}$$

Compute $\bar{u}$ and $\bar{v}$ for this last example. We have found $\log \bar{X}_0 = 0.90726$; and a reference to the table shows that corresponding to this is $x = 11.0$, nearly. Therefore
$\bar{u} = 11 \times 3.2652 \text{ ft.} = 35.9172 \text{ ft.}$

For computing $\bar{v}$ make use of equation (53) as follows:

$$\begin{aligned} \log V_1^2 &= 7.33065 \\ \log X_2 &= 9.75067 \\ \hline & \, 7.08132 \\ \log \bar{v} &= 3.54066 \qquad \therefore \quad \bar{v} = 3473 \text{ f.s.} \end{aligned}$$

The same value of $\bar{v}$ would be obtained by using the general expression for v on page 289 making $x = 11.0$.

Computation of $\bar{p}$.

(*a*). *By formula for pressure on page 289.*

$\log N' = 6.08857$
$\log X_5 = 2.15437$

(add unity) 1.01750 $= 8.24294$

$\log N = 8.41080$
$\log X_4 = 1.10963$

0.33146 $= 9.52043$

log 0.68604 $= 9.83635$

$\log X_3 = 9.38233$
$\log M' = 4.74665$

$\log \bar{p} = 3.96523 \quad \therefore \quad \bar{p} = 9233$ lbs.

(*b*). *By formula for pressure on page 37.*

$\log P' = 5.07988$
a.c. $\log (1 + x) = 8.92082$
(Divide by 3) $= 9.64027$

$\log \bar{p} = 3.64097 \quad \therefore \quad \bar{p} = 4375$ lbs.

The difference in the two values of $\bar{p}$ just computed illustrates what is said on page 284. It is easy to see that there must be a point of discontinuity in both the pressure and velocity curves when $u = \bar{u}$, for a charge made up of grains which have a finite burning surface when about to disappear as grains.

Example 6. What was the volume of the powder chamber (a) of the real gun; (b) of the hypothetical gun of Ex. 5?

(a) We have from equation (20),

$$C = \frac{27.68\,\bar{\omega}}{\Delta} = \frac{27.68 \times 27.5}{0.55} = 1384 \text{ cubic inches.}$$

(b) $$C = \frac{34}{27.5} \times 1384 = 1711.12 \text{ cubic inches.}$$

Example 7. Compute velocity of projectile when the pressure was a maximum; also weight of powder burned.

$\log N' = 6.08857$
$\log \overline{X_0}^2 = 0.69492$

(add unity) 1.00061 $= 6.78349$

$\log N = 8.41080$
$\log X_0 = 0.34746$

0.05731 $= 8.75826$

log 0.94330 $= 9.97465$

$$
\begin{aligned}
& 9.97465 \\
\log X_1 &= 9.41375 \\
\log M &= 6.52030 \\
\hline
\log v^2 &= 5.90870 \\
\log v &= 2.95435 \qquad \therefore \quad v = 900.2 \text{ f.s.} \\
\log v^2 &= 5.90870 \\
\text{a.c. } \log V_1^2 &= 2.66935 \\
\text{a.c. } \log X_2 &= 0.93370 \\
\hline
\log k &= 9.51175 \qquad \therefore \quad k = 0.3249 \\
\log \bar{\omega} &= 1.53148 \\
\hline
\log y &= 1.04323 \qquad \therefore \quad y = 11.047 \text{ lbs.}
\end{aligned}
$$

In the same way we find $y = 27.157$ lbs. when $u = 16.6$ ft.

It will be seen from the results deduced in the solutions of examples 5 and 6 how, by a few changes in gun, and form of powder grain, both easily made, the muzzle velocity may be maintained while the maximum pressure is reduced from 47000 lbs. to 37000 lbs., and the muzzle pressure increased from 11826 lbs. to 16553 lbs.

It would probably not be considered an advantage to increase the muzzle pressure to so great an extent as this, and it certainly would not be safe to do so with our present guns, which are not sufficiently strong near the muzzle to resist such pressure.

It will be apparent to the reader by this time that the maximum pressure, while not exactly proportional to the initial burning surface (S) of a pound of the powder employed, is largely dependent upon it, while the muzzle pressure is chiefly influenced by thickness of web.

We will conclude the discussion of the Noble experiments by giving the formulas for velocity and pressure for cordite of 0″.3 diameter and for French B.N. powder.

Cordite, 0″.3 in diameter. Charge 20 lbs. Travel of projectile when powder is all burned $(\bar{u})$, 30.5 ft. $\bar{v} = 2774.5$ f.s. The equations of the velocity and pressure curves are

$$v^2 = [6.55251] X_1 \left\{ 1 - [8.80529 - 10] X_0 \right\}$$

and

$$p = [4.81087] X_3 \left\{ 1 - [8.80529 - 10] X_4 \right\}$$

The maximum pressure given by this last equation (that is, when $x = 0.45$), is 37423 lbs., and the corresponding travel of projectile about 16.5 inches. The crusher-gauge pressures ranged from 34496 to 39424 lbs.

The following gives the correspondence between the computed and chronograph velocities:

Travel of projectile	16.6 ft.,	21.6 ft.,	34.1 ft.,	46.6 ft.
Chronograph velocities	2495 f.s.	2632	2821	2914
Computed velocities	2495	2632	2812	2910

French B.N. powder. Charge 25 lbs. For this powder the formulas indicate that the charge was all burned when $\bar{u} = 43.0$ ft., for which travel the velocity $(\bar{v})$ was 2764 f.s. The equations of the velocity and pressure curves are

$$v^2 = [6.61868]X_1 \left\{ 1 - [9.04172-10]X_0 + [7.60632-10]X_0^2 \right\}$$

and

$$p = [4.91620]X_2 \left\{ 1 - [9.04172-10]X_4 + [7.60632-10]X_5 \right\}$$

The pressure given by this last equation when $x = 0.45$, (maximum pressure) is 41407 lbs. while the crusher-gauge pressure was 44800 lbs.

The following shows the close agreement between the computed and chronograph velocities:

Travel of projectile	16.6 ft.,	21.6 ft.,	34.1 ft.,	46.6 ft.
Chronograph velocities	2422 f.s.	2530	2700	2786
Computed velocities	2422	2535	2696	2787

The following table of the ballistic functions X_0, X_1, X_2, X_3, X_4 and X_5 (or rather of their logarithms) is an extension of the table published in the JOURNAL U. S. ARTILLERY for November and December, 1903. Attention is invited to the change in notation, which it is hoped will cause no confusion to those who may have used the former table. In that table the auxiliary angle φ, though not appearing, is the argument, and was so taken to lessen the labor of computation. In the present table, x (volumes of expansion) is the argument.

The author is greatly indebted to Lieutenants Ennis and Bryant of the Artillery Corps, Assistant Instructors in the Department of Ordnance and Gunnery at the Military Academy, for computing a large portion of this table.

Table of Logarithms of the X Functions.

x	log X_0	log X_1	log X_2	log X_3	log X_4	log X_0
0.001	9.03899	5.56162	6.52263	8.73764	9.16405	8.30001
0.01	9.53911	7.05911	7.52000	9.23296	9.66437	9.30059
0.05	9.88671	8.09440	8.20769	9.56059	0.01322	9.99778
0.10	0.03494	8.53009	8.49515	9.68493	0.16295	0.29663
0.15	0.12078	8.77897	8.65819	9.74798	0.25023	0.47060
0.20	0.18111	8.95170	8.77059	9.78653	0.31194	0.59347
0.25	0.22750	9.08291	8.88541	9.81206	0.35965	0.68834
0.30	0.26509	9.18802	8.92293	9.82962	0.39851	0.76552
0.35	0.29661	9.27522	8.97861	9.84191	0.43127	0.83052
0.40	0.32372	9.34942	9.02570	9.85051	0.45956	0.88660
0.45	0.34746	9.41375	9.06630	9.85640	0.48444	0.93587
0.50	0.36855	9.47036	9.10181	9.86028	0.50663	0.97980
0.55	0.38750	9.52077	9.13327	9.86260	0.52665	1.01937
0.60	0.40469	9.56610	9.16141	9.86371	0.54488	1.05539
0.65	0.42041	9.60719	9.18678	9.86386	0.56161	1.08840
0.70	0.43489	9.64471	9.20982	9.86325	0.57705	1.11887
0.75	0.44829	9.67918	9.23089	9.86201	0.59140	1.14715
0.80	0.46075	9.71100	9.25025	9.86027	0.60479	1.17352
0.85	0.47241	9.74052	9.26812	9.85811	0.61733	1.19821
0.90	0.48334	9.76802	9.28468	9.85562	0.62913	1.22143
0.95	0.49363	9.79373	9.30010	9.85284	0.64027	1.24332
1.00	0.50334	9.81784	9.31450	9.84984	0.65081	1.26404
1.05	0.51255	9.84053	9.32798	9.84664	0.66082	1.28369
1.10	0.52128	9.86193	9.34065	9.84329	0.67034	1.30239
1.15	0.52960	9.88217	9.35258	9.83981	0.67942	1.32020
1.20	0.53752	9.90136	9.36384	9.83623	0.68809	1.33721
1.25	0.54508	9.91958	9.37449	9.83256	0.69640	1.35348
1.30	0.55234	9.93693	9.38459	9.82882	0.70436	1.36908
1.35	0.55929	9.95346	9.39417	9.82503	0.71201	1.38406
1.40	0.56597	9.96926	9.40329	9.82119	0.71936	1.39846
1.45	0.57238	9.98436	9.41198	9.81732	0.72644	1.41230
1.50	0.57856	9.99884	9.42028	9.81343	0.73328	1.42569
1.55	0.58452	0.01272	9.42820	9.80953	0.73988	1.43858
1.60	0.59026	0.02605	9.43579	9.80561	0.74625	1.45104
1.65	0.59582	0.03887	9.44305	9.80169	0.75242	1.46310
1.70	0.60119	0.05122	9.45003	9.79777	0.75840	1.47478
1.75	0.60639	0.06311	9.45672	9.79386	0.76419	1.48608
1.80	0.61143	0.07459	9.46316	9.78996	0.76981	1.49705
1.85	0.61632	0.08567	9.46935	9.78607	0.77527	1.50770
1.90	0.62106	0.09638	9.47532	9.78219	0.78057	1.51803

Table (continued)

x	log X_0	log X_1	log X_2	log X_3	log X_4	log X_5
1.95	0.62567	0.10675	9.48108	9.77833	0.78573	1.52808
2.0	0.63015	0.11678	9.48663	9.77449	0.79075	1.53788
2.1	0.63875	0.13591	9.49717	9.76687	0.80040	1.55668
2.2	0.64691	0.15395	9.50704	9.75939	0.80958	1.57456
2.3	0.65467	0.17097	9.51630	9.75193	0.81833	1.59158
2.4	0.66207	0.18708	9.52501	9.74461	0.82668	1.60783
2.5	0.66914	0.20236	9.53322	9.73740	0.83467	1.62338
2.6	0.67589	0.21687	9.54098	9.73031	0.84232	1.63824
2.7	0.68237	0.23070	9.54833	9.72333	0.84966	1.65250
2.8	0.68859	0.24389	9.55531	9.71645	0.85673	1.66623
2.9	0.69457	0.25650	9.56194	9.70969	0.86353	1.67945
3.0	0.70032	0.27858	9.56826	9.70304	0.87009	1.69216
3.1	0.70587	0.28014	9.57427	9.79650	0.87642	1.70442
3.2	0.71122	0.29124	9.58001	9.69007	0.88252	1.71627
3.3	0.71639	0.30190	9.58551	9.68374	0.88842	1.72773
3.4	0.72140	0.31217	9.59077	9.67752	0.89416	1.73882
3.5	0.72624	0.32205	9.59582	9.67140	0.89970	1.74956
3.6	0.73093	0.33158	9.60066	9.66538	0.90508	1.75997
3.7	0.73548	0.34079	9.60532	9.65946	0.91027	1.77004
3.8	0.73990	0.34969	9.60979	9.65363	0.91537	1.77989
3.9	0.74419	0.35829	9.61410	9.64790	0.92037	1.78955
4.0	0.74836	0.36662	9.61825	9.64225	0.92510	1.79872
4.2	0.75637	0.38250	9.62613	9.63122	0.93432	1.81656
4.4	0.76398	0.39745	9.63348	9.62053	0.94308	1.83349
4.6	0.77121	0.41157	9.64036	9.61015	0.95143	1.84962
4.8	0.77810	0.42492	9.64682	9.60008	0.95939	1.86500
5.0	0.78469	0.43759	9.65290	9.59029	0.96700	1.87971
5.2	0.79099	0.44963	9.65864	9.58079	0.97430	1.89379
5.4	0.79703	0.46110	9.66407	9.57153	0.98130	1.90730
5.6	0.80284	0.47205	9.66921	9.56252	0.98803	1.92028
5.8	0.80842	0.48251	9.67409	9.55375	0.99450	1.93277
6.0	0.81379	0.49253	0.67874	9.54521	1.00074	1.94479
6.2	0.81897	0.50213	9.68316	9.53687	1.00676	1.95640
6.4	0.82397	0.51136	9.68738	9.52874	1.01257	1.96760
6.6	0.82881	0.52022	9.69142	9.52081	1.01819	1;97844
6.8	0.83349	0.52875	9.69528	9.51306	1.02363	1.98891
7.0	0.83801	0.53698	9.69897	9.50549	1.02890	1.99905
7.2	0.84241	0.54492	9.70252	9.49809	1.03402	2.00892
7.4	0.84667	0.55259	9.70592	9.49085	1.03898	2.01847
7.6	0.85081	0.56000	9.70919	9.48377	1.04379	2.02776
7.8	0.85483	0.56717	9.71234	9.47683	1.04848	2.03677
8.0	0.85873	0.57411	9.71538	9.47004	1.05304	2.04552
8.2	0.86254	0.58084	9.71830	9.46341	1.05748	2.05408
8.4	0.86625	0.58737	9.72112	9.45689	1.06180	2.06240
8.6	0.86986	0.59371	9.72385	9.45050	1.06601	2.07050
8.8	0.87338	0.59986	9.72648	9.44424	1.07012	2.07841

Table (continued)

x	log X_0	log X_1	log X_2	log X_3	log X_4	log X_5
9.0	0.87682	0.60585	9.72903	9.43809	1.07413	2.08612
9.2	0.88017	0.61167	9.73150	9.43206	1.07804	2.09345
9.4	0.88345	0.61734	9.73390	9.42614	1.08187	2.10100
9.6	0.88665	0.62286	9.73621	9.42033	1.08560	2.10819
9.8	0.88978	0.62824	9.73846	2.41462	1.08926	2.11502
10.0	0.89284	0.63349	9.74065	9.40901	1.09283	2.12209
10.2	0.89584	0.63860	9.74276	9.40349	1.09633	2.12882
10.4	0.89877	0.64360	9.74482	9.39807	1.09976	2.13540
10.6	0.90165	0.64848	9.74683	9.39274	1.10312	2.14186
10.8	0.90447	0.65324	9.74877	9.38749	1.10640	2.14818
11.0	0.90723	0.65790	9.75067	9.38233	1.10963	2.15437
11.2	0.90993	0.66245	9.75252	9.37725	1.11279	2.16045
11.4	0.91259	0.66691	9.75432	9.37225	1.11589	2.16642
11.6	0.91520	0.67127	9.75607	9.36732	1.11893	2.17227
11.8	0.91776	0.67554	9.75778	9.36247	1.12192	2.17801
12.0	0.92027	0.67972	9.75945	9.35770	1.12485	2.18364
12.2	0.92274	0.68381	9.76108	9.35301	1.12772	2.18916
12.4	0.92516	0.68783	9.76267	9.34836	1.13057	2.19462
12.6	0.92754	0.69176	9.76422	9.34379	1.13335	2.19996
12.8	0.92989	0.69562	9.76574	9.33928	1.13609	2.20522
13.0	0.93219	0.69941	9.76722	9.33484	1.13877	2.21039
13.2	0.93446	0.70313	9.76867	9.33045	1.14142	2.21547
13.4	0.93669	0.70678	9.77009	9.32613	1.14402	2.22047
13.6	0.93888	0.71036	9.77148	9.32186	1.14659	2.22539
13.8	0.94104	0.71388	9.77284	9.31766	1.14911	2.23023
14.0	0.94317	0.71734	9.77417	9.31350	1.15159	2.23500
14.2	0.94527	0.72074	9.77547	9.30940	1.15403	2.23970
14.4	0.94733	0.72408	9.77675	9.30535	1.15644	2.24433
14.6	0.94936	0.72736	9.77800	9.30136	1.15882	2.24888
14.8	0.95137	0.73059	9.77922	9.29741	1.16115	2.25337
15.0	0.95334	0.73377	9.78043	9.29351	1.16346	2.25780
15.2	0.95529	0.73689	9.78160	9.28966	1.16573	2.26216
15.4	0.95721	0.73997	9.78276	9.28585	1.16797	2.26647
15.6	0.95910	0.74301	9.78391	9.28208	1.17018	2.27073
15.8	0.96097	0.74599	9.78501	9.27837	1.17236	2.27495
16.0	0.96282	0.74892	9.78610	9.27470	1.17450	2.27902
16.2	0.96463	0.75181	9.78718	9.27107	1.17663	2.28309
16.4	0.96643	0.75466	9.78823	9.26748	1.17872	2.28711
16.6	0.96820	0.75747	9.78927	9.26393	1.18078	2.29108
16.8	0.96995	0.76024	9.79029	9.26042	1.18282	2.29500
17.0	0.97168	0.76297	9.79129	9.25695	1.18483	2.29886
17.2	0.97338	0.76566	9.79227	9.25352	1.18682	2.30268
17.4	0.97507	0.76831	9.79324	9.25012	1.18879	2.30645
17.6	0.97673	0.77093	9.79419	9.24676	1.19072	2.31017
17.8	0.97838	0.77351	9.79513	9.24344	1.19264	2.31385
18.0	0.98001	0.77606	9.79605	9.24015	1.19454	2.31750

Table (continued)

x	log X_0	log X_1	log X_2	log X_3	log X_4	log X_5
18.2	0.98161	0.77856	9.79696	9.23689	1.19640	2.32108
18.4	0.98320	0.78104	9.79785	9.23367	1.19825	2.32463
18.6	0.98477	0.78349	9.79872	9.23048	1.20008	2.32814
18.8	0.98632	0.78591	9.79959	9.22732	1.20188	2.33161
19.0	0.98785	0.78829	9.80044	9.22419	1.20367	2.33504
19.2	0.98937	0.79065	9.80128	9.22109	1.20543	2.33843
19.4	0.98086	0.79296	9.80210	9.21803	1.20717	2.34177
19.6	0.99235	0.79527	9.80292	9.21499	1.20891	2.34510
19.8	0.99382	0.79754	9.80372	9.21198	1.21062	2.34838
20.0	0.99527	0.79978	9.80451	9.20900	1.21230	2.35162

TEACHINGS OF THE RUSSO-JAPANESE WAR

COLONEL NEZNAMOV, Chief of Staff, 35th Division, 17th Army Corps, in the "Rouskii Invalid."*

Translated from "Journal des Sciences Militaires," March, 1906.

BY CAPTAIN WILLIAM LASSITER, ARTILLERY CORPS.

PART I.—MATERIAL.

CHAPTER I.

ARMAMENT

GUNS.—Our rapid-fire guns are remarkable engines of destruction. Their precision, rapidity of fire and range, are superior to those of the Japanese guns. The action of the shrapnel is remarkable.

Injury to the material occurred only rarely during the progress of the battles; at the end of eight days of the severe struggle on the Shaho, there were only two pieces out of service out of forty-eight in the 35th artillery brigade, one due to the deterioration of a compressor, the other in consequence of scoring caused by gas.

Artillery ammunition.—Artillery ammunition has acted in a regular manner. The supply is sufficient.

The system of having shrapnel as the only projectile has not been borne out by the experience of the war. A percussion shell with powerful explosive action is *absolutely indispensable.*

Our shrapnel, bursting on percussion, was not adapted to the destruction of the weakest obstacles. It made, in such obstacles, round holes of a diameter equal to its own caliber, but it could not knock down a wall which even an infantry bullet could perforate. Against trenches it is altogether powerless.

On the other hand, as experience shows, the Japanese high explosive shell (shimose) easily performed these tasks. In November, 1904, having noticed that the observers of the 35th

* See JOURNAL, No. 75, p. 172; No. 77, p. 72.

Division used an isolated house, a Japanese battery razed this house in one hour's time and by means of 64 high explosive shell.

The action of high explosive shell on the parapets of trenches is insignificant, in consequence of the difficulty of hitting them with precision. But fortunate shots produce a sensible effect upon them, especially when they strike upon hard, frozen ground, or upon sand bag parapets.*

Field mortars.—Field mortars, under the new conditions of battle which rapid fire and long range artillery have introduced, must be regarded as without sufficient range and accuracy. Shells were employed almost entirely with the mortars, in concert with shrapnel fire from the field pieces.

The latter is considerably more intense, more accurate, and of a greater moral effect.

It is desirable to have a piece sending powerful high explosive shells to a range approximating that of the field gun, and having the mobility of the latter. This piece, as in the case of the field gun, should have a goniometric sight. It does not seem to us necessary that it should have a shrapnel for plunging fire.

Siege guns.—Siege guns have been employed by both sides, but for opposite reasons.

On the side of the Russians, their employment was due to the absence of high explosive shell in the field batteries.

The Japanese made use of them in February:—

(*a*) To make a demonstration on our center, and to hold it under the constant menace of attack;

(*b*) To reinforce their field artillery in their center, which was inferior to ours by a verst in range, and which, moreover, did not fire so quickly;

(*c*) To contend against our siege artillery;

(*d*) Finally and especially, to render available their field artillery of the center for use on the left flank where the decisive effort was to be made.

These views are confirmed by the following considerations:

(1) There remained on the Japanese center during the last days of February only a very few field guns, and a part of these, on February 21st, March 6th, after the action at Khantchenpou, were withdrawn toward Safantai in the northwest.

*An advanced trench near a wood in the neighborhood of Lamatoun, and others on the line of the railway, were several times destroyed during January and February by high explosive shell.

(2) When our siege artillery had been withdrawn, there reached us only isolated shrapnel (from 3 to 5 per day) from the navy 12 cm. gun, which the Japanese had posted behind Linchinpou.

(3) In the center, to judge at least from the fragments of bursts, there were posted only antiquated models, pieces of the most diverse calibers, provided with a great variety of projectiles and fuzes. Undoubtedly they had the intention of abandoning these pieces in case of an offensive move from our center, and of withdrawing in the direction of Liaoyang, so as to draw us thither, and thus facilitate the task of Nogi's army in the west. The fire of these pieces, unaccompanied save on February 22d, March 7th, by the fire of shrapnel, produced only a moral impression. The losses caused by them were insignificant.

On our side, the siege pieces, excellent in themselves, were not used for reasons which were foreign to the troops concerned. Upon their arrival in position, these pieces were not placed under the orders of the commander of the sector, and in order to have them open fire, if for any reasons it appeared desirable to the commander of the sector (general of division) that they should do so, it was necessary to seek special authorization.

In the isolated cases when they were employed to bombard fortified villages, as in the zone of action of the 10th Corps (2d Army), brilliant results were obtained; the Japanese abandoned their positions due to this bombardment alone.

In conclusion it is certain that when one has the opportunity to reinforce his means of destruction by the employment of calibers heavier than field guns, there is no reason to deprive one's self of such assistance. But to-day, as formerly, we cannot regard as normal the employment of siege artillery in field warfare. The presence of heavy calibers in the battles of the present day must be regarded as constituting special cases. From Tiourentchen (passage of the Yalu), the Japanese brought their siege guns by water to Mukden. At Mukden transport of the pieces and of their heavy ammunition was rendered possible only the existence of the railway near which they operated, although in winter the roads of Manchuria are very hard and firm. At Liaoyang and at the battles of October, 1904, on the Shaho, there were on the Japanese side but very few siege guns, and, in consequence, we cannot speak seriously in these two cases of their having been employed in battles in open country.

Siege guns, and even the 11-inch seacoast mortars, played no decisive rôle in the battles of Mukden. For four days they bombarded the villages of Gouantoun and of Khantchenpou, and yet the garrisons of those localities abandoned them on the night of February 23, March 8th, only on account of the order given by the General-in-chief to withdraw upon Mukden; that is to say, only by their own free will and without being constrained.

The strong positions of the Shaho were abandoned by us only in consequence of the turning movement; that is to say, of a maneuver, and not on account of hostile artillery fire.

It has seemed desirable to enter at some length into this subject in order to throw light upon the rôle of heavy artillery in warfare in open country, and for the reason that in certain military circles the opinion has arisen that the permanent presence of heavy artillery in battle is necessary.

Machine guns.—Machine guns have acquired an enormous importance. Our troops regard them more than guns. It would be desirable to have in each division from 12 to 16 machine guns, forming distinct units not attached to regiments.

The Japanese brass loading band (30 cartridges) is better than ours of cloth, because it does not lead to jamming during fire.

The infantry should have machine guns which may be readily transported by hand.

On the offensive, to assure possession of captured positions, nothing can replace them in resisting counter attacks on account of their character as insensible machines, and on account of their great moral effect.

Personal weapons.—With respect to sabre and lances we will not enter into a technical examination of their strength and method of construction. So far as their employment has been concerned, they have shown themselves absolutely satisfactory.

Opportunities have arisen both for the lance and for the saber. For the artillery the saber is absolutely useless, and interferes with the work of the men. It should be replaced by kinjal.*

Telephone and telegraph. — The telephone has rendered enormous service in battles of position, and has functioned perfectly. The instruction of telephone operators has offered not the least difficulty either in the infantry or in the artillery.

* A straight poignard, two-edged, 40 to 50 cm. long, carried by the Caucaussian Cossacks.

Experience has shown that the telephone should form part of the equipment furnished to the staff, to regiments, to batteries, etc., at the rate of three or four stations and 10 versts of light cable per regiment or division headquarters, three or four stations and six versts of wire per battalion or isolated battery of artillery.

The equipment of the "telephone company" (85 versts of line) ought to remain exclusively at the disposition of corps headquarters and suffices for its needs.

In the present war there has always been an insufficiency of equipment in this respect. In the infantry and artillery there were no telephones at all, or there were very few (two stations and six versts of wire per regiment, and sometimes purchased at the expense of the latter.) The equipment pertaining to corps headquarters was withdrawn and put at the disposition of army headquarters, etc.

We must regard the telephone as especially useful for regimental use while occupying positions, within the divisions and between headquarters of neighboring divisions. For the larger units it is preferable to employ the telegraph because the possibility of talking by telephone with all the subordinate officers leads superior headquarters to wish to know everything and direct everything; and this to such an extent that there often results interference with the initiative of subordinates, a superabundance of orders, embarrassment, and even orders contrary to those of the immediate chiefs.

Balloons.—It would be desirable to have a captive balloon for each army corps. Measures must be taken, however, to keep the balloon detachment constantly supplied with all the necessary ingredients so as to avoid what happened in February and March, 1905. On February 17th, March 2d, a balloon battalion was unable to make ascensions because there was no longer the means of producing gas with which to inflate its balloons.

From the technical point of view our balloons are well adapted to observation, and, as observatories, they may have an enormous importance in modern war.

Searchlights.—On our side, we have not utilized searchlights during the stay upon the Shaho.

At the Somatoun station, there were a few searchlights on trucks; one of them was operated only a single time, near Khantchenpou, and unsuccessfully; it lighted up our own trenches. Its employment ceased after this experience.

Troops never knew under whose orders these instruments were placed, and hence the cause of their lack of use. It would have been well to have placed them at the disposition of the corps commanders, and, for the execution of field works, even at the disposition of the commanders of sectors (generals of division); otherwise, for lack of information as to the situation, those who used them could only do harm.

The Japanese searchlights were operated on the Shaho during almost all the dark nights and interfered greatly both with our field works and with the enterprises of our detachment of scouts. During the night of the 27-28th of February, a Japanese searchlight, situated near Sandiasa, caused a delay of three hours in the attack against Black Hill and the railroad bridge over the Shaho.

PART III.—TACTICS.

CHAPTER III.

ACTION OF ARTILLERY.

New conditions affecting the employment of artillery. — The long range, the great rapidity of fire of modern guns, their ability to act from masked positions, and the feebleness of effect of their fire against trenches and against masked objectives,* are the data which govern the conditions of employment of artillery in the battle of the present day.

Everything which shows itself in the open, even accidentally, in the sphere of action of shrapnel, risks suffering terrible losses in a few minutes. The long range (five verst† and a half) extends the sphere of action of artillery to great distances.

In consequence of the small effect of the percussion burst of shrapnel, this projectile produces small effects on material objects.‡ The sphere of action of the high explosive shell, bursting on percussion (the Japanese shimose), is limited by the difficulty of obtaining a sufficient precision of fire. Conse-

* A wall, a house, a ravine with steep sides, etc., are natural shelters against shrapnel balls.

† A verst is equal to 1066 meters.

‡ The only part of a gun which is sensitive under shrapnel fire is the recoil-checking apparatus; but we have never heard of a single case of a gun being put out of action by this means. Against walls and trenches the shrapnel is absolutely powerless.

quently the *fundamental task of modern artillery is the destruction of animate objects; the natural method of fire is the rafale** (*rapid fire with shrapnel*).

The artillery struggle: Concentration of fire.—We can no longer speak of the artillery duel in the sense in which it was formerly understood. If the enemy has regulated his fire on your battery and there is risk of undergoing great losses in personnel, you suspend the fire.†

After having fired a few rafales, the adversary, to avoid a useless expenditure of ammunition, ceases firing or passes to slow fire. Then in your turn you open fire on him. If your shots are happily placed, your adversary will keep silent and shelter his cannoneers in his trenches.

Under these conditions to seek the destruction of hostile artillery in position is useless, since the cannoneers cannot be reached in even the most insignificant trenches.‡

The *artillery combat*, as we must now understand it, must have for its object: *holding adverse artillery under the constant menace of a rafale, and preventing it from firing on our own infantry* (or upon artillery in movement, or cavalry, or on other animate objects).

The happy choice of position so that the enemy cannot divine it, skilful execution of the preparatory work which makes possible sudden opening of fire and prompt acquisition of superiority of fire, a suitable organization for observation,—these may enable us to use a great number of batteries against hostile objectives and upon the chosen point of attack.

Thus, for example, on the 1st, 14th, of October, two batteries of the 35th Brigade of Artillery, well placed at Khantchenpou, paralyzed by their fire the Japanese batteries which were posted at the station of the Shaho and at Lamatoun, and thus permitted two other batteries,§—and that

* Slow fire is adapted to attacking the supposed positions of masked reserves, convoys, villages, etc. When shrapnel continue to burst in the same locality, they render a stay in that locality disagreeable, particularly when it is noticed that the explosions occur in the same place, and it is recognized that if the enemy finds by any means that he has found a favorable target, he will pass to a *rafale*.

† And you shelter the personnel, needless to say.

‡ The first battery of the 35th Artillery Brigade was obliged after various resumptions temporarily to cease its fire in the battle of September 29, October 12, because it found itself attacked from two different directions by the Japanese artillery. But it kept the hostile fire fixed upon it for a whole day, and yet lost in all only one officer and six men.

§ The 4th and 5th of the 35th Brigade in position near Gouauntoun.

without being fired upon themselves,—to fire tranquilly upon Shakepou, where large Japanese forces were at this time concentrated.*

The long range greatly facilitates concentration of fire. It permits obtaining this result without massing the artillery in long, easily discovered lines, which occasion great losses to batteries. The batteries may now remain almost isolated. That prevents their discovery by the hostile artillery and affords them the possibility of overlooking, and consequently of reaching with their fire, a large extent of ground on their front and flanks.

Service of observation.—Concealment and the employment of all possible means of rendering troops invisible, are the best means, as we have already seen, of avoiding losses. Consequently it is absolutely necessary for artillery carefully to organize its observation of the enemy. Observers, both officers and men, must be distributed over the whole fighting front, observe themselves, and utilize the observation of neighboring troops. The telephone† permits transmitting information without delay to artillery commanders and to batteries, and the latter have thus always the time to fire a few salvos before the objective can change his position sufficiently to render it impossible to reach him.‡

The senior staff officer in a sector, and commanding officers of infantry and cavalry, should take steps to transmit without delay to the artillery such observations as they are able to make of the enemy.

The Japanese had a remarkably efficient observation service themselves, and had excellent auxiliaries among the Chinese. It has not been a rare occurrence to capture Chinese transmitting signals by means of mirrors, by flags, by fires, by burning houses, or even by simple arm signals; and yet, in spite of all this, the Japanese have often hurled hundreds of projectiles in progressive fire against zones entirely unoccupied.§

* Twelve battalions; according to reports received.

† Flag signals are less advantageous, because they are visible to the enemy, and because the latter will not miss an opportunity to destroy the observers, as happened at Daliantoun in February, 1905.

‡ There should be allotted to each battery six versts of wire and three or four telephone station equipments (three observers and the battery or group commander).

§ On September 30th, and October 1st, 2d, and 3rd, they have especially searched by means of high explosive shells, for an hour and a half of each day, a zone in rear of the village of Ingona, where they supposed our batteries were situated, which really were at Kantchenpou.

Three of four observers upon well-chosen points may, in spite of the extraordinary difficulty of locating a well-placed battery, determine its exact emplacement by means of the flashes and by the dust thrown up, and thus secure a successful adjustment of the fire.

The precision and accuracy of fire of the modern gun added to its great range makes it a powerful weapon in battle. A well ordered initiative exercised by the officer conducting the fire may lead to great results, but for that purpose the artillery must be suitably placed and must have a great field of view. Shields, by providing shelter from fire, may in such cases render immense service.

But, in case of need, modern artillery may accomplish its purpose even from a masked position. In such a case good organization of the observation service acquires a very especial importance.

It is important that the commander of the battery (or of the group) should see the target. Hence, his position may not always be in close proximity to his command. He may be obliged to post himself at some distance from his guns, either in front to one side, or in rear, in order to have the greatest possible field of view. *The telephone is his indispensable tool.*

The choice of position for the batteries is determined by the missions which they are to fulfil, the effective range of the shrapnel and the possibility of securing a complete observation of the targets and, if possible, of the whole zone in front of the pieces.

Changes of position.—It is frequently necessary in order to get out of the limits of a zone well known to the adversary and one well beaten by his fire, to have recourse to a displacement of the batteries by small distances. This displacement ought to be made entirely by hand and out of sight; otherwise it is useless.

A change of position to approach the enemy should be made only when the objective is at least 3½ or 4 versts distant (3600 to 4200 m.). During preparation of the attack, it is better to continue the fire on a well-determined point, the batteries being left in their first positions; and to bring forward to a nearer position and, if possible, a position on the flank, *one or more new batteries drawn from the reserve.*

Under such circumstances the first batteries will not be exposed to useless losses during their displacement; moreover the new battery will produce a powerful moral effect both upon the enemy and upon our own troops.

Certainly, however, when circumstances are favorable, the possibility is not to be renounced of pushing forward the artillery, and firing at the shortest range upon the designated point of attack; the impression to be produced thereby will be enormous. But this is merely something to be desired; it cannot be said to be always realizable. A forward movement of the batteries, boldly and rapidly executed, is necessary when the adversary commences to yield. This is a very powerful factor, and in such a case is worth the risk incurred.*

Conduct of fire.—Fire directed on the ground in rear of the first line and upon the reserves may give brilliant results.

Fire over our own troops is henceforth to be regarded as altogether logical. Only by recourse to it may we avoid the danger resulting from massing the artillery, obtain the distribution of this arm along our whole front, and utilize its range by concentrating fire against different objectives situated to the front and to the flank. Then only will the artillery be what it ought to be in battle; that is to say, a constant menace to every movement of a living object away from cover. Then only can it utilize its whole power.

Moreover, experience shows that the fuze very rarely functions very irregularly, and that with a well-instructed personnel there are no premature bursts.

The ability of artillery of the present day to inflict terrible losses in a very brief period of time, the enormous moral effect of a sudden rafale of shrapnel, and consequently the tendency on both sides to act as much as possible under cover, require of commanding generals a profound knowledge of the rules for the employment of the new gun and for the conduct of its fire; and of artillerists a great capacity to recognize the military situation, and more respect for the demands and needs of the other arms.

The *commander of the troops* distributes his artillery, indicates the positions, and assigns the general objectives in each

* The fire of the batteries thus employed should be first opened at a fixed range, and should then be shifted about so as to bring under its action as large a proportion as possible of the enemy. The Japanese, on the evening of September 29th, feared to displace their batteries at the moment of our retreat, and it is thanks only to their prudence that we succeeded in putting across the Shaho all the trains of three divisions (3d, 35th, and 55th) on a single light bridge, and of removing from the Shaho station all the mobile material and more than 500 wounded.

sector. Thus: to prepare the attack on such a point; to render such a village unapproachable from the south and from the west; to drive the enemy from such a wood; or merely to observe such and such a portion of the terrain, etc. As the combat develops he keeps the artillery commander in touch with the situation, modifies the duties previously assigned to this arm, gives it new duties, orders it to concentrate the fire of all the batteries, or a portion of them, upon certain points, etc.

The *commander of the artillery* distributes the duties among his various batteries; he organizes a system of observation over the whole front and the flanks of the position, not only with respect to the indicated objectives, but in general, with respect to his whole radius of action, with a view to preparing for the appearance of new objectives. He organizes the means of communication between the observers, the batteries, and himself, and assures the replenishment of ammunition of the batteries.

Observation: Orientation.—Timely observation permits not only the commander of the artillery, but also battery commanders to exercise a personal initiative in bringing fire to bear upon new targets.

In such a case to wait for orders is equivalent to losing a favorable moment.

But in order that officers of artillery may exercise a suitable initiative, it is necessary that they should be amply and constantly informed as to the situation; at least with respect to the whole sector in which they are acting.

The staff and personnel assigned to the commander of the artillery should never forget this. On the other hand, information collected by all artillery observers are transmitted without delay to the artillery commander. This method of procedure has given excellent service in the 35th Division in the battle around the station of the Shaho and Linchinpou. Observation and reciprocal communication was there so well organized that the Japanese could not do the simplest thing without being observed; for example, to move by hand batteries located in the kaoliang; or to move a company over the railway track. Each of their movements was noted and made the occasion for opening fire.*

* Here are some minor examples of this intercommunication:

1st. A battery was cannonading the station; its fire was well regulated. The Japanese were hiding in the station, and, to the right, sur-

Kinds of fire.—Against visible targets, as we have seen above, the most effective kind of fire is the rafale.

When objectives were masked the Japanese would cover with a slow fire the whole terrain immediately in rear, seeking especially the supposed position of the reserves, or the limbers, etc. The slightest movement of the latter, with the object of withdrawing from this fire, rarely escaped the observer, and led to a rafale.*

In fire conducted against villages, entrenchments, etc., recourse was had in general on our part† to the combined use of time and percussion shrapnel; or the fire of shell from mortars was combined with that of shrapnel from the field pieces. In this case the Japanese employed the same proportion of high explosive shell and shrapnel. The purpose of this combination is easy to understand; the percussion shots lead to movement behind the shelter, and the shrapnel is able, in consequence, to produce losses.‡

Occupation of positions.—Immediately upon the reception of an order to take a position, whether acting on the offensive or defensive, before bringing the pieces into position, there should be made a most careful reconnaissance of the targets seen from the position, and a careful determination of their range.

Moreover, it is necessary to draw a diagram showing all the characteristic objects appearing in the zone of action, the range and deflection being noted for each.§

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rounded an isolated house. The division commander was informed of these facts.

2d. To the left of the Shaho station, the enemy continued to dig trenches. The captain of the 7th Company sent word that his fire has caused the Japanese to stop their work and to hide behind the station. This information was furnished to a battery.

* At Kantchenpou, October 4-17, fire was directed upon the 10th Regiment of Infantry Novo-Ingermanlandski. The limbers of the 35th brigade of artillery escaped destruction only by a miracle, thanks to the rapidity of their movement; eighteen shrapnel struck the place where they had just passed.

† The Russian field artillery had no high explosive shell; hence, they were obliged to fire percussion shrapnel against material objects. The absence of a high explosive shell has been most embarrassing to the Russian field artilleryman during the war.

‡ Constantly practiced by the Japanese (and also by ourselves) during the preparation of the attack, fire directed upon the ground immediately in rear of a position produced a powerful effect.

§ All this ought to be done concealed from view as far as possible—no flags, stakes, or other objects easy to be seen from a distance—so that the

If possible, the estimated data for the most important targets should be verified by a few adjusting shots.*

This diagram is absolutely necessary; without it, we can not develop the whole power of the modern gun.

As soon as possible, the battery constructs shelter for itself.†

Support of the artillery.—The complication of modern battle, the enormous nervous tension that it induces, and the difficulty of directing it, demand that we give the artillery a special support under all conditions of field service.

In position, one company for two batteries suffices; on the march, one per battery.‡

The task of these supports is to protect the artillery from aggressive action exposing it to loss of horses, and to aid it in difficult places. The nature of modern battle is so complicated that sometimes, in difficult moments, the infantry operating near the artillery will not have, in spite of the best wish in the world, the power to come to its aid; a special support will, however, always do so, since that will then by its special mission, be its military duty. (Without the aid of the 12th Company of the 138th Regiment of the Volkhovski infantry at the Shaho fight, September 29, October 12th, 1904, which was

battery when brought into the position may open fire before the enemy has suspected its presence; if discovered, it is possible that it may not be able to open fire at all. To anticipate the enemy in opening fire is one of the first conditions of artillery success.

* This may be done during the progress of the action by utilizing a specially designated piece.

† The depth of trenches for the cannoneers, if the nature of the ground or the presence of water does not prevent, should be such as to give protection as high as the shoulders; their length, three or four paces for each trench; their width at bottom, about 2½ feet. All the earth is thrown to the front toward the enemy. The gun is not protected by earth, but merely concealed. This work, on ordinary ground, and under the pressure of danger, is accomplished in from ten to fifteen minutes.

A shelter of this nature, as experience shows, is absolutely sufficient. The personnel is completely protected from shrapnel fire; against high explosive shell acting on percussion, overhead cover, even very substantially made, does not afford protection.

Note by the French translator.—Due to our shields it would not be necessary for us to provide earth protection to the same extent around our pieces. But it would be useful to have a bank of earth to close the intervals between the bottoms of our shields and the ground.

‡ This would often mean a useless diversion of infantry from their proper duties, and cannot, in our opinion, be regarded as the usual rule. (Note of the French translator).

acting as a support of the 8th Battery of the 35th artillery brigade, this battery, subjected to the fire of infantry while delayed in a quagmire, would have been the prey of the Japanese. The 15th Company of the 137th Regiment of the Niejinski infantry during the night of the 25th of February, carried off by hand a battery of pieces of irregular model which was ordered to withdraw; and in the absence of teams, dragged these pieces by hand for four versts and as far as Mukden, where they were joined to the 35th Brigade of artillery, which brought them to Tieling.)

Limbers and caissons.—The question of the posting of limbers and caissons of the firing battery is merely a matter of securing the maximum shelter and an uninterrupted supply of ammunition.

The limbers, in consequence, should be placed behind shelter and, if practicable, at least one-half a verst from the battery. The caissons, after their ammunition has been placed near the guns,* should go to be refilled and should then return and place themselves on the flank or in rear, where they are covered by entrenchments. It is useless and dangerous to keep them near the guns. The ammunition should be carried by hand, as the movement of teams may readily reveal a battery until then undiscovered by the enemy. A lack of ammunition is not to be feared; there exists enough of it for a calm and well-conducted fire.

Storing the cartridges in little trenches near the guns is not the cause of any danger. Shrapnel do not explode when they are hit by bullets from a shrapnel or from a rifle.†

In concluding the subject of the action of artillery, there remains a few words to be said about organization. The rapidity of fire of the modern gun warrants organizing 6-gun, or even 4-gun, batteries. The battery of 8‡ pieces is too unwieldy, especially in column of route.§

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* The soldiers of the support may be used for this work.

† The Japanese high explosive shell sometimes burst, however, in consequence of the explosion of a projectile in their neighborhood. In the fight on the Shaho, a caisson blew up in a Japanese battery posted near the Shaho station, producing an enormous cloud of black smoke.

‡ The Russian field battery has eight pieces.

§ If well supplied with ammunition, a four-gun battery:

(a) Can successfully accomplish all the missions normally assigned to an eight-gun battery, for there has been no occasion in this war to have recourse to the maximum rapidity of fire.

(b) The four-gun battery is not so unwieldy, and it is more mobile.

Moreover, besides other advantages, human nature must be taken into account. The increase of the number of pieces in a battery does not produce a measurably greater impression; whilst the entry into action of a new battery, even if it includes only 2 or 4 pieces, produces a very great impression, as in all cases of the arrival of new and fresh troops on the terrain.

Good *range finders*, *battery telescopes* able to find and distinguish those of the enemy, *telescopic sights* and *field glasses for the observers*, are indispensable.

Employment of the different kinds of fire.—The shell loaded with high explosive charge and producing a cloud of smoke which is easily seen at great distances, facilitates the adjustment,* and, in fire against shelters and villages, greatly increases the efficacy of the fire.

For the attack of material obstacles (entrenchments, solid walls, etc.), a piece is needed which fires projectiles having the effect of powerful mines, and a range of six versts. The field howitzer best answers these conditions.

Shrapnel, in our opinion, is useless for plunging fire.

As an example of the employment of modern fire on a large scale, we may cite the brilliant action of the batteries of the 35th Brigade of artillery on the 2d, 15th, of October, 1904.

Toward 4:00 o'clock, the regiments of Niéjin, and of Morchansk, which for five days had been fighting without cessation, and which had just executed two successful attacks on the ground south of Linchinpou, found themselves, with ammunition exhausted, subjected to a Japanese counter attack debouching between Linchinpou and Kiciaotoun, and resisted it with great difficulty; the regiments of Volkhov and Zaraisk were entrenched under a violent artillery fire in sight of Lamatoun. Word was then received that the Japanese were massed

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(c) It can be better posted on the terrain.

(d) It costs much less.

The rapidity and intensity of fire of guns of the new model induce the thought that it is possible to reduce the number of guns per 1000 infantry. We will not raise this question, however, as we have not at hand enough information based on the experience of the war.

Note by the French translator.—The preceding note is of special interest to us. It shows us that our adoption of the four-gun battery is reasonable, and that apparently we have not excessively reduced the proportion of our artillery.

* In shrapnel fire, however, there is scarcely any smoke, and in order to judge of the sense of bursts in air, lateral observers are needed.

Note by the French translator.—We succeed very well in France, however, in adjusting our fire by means of bursts in air.

near Choulinsa and in the valley of the Shaho to the west of this locality.

There was almost no reserve.

It was decided to utilize the long range and the rapidity of fire of our guns.

In 45 minutes, with 20 minutes of interruptions,* seven batteries (42 pieces) fired about 8000 rounds (progressive concentrated fire), and literally dispersed the Japanese reserves. From that day the real attacks of the Japanese ceased on the Shaho,† and the position of the 17th Corps on this river was established. Judging from a telegram, the Japanese loss near the railway in the days from the 1st, 14th, to the 4th, 17th, of October was about 5000 killed and 7000 wounded.

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* Interruptions caused by waiting for information as to the effect being produced.

† The losses and the expenditures of ammunition give the proof of this. The artillery fired:

October 1-14......................12997 rounds.
October 2-15...................... 9652 "
October 3-16...................... 3142 "
October 4-17...................... 1656 "

The infantry and artillery casualties (killed, wounded, and contused) are as follows:

Date.	138th Regt.		139th Regt.		140th Regt.		35th Arty. Brig.			Cartridges expended in the 138th Regt.
	Officers	Men	Officers	Men	Officers	Men	Officers	Men	Horses	
Oct 1-14	—	14	8	217	3	140	1	16	10	974460
Oct 2-15	1	48	2	22	4	485	2	12	1	93600
Oct 3-16	—	9	—	35	—	3	3	7	20	10000
Oct 4-17	—	6	—	8	—	—	—	4	—	5100
Oct 5-18	—	5	—	4	—	—	—	—	—	2000

137th Regiment: data lacking.

A part of the cartridges shown as expended by the 138th Regiment on the 1-14 October, were transferred to the 139th Regiment.

PROFESSIONAL NOTES

PROGRESS IN ORDNANCE.

The year has witnessed a very important change in the armament of battleships by the suppression of the medium armament in many new vessels. This measure has been taken in the case of the Dreadnought, which has a main armament of ten 12-in. guns with no medium armament, but a large equipment of guns firing 18 lb. shots as a defense against torpedo attacks. In the new French battleships, unless the plans should be changed, there will be four 12-in. guns and twelve 9.4-in., but no smaller armament, except the 2.9-in. anti-torpedo-boat gun. The rapidity of fire with big guns has greatly increased within recent years. The destructive effect of their shell fire, not only to life, but to the structure of ships, is far greater than with smaller guns ; and future naval actions will presumably be fought at ranges exceeding 3000 yards, at which big guns are much more effective than smaller ones. Therefore, in many naval circles it is contended that the medium armament has lost its value, although it is right to say that in some navies this view is not held to be absolutely confirmed. The lighter armament has for its purpose to deal only with torpedo craft, and, therefore, the character of the light gun becomes a matter of great importance. There are those who say that the proposed minor armament of the French ships, as also of the Dreadnought, is not sufficient, and in some quarters it is maintained that the 4-in. or 4.7-in. gun is the right protection from torpedo-boat attack. For the better co-ordination of fire, it seems now to be the practice to place these smaller guns in groups.

Progress in gun designing has principally taken the direction of increase in length and the use of higher pressures to obtain higher velocities. Thus in the British service a 50-caliber 9.2-in. gun is under construction, with a view to replacing the 45-caliber gun, and the 45-caliber 12-in. will supersede the 40-caliber gun now mounted in our latest ships. The increase in length greatly augments muzzle energy, velocity, and penetration, and there is a tendency to a redistribution of the thickness between tubes, wire, and jackets, and to the adoption of a uniform or similar type of rifling. In the Japanese battleships just completed at Elswick and Barrow the 10-in. guns are of 50-calibers, and the 12-in. of 45 calibers. Taking these ships as examples of progress, it may be mentioned that the Mikasa's 12-in. guns fired charges of only 147 lb. of the old cordite, whereas the new ships' 12-in. guns fire 260 lb. of M.D. cordite. The Mikasa's guns realize a velocity of 2400 f. s., while those of the Kashima and Katori have a velocity of 2850 f. s. The service 12-in. guns will obtain somewhere near 2800 f. s. Experiments have clearly proved the advantage of uniform rifling over the increasing twist with the modern high-velocity guns, and more accurate shooting has been the result, as the projectiles take their twist with more certainty. The rifling has been the cause of considerable trouble with some experimental high-velocity guns having an increasing twist.

Attention has been concentrated on appliances for insuring greater rapidity of accurate fire with large guns. Amongst these may be named a modified arrangement of breech mechanism, known as the "pure couple," which has been introduced by Messrs. Vickers, to increase the power (at the expense, of course, of more turns of the hand mechanism) for seating and unseating the obturator pad, which was highly desirable, on account of the hard work involved in these operations. Hydraulic breech mechanisms have been generally introduced for 12-in. guns, and in the Japanese battleships this is also to be found with the 10-in. guns. Loading at any angle of elevation is adopted for all the new 12-in. guns, although the advantages gained by this system are very nearly, if not quite, balanced by the disadvantage of extra complication and weight. It seemed to have been adopted entirely on account of the possibility it provides of keeping the sight on the target during the operation of loading.

In regard to training and elevating gear, it may be said that there has been no change beyond making it easier to work the gun, and with regard to the training gear, the present idea is to attain a slow and accurate creep under absolute control, so as to follow a target with certainty. The maximum speed with turrets is one turn in two minutes, but the minimum speed is one turn in six hours or more, while the Kashima turrets can train as slowly as one turn in thirteen hours.

The Vickers breech mechanism for the 12-in. 45-caliber gun is of a new and improved type, giving considerable increase of power when closing the breech, and is operated by a hand wheel, with worm-wheel gear, mounted in a suitable bracket on the end frame of the gun.*

We turn now to the smaller guns intended for defense against the attack of torpedo craft. This question, as we have said, has been much discussed as a result of the Russo-Japanese war, and calibers of guns have been advocated or adopted which seem out of proportion to the object to be attained. It is pointed out that with the heavier ordnances, preferred in some quarters for this minor purpose, the provision of sufficient ammunition might become a difficulty. It has been contended that the insufficient stopping power of the 12-pdr. guns was not definitely shown by the events of the late war, and that any failure probably resulted from the character of the projectiles employed, and, still more, from insufficient rapidity, and, above all, from want of precision of fire. Messrs. Vickers' latest 12½-pdr. gun on its naval mounting meets the difficulty. The breech mechanism is of the vertical block type, and can be operated semi-automatically by the mechanism being opened by the recoiling of the gun after firing, and closed by the operation of loading; or quick-firing by the mechanism being opened and closed by hand.

We are indebted to Messrs. Schneider, of Paris, Le Creusot, and Havre, for interesting particulars concerning their new patterns of ordnance. The remarkable Schneider-Canet powerful, semi-automatic 12-pdr. may be mentioned first. Its breech mechanism is upon the principle of concentric screws (*filets concentriques*), which are worked by hand with very great rapidity, and lend themselves very readily to the adaptation of a semi-auto-

* See JOURNAL, No. 74, page 64.

matic movement operated by a hand lever and crank with springs. The breech can be opened only after the discharge and throws out the empty cartridge case, and it is closed with the introduction of a new cartridge. Firing is automatic, or at the will of the gunner, and danger is said to be impossible, because the percussion needle can only be brought into position when the breech is completely closed. The breech mechanism consists of a very few pieces, and is easily removed by hand. The mounting has a central pivot, and the gun is so well balanced and provided with arrangements against friction, that it is moved in any direction with the utmost ease, while the arrangements are such that its movements can be arrested immediately, enabling it to be laid and maintained precisely upon the object. The sighting is telescopic. Great attention has been paid to the rapid supply of ammunition, which is made semi-automatically by suitable arrangements. The whole disposition of the gun seems to be exceedingly simple, and we are informed that the rate of fire is from 35 to 40 aimed rounds per minute. The explosive charge is "Schneiderite," a powerful and very safe explosive and the fuze is arranged with the object of bringing about the explosion while the shell is passing through the plates of the torpedo boat attacked. MM. Schneider have constructed a completely analogous gun of smaller caliber, 57 mm. (6-pdr.)

The same enterprising firm have devoted attention to a system of rapid ammunition supply to guns of large caliber, so arranged that little or no mechanical aid is required. Any mechanism actuated by power, hydraulic or electric, is subject to breakdown, and a mechanism has therefore been introduced whereby shells of 12-in. and 10-in. guns can be man-handled, the motive power required being reduced to a strict minimum, and involving only the application of mechanical arrangements which are very simple and strong. A gun so adapted for coast use is of 9.4-in. caliber. The breech mechanism is of great simplicity, and can be operated by hand if required. The gun is mounted upon a central pivot with hydraulic brakes, and is provided with very ingenious arrangements to absorb the recoil and bring the gun into the loading position. Moreover, the adjustments are such that the aim can be taken by telescopic arrangement while the gun is being loaded.

Mr. Meigs makes some interesting remarks upon the subject of erosion, remarking that the power of the gun can be augmented either by increasing the velocity or the weight of the projectile. If the weight be increased less ammunition will be carried, and the rate of fire will be reduced, while if the striking energy be developed, the "life" of the gun may be reduced. He says that in the United States the high velocities now employed have brought into prominence the question of the rapid burning or wearing away of guns, particularly of the larger calibers; but in this country it is considered that with the new M.D. cordite, using high velocities, the "life" of the gun will be sufficient for all purposes. Yet it would seem that in the United States it is proposed in some quarters to lower the velocities of guns, particularly of the large guns, on the ground that the "life" of these guns is so short as to constitute a serious menace. It has even been proposed, says Mr. Meigs, that the guns of a fixed weight (probably the present weight, or about 60 tons) should be made of larger caliber—that is, should be of more than 12-in. caliber, with the object of lowering the velocities of these guns and increasing the weights of their projectiles, lowering the pressures and temperatures of the gas in them, and extending their "life." This is obviously a matter upon which different opinions are likely to be held, and the erosion of United States guns would seem to offer a practical commentary upon the nitrocellulose propellant in use, which was supposed to reduce this evil to a minimum. It may be pointed out that the "life" of a gun depends principally on the weight of cordite burned, and that if in a 12-in. gun 200 lb. of cordite gave a certain energy, evidently more would be required to obtain the same energy in a larger gun of approximately the same weight, for the larger gun would be shorter in proportion, and the "life" of the gun would accordingly be shorter.

—*The Naval Annual, 1906.*

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NEW CAPPED PROJECTILES

In relation to the new projectiles it is impossible to give precise data without divulging confidential information, but the difficult nature of the specification of the new capped A.P shell for the British Government is well known. Supplies have been called for of various calibers of this new type of shell. Messrs. Thomas Firth & Sons, of Sheffield, though they have not yet submitted any of their 12-in. projectiles of this latest type for proof, have fired successfully those of 10-in. and 9.2-in. calibers in the severe tests required by the stringent conditions laid down for acceptance. The 10-in. and 9.2-in. capped A.P. shells penetrated a 9-in. K.C. plate at a velocity of 1963 f.s. for the 10-in. and 2030 f.s. for the 9.2-in. The same firm have been equally successful with 8-in., 7.5-in., 6-in., and 4.7-in. shells fired respectively against K.C. plates of the same thickness as the caliber. The velocities for the 8-in., 7.5-in., and 6-in. shells were respectively 1931 f.s., 1997 f.s., and 2016 f.s. These armor-piercing capped shells are known as "Firth-Rendable," and the caps are made of soft material, and fixed to projectiles very carefully designed. They are intended to burst after perforating the armor plates attacked, and have a chamber capacity to carry a bursting charge equivalent to two and one-half per cent. of the total weight of the shell. In regard to the 8-in. shell the official report states that there was a "perfect test, the shell having been recovered without the slightest deformation, and quite cold."

The Hadfield Company has also been very successful with its capped "Heclon" A.P. shell, of which large quantities have been passed into the army and navy services, including 9.2-in., 7.5-in., and 6-in. caliber. Important tests have also been carried out in Spain, with the result that a considerable supply of large-caliber capped shell are to be supplied. One of the "Heclon" projectiles was recently fired at an important foreign proving ground, giving very remarkable results. The plate attacked was 12 in. in thickness, of the K.C. type, backed with 12 in. of oak backing, and three one-half inch skin plates. Such a plate is usually attacked by a one-caliber projectile, that is 12 in., but in this case one of the "Heclon" projectiles, 10-in. caliber, was fired at it with the low velocity of 1877 f.s. The shell perforated the plate and backing, and was found with only the point and two pieces of the shoulder broken off no less than 2600 ft. beyond the target. The 7.5-in. "Heclon" projectiles have also repeatedly perforated 9-in. K.C. plates at 1975 f.s. velocity, the shell passing through this severe ordeal, and being found practically undamaged a considerable distance behind the plate. It is recorded that on 14 lots of this caliber shell supplied to the British Government no less than 14 proof shell have been fired, every one of which passed through a 7-in. K.C. plate and was recovered on the other side in a condition for bursting. A later trial of a 9.2-in. "Heclon" A.P. shell against a K.C. plate 11 in. thick is reported. The shell had a striking velocity of 2000 f.s., and perforated the plate, being found undamaged at the back.

There is a tendency in the United States to do away with all projectiles except those that are armor-piercing, and so to modify and improve these that, while retaining their ability to penetrate armor, they can be fragmented as effectively as weaker steel shell. Armor-piercing projectiles of these new types, containing large bursting charges, have been made and subjected to the usual acceptance tests, and have been successful. Photographs showing bursts of 4-in. and 6-in. projectiles of these types are very interesting. Both shells passed through a thickness of hard-faced armor equal to their diameter, and were burst in flight behind the plate by the charges which they contained. Like results have been obtained with 3-pdr. and 1-pdr. projectiles of the same type. (It should not be understood however that there is a disposition in the United States Navy to do away entirely with shrapnel, and many gunnery experts consider shrapnel fire as very effective and valuable.)

It may be noted that, because an A.P. shell bursts with good fragmentation after passing through an armor plate whose thickness is that of the caliber of the gun, it does not follow that it will break up well after passing through a half-inch plate. This is a real difficulty, and if the Americans have got over it, they have certainly made a step in advance.

—*The Naval Annual, 1906.*

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LAND DEFENSES OF COAST BATTERIES

The primary object of coast fortresses is to protect harbors, roadsteads, and dockyards, and the ships lying in them. An enemy would naturally seek to defeat this object. He would endeavor to gauge the strength and the weakness of the defenses and strike at the joints in the armor. His course of procedure would be problematical; but in each case certain constant factors—the strength and composition of his forces, the number and nature of his ships, the proximity of his coast, national characteristics and historical precedents—would aid in the solution of the problem. Only by carefully weighing these considerations, by a good intelligence system, by constant watchfulness, and by keeping a fortress well equipped with modern appliances, and well up to the requirements of contemporary tactics, can a successful defense be maintained.

One effect of the Russo-Japanese war has been greatly to enhance the respect of the sailor for shore batteries. The Japanese admirals recognized very early that, if they were to retain the command of the sea, they must keep out of range of the Russian guns in Port Arthur, comparatively obsolete and poorly equipped as they were. Only two resources remained—to block the channel of exit by sinking ships in the fairway, and a long-range bombardment from such portions of the sea-area as were not covered by fire from the forts. The former was successful; but it is doubtful if the value of this method is proportionate to the heavy losses it must entail, for the obstructions caused by sunken ships can be cleared in a short space of time by the use of high explosive. The bombardment was found to be slow, expensive of ammunition, and by no means surely effective.

The happy combination of pluck and prudence displayed by the Japanese navy won unstinted admiration from the sailors of all nations. It has been generally taken for granted that the work effected by them was a near approximation to the humanly possible. It may then be fairly deduced that an admiral must be prepared either to suffer heavy losses in forcing a passage, or to content himself with dropping shell from some distant point into the fortress. But in most modern fortresses batteries have been constructed, well out to either flank, with a view to obviate this latter contingency, and the inner or main defenses so powerfully armed that an attempt to pass them would spell most of the letters of the word annihilation.

The principal rôle of torpedo boats has been hitherto held to consist of raids upon ships of war in harbors. Two or three divisions of these craft may yet be adventured in such enterprises in the hope that a few of the more fortunate may reach their objectives. Surprise would be essential for success, surprise absolute and complete, such as is only likely to be obtained by hostilities prior to the declaration of war.

It would appear, therefore, that no bright prospect is open to the fleet led to attack under what have been, till recently, the ordinarily accepted methods. It has thus become necessary for naval experts to formulate other plans. That most in vogue upon the Continent at present is to capture the batteries by sudden raids on the land defenses, and then, either to disable the guns, or to make use of them against other batteries, or against hostile ships. The teeth of the fortress having been, so to speak, drawn, the work of the attacking fleet becomes largely simplified.

The mode of procedure of the raiding parties, their strength, means of transport, etc., would, of course, vary largely with the distance from the starting point of the objective, the possibilities of landing, the nature of resistance likely to be met with; but it is held that certain general principles should be observed in all cases.

The parties should be as small as possible, and should be conveyed in small, swift ships, or in launches. The utmost secrecy should be maintained. The landing-places selected should be numerous, near the objectives, and, as far as can be ascertained from the mobilization schemes of the opponent, undefended. The parties should be timed to arrive either before or during the attack by sea. The men employed on this duty should be volunteers, and should understand that they are going to almost certain death, that there is to be no retreat, and that they must be prepared to sacrifice all to attain their object. If unable to effect an entrance into a fort, they should endeavor to occupy commanding ground in the vicinity from which, by their fire, they could render the working of the guns impossible. They should be competent to work the captured guns, or to disable them if necessary. Electric lights and position-finding stations should be made a special object of attack. It should be arranged to hoist distinctive signals in the captured works, both for the information of the fleet, and to enable fire to be concentrated from them on the other batteries.

It remains then to be considered how attacks of every description can be met and defeated.

In war-time, or when war is momentarily expected, the garrisons would be in their forts and ready for all emergencies. In this case a small raiding party would be unable to effect much in open daylight, but might be able to break through the land defenses by night, as in many batteries the latter are of great length. A large party, either by day or night, would attempt to storm at least some of the works, and, if unsuccessful, would probably occupy commanding ground in rear or to a flank, and by their fire make it impossible for the defenders to man the guns.

To assist the garrisons there would, no doubt, be infantry detachments, who would hold selected posts at a distance from the fort and patrol the intervening spaces. But such detachments must necessarily be small, or the field army would be sadly reduced; and history shows that no such cordon system of defense, passive in its very essence, is infallible.

When relations with a neighboring foreign Power are strained or broken, the measures to be taken by the defenders would include—

Intimate communication between the coastguard service and section commanders.

Increased watchfulness at all forts, and good alarm signals.

Local mobilization schemes well adapted to meet sudden emergencies.

A warning to the police, to steamship and railway companies, and to hotel proprietors, to report an unusual ingress of foreigners.

The clearance of foreground, creation of obstacles and of automatic alarms, if this work has not already been carried out.

The general improvement of land defenses of coast fortresses is a matter of policy, and can only be arranged for at leisure in peace-time. The financial aspect of the question is of prime importance. It is fully recognized that the safest defense lies in a strong power of offense. A powerful navy, backed by a large and well-equipped army, is of greater worth than all the fortresses in the world. Political economy teaches us that there is a limit to the burdens that may be imposed upon a nation, if that nation is to thrive. Out of this limited amount a certain portion is set aside for the naval and military forces, the larger part of which is rightly devoted to "offensive" services. Only a comparatively small sum of money is then available for coast defense, and the question is, "How should it best be spent?" The answer to this may be best evolved by a study of the coast batteries to be met with in the British Empire. They are, generally, of three kinds, namely—

(1) A species of huge redoubt, with a high parapet, deep ditch, and caponiers.

(2) A more open work, with a long, even glacis in front, protected only by an unclimbable fence, and, in rear, a loopholed wall or a continuous line of parapet with a small ditch.

(3) Similar to (2) in front, with an ordinary iron fence, supported by a barbed wire fence in rear.

The first affords fair protection against reverse and enfilade fire, is difficult to silence or capture, is valuable in exposed and isolated positions, but forms a conspicuous target. The second offers many advantages. It is impossible, of course, to build cover high enough to screen the gun-detachments from fire from high ground in the vicinity, but the wall, or parapet, provides a distinct line to hold on to, and is sufficiently strong against ordinary raiding parties, especially as the latter are unlikely to be possessed of artillery.

The third is of the design most in favor at present, and is open to strong objections. The fences are not at all a serious obstacle except against trespassers. The garrison is completely exposed to reverse fire, to which they could not reply, for there is no covered position which they could take up.

In endeavoring to apply the trade motto of "cheapness with reliability" none of the present types are suitable.

1. Is much too expensive.
2. To a lesser extent, is also too expensive.
3. Has too many disadvantages.

The last could, however, at very little expense, be considerably improved, and, in its new guise, should fulfil sufficiently all requirements to act as a model for future forts.

A small parapet, the profile of which might be varied to suit the different conditions of terrain, but roughly, with a command of from three to six feet, could be made at little expense along the whole length of the gorge. A short distance in front of this a serious obstacle could be erected, such as a barbed wire entanglement, five to eight yards deep, and provided with automatic alarms. Trees planted just in rear of the guns should give protection from view; but if they, as is often the case, failed to grow to a sufficient height, it would be necessary to resort to smoke-balls, or to some such device, to screen the troops manning the battery. For obvious reasons this is of the utmost importance, and any scheme calculated to obviate the difficulty should be gladly welcomed. The parapet should be so traced as to give a flanking fire across the entrance gate, and a simple form of *chevaux-de-frise* might be placed across the road in front, which, in peace-time, could be put up at retreat and taken down at reveillé.

The safeguarding of isolated fire commanders' posts, position-finding, and electric-light stations presents some difficulty. Apparently the only way to defend these is to erect tiny inconspicuous redoubts, well protected by wire entanglements and giving an all-round fire, in the nearest position from which every approach could be swept, and which could be manned at short notice by the F.-C. Staff, P.-F. or E.-L. operators, or by men specially told off for the purpose.

There is nothing new in the suggestions put forward, for most affairs mundane run in cycles; and it is not so many years since the land defense of coast batteries was considered almost equal in importance to their *raison d'etre,—i.e.* their power of offense against ships. This is obvious in most of our older works. Then a school of thought arose which went, tooth and nail, for gun-power, leaving to the field forces the duty of protection. It was the age of the renaissance of coast artillery, and, ruled by men of marked ability and untiring perseverance, this school wrought wonders. The result of their efforts may be seen in any of our coast fortresses: cleverly selected positions, admirably emplaced guns, good systems of communication and of fire control, bear witness to their efforts. If the final test of war be applied, it will surely prove their worth, and bring to fruition the long labors of peace. But their task is fulfilled; other hands must put a finishing touch to the work. The sword and the buckler are there, but the armor is lacking in back-pieces. Enough money, for the present, has been spent on gun-power, and all available funds should now be directed towards rendering batteries immune from land-attack.

—*United Service Magazine.*

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FRENCH DREADNOUGHTS

After the launch of the Dreadnought the efforts of all naval powers of the world have been concentrated on the solution of the problem as to what type of vessel is most fitted to combat with her. In France the debate between the "new" and the "old" school has now reached an acute phase. The followers of Admiral Aube's doctrine still maintain that the fatal blow to English mastodons must be brought "below the water-line belt"; *la torpille est l'arme francaise par excellence,* says M. Fontin, in his preface to M. Noalhat's new book on mines and torpedoes. Lieutenant Suarez, in "La guerre avec l''Angleterre," and other writers of the new maritime league attack the naval policy followed until now—the English—and advocate a purely French policy. France is to do away with armored vessels; line-of-battleships and big cruisers only are responsible for the great disproportion of British and French forces. If the resources of the nation are concentrated in the building of corsaires and the preparation of flotilla warfare, it will be possible in a few years to create a number of commerce destroyers, submersibles, and blockading ships able to convert "Portsmouth, Gibraltar, and Malta into mousetraps for the English fleet."

The influence of these theories on French naval opinion must not be under-estimated; the steady progress of submarine and torpedo craft construction is a sure sign of the revolution torpedoes will bring in sea fighting.

But as it is yet too early to prophesy the degree of efficiency and reliability to which torpedoes may be brought, it is no wonder that all responsible authorities have decided in France also to follow the example of England. Thus, as a result of the Dreadnought panic, the English, German, American, and Japanese Dreadnoughts will have to count with a new rival—the French battleship-cruiser. The naval standard of the reorganization of French forces is based on that of the British navy. An approximate idea of the comparative strength at the beginning of 1906, and within a period which can be roughly estimated up to 1910, is given by the following table:—

TABLE I.

	1906.		1910	
	No.	Aggregate Displacement	No.	Aggregate Displacement
BATTLESHIPS.				
British, . .	56	775,000	56	815,500
French, . .	26	262,000	26	299,000
ARMORED CRUISERS.				
British, . .	26	295,900	39	482,800
French, . .	19	159,400	23	219,400

As a basis for all estimates the assumption has been made that the useful age of men-of-war can be computed as follows:

For Battleships,	25 years
" Cruisers,	20 "
" Submarines,	15 "
" Destroyers and torpedo boats,	11 "

The Conséil Supérieur de la Marine in 1905 compiled a program of naval constructions to be carried out in fourteen years. The number of vessels at the end of this period, compared with the number of ships existing in 1905, is given below:

	In 1905	In 1919
First-class battleships,	11	19
Second-class battleships	10	18
Coast defense battleships,	9	—
First-class armored cruisers,	10	18
Second-class armored cruisers,	9	18
Protected cruisers and scouts,	29	6
Destroyers,	50	109
Submarines,	31	49
Submersibles,	7	82

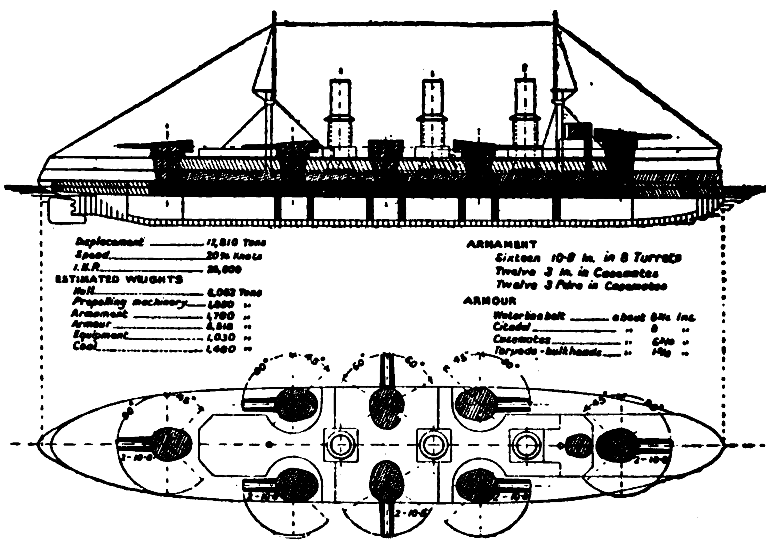
To realize the importance of this projected increase of naval power it must be remembered that by the time the new naval standard will be attained, all obsolete battleships—Hoche, Marceau class, Courbet, etc.—the coast defense ships (Bouvines, Jemmappes, etc.), and all the protected cruisers now existing will have ceased to make part of the active fieet. There will be a strong nucleus of six units of the République class, around which will be grouped a formidable force of battleship-cruisers, an aggregate of uniform vessels whose characteristics are now being discussed, and are to be settled within this year. The French also have assumed the Dreadnought as the probable rival in future sea fights. There is yet but little data available concerning the German and Japanese Dreadnoughts, but there is enough information to hand to foresee the final stage of the evolution which, in France, will lead to a national type of battleship.

The design of this type is far from embodying the American conception of the "compromiseless" battleship. Armament, protection, and speed have to combine in a compromise which fixes the displacement at 18,000 tons. One party maintains that the first two of these cardinal virtues of a battleship must be developed to the detriment of speed, the most unreliable of tactical qualities. Having proclaimed the "fragility" of speed, this party adds: "Speed is not a weapon, and cannot substitute a weapon; at the service of the weakest, it may induce him to run away." A project which characterizes this tendency to neglect speed for the benefit of guns and armor contemplated an armament of sixteen 12-in. guns and 12-in. armor, but it has not been taken into account.

In the original designs presented last year by the Conséil Supérieur the armament was, four 12-in., twelve 9.4-in., and sixteen 3-in. guns. The Marine Minister in this year's discussion of the program has modified the design, reducing the water-line armor from 280 mm. (11 in.) to 250 mm. (10 in.), in order to increase the speed from 18 to 19 knots. The results of the Russo-Japanese war are also responsible for the reduction of armor thickness; the experience of the sea-fighting in the Far East seems to prove that the water-line belt is seldom hit, and never pierced.

Parliament, which was asked to approve the construction of six units of the type proposed by the government, has not accepted this type, demanding an increase of speed, which, according to the conclusions of the Budget Commission, ought to be at least 20 knots. M. Charles Bos, backed by M. Lockroy and Admiral Bienaimé, has presented a project of a standard type of battleship-cruiser, embodying the desideratum of the majority of naval authorities.

M. Bos's design is based on the adoption of a uniform caliber gun, the 10.8-in. The reduction of caliber will correspond to an increase in the ballistics of heavy guns, a practice not at all unusual with naval guns, especially in France, where the caliber of primary armament from 420 mm. has gradually been reduced to 370 mm., 340 mm., and finally to 305 mm. It is asserted that, in many respects, the armament of the new French ships will be superior to that of the new English Dreadnought. The 12-in. guns,



Mark XI., of this ship will have, as is known, an effective range of 10,000 yards or more, so that the superiority of the French armament can only lie in the number of guns and the velocity of fire. But the tactical value of these qualities, dependent upon speed, is much diminished by the fact that the choice of range of fire will remain with the Dreadnought, which, beyond 8000 yards, can smash her French rival without getting hurt by her 10.8-in. shot. The new projected naval gun for the French navy would have the following characteristics: Caliber, 274 mm. (10.8-in.); length, 45 calibers; weight of projectile, 740 lb.; initial velocity, 2800 foot-seconds; the length of the projectile to be greater than that of the 12-in. guns—length 40 calibers—now existing. The number of rounds for each gun from 60—Minister's program—is raised to 100.

The discussion of the French naval program cannot fail to recall the instance of the Edgar Quinet. The building of this armored cruiser of 14,000 tons and 24 knots was to have commenced more than a year ago at Brest, and has been delayed till the end of 1905 on account of the armament.

The Quinet, and her sister ship Waldeck Rousseau, according to the original design were to have been armed with four 7.6-in. guns and sixteen 6.4-in. guns, but owing to the efforts of M. Bos it has recently been decided that the armament shall consist only of 7.6-in. guns. This is the first step to the realization of the ideal to which, according to M. Lockroy, the French navy must aim. One type of ship, one type of gun, one type of shot. The next step, with all probability, will be the battleship-cruiser of 18,000 tons. A rough sketch is given herewith of the disposition of guns and armor of this proposed type of war unit for the French navy, with some data showing the scheduled weights, *a propos* of which it is scarcely necessary to call attention to the fact that the aggregates of weights comprised under each of the heads given have surely been under-estimated. The displacement of a vessel satisfying all the requirements to be embodied by the design in question would be nearer to 19,000 than to 18,000 tons.

The choice of the 10.8-in. gun for the main armament will furnish artillerists sufficient matter for elaborate debates; here we may only point out that the anti-torpedo boat armament, 3-in. guns, seems inadequate for the purpose it may be called to fulfil. With the abolition of intermediate calibers, the rôle of destroying the unprotected parts and superstructures of the enemy's ships must be combined with that of repelling attacks of sea-going destroyers and torpedo boats, and this can only be obtained by the adoption of a bigger caliber for small guns. As the practice of the leading naval powers shows, this caliber cannot be chosen under 4-in.

A novel feature in the French design in question will be the number of engines, two instead of three; the triple screw, adopted after the German pattern, does not seem to give much satisfaction in France either with battleships (Suffren, Henry IV.), or with armored cruisers (Jeanne d'Arc).

The ram is to be suppressed, thus following the practice initiated by the Japanese with the Satsuma. Superstructures, which now disfigure all war vessels of French design, are to be much reduced, and military tops abolished. The funnels are to be higher, and protected at the base by armor grating.—*The Engineer, London.*

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GUN-POWER AND SPEED OF THE KATORI

Japan's new battleship, the Katori, has, on her trials, marked a record in her combination of fighting power and speed. Built and completed in every respect for war by Messrs. Vickers Sons and Maxim, Limited, she represents what may be regarded as the highest conception, prior to the late war, of what a battleship should be; and the anticipations of the design have been more than fulfilled during the searching tests as to guns and speed made by the Japanese naval authorities in this country, terminating with most successful ordnance trials. The vessel is a compromise between the two present-day schools on the question of ordnance. Having four 12-inch and four 10-inch guns, all of 45 calibers in length, she has eight primary guns able to penetrate, at 4 miles range, the maximum thickness of armor on the broadside of any existing ships, for on trial the 12-inch pieces developed an energy at the muzzle of 48,000 foot-tons, and the 10-inch breechloaders, of 27,570 foot-tons. There are four of these guns available

for both bow and stern fire, and six for broadside attack. The feature is the adoption of the 10-inch guns in barbettes on the corners of the citadel, and interest was centered in the tests as to rapidity of their fire. Improvements by the Vickers Company in breech mechanism, in the mountings, and in the system of supplying ammunition to the guns, proved most effective in both calibers of guns, and it was found that five shots were fired from the 10-inch weapons in 2 minutes $8\frac{2}{5}$ seconds. This result places the gun in a most advantageous position, as the rate of fire equals many pieces of lighter attacking power. These heavy pieces are unequal in number to those of some of the much larger ships now projected, for the Katori is under 16,000 tons displacement; but she possesses, in addition, twelve 6-inch guns, which are still favored because they facilitate concentration of fire owing to their quick-acting mechanism, and their fusilade of shell may paralyse the *personnel* on an enemy's ship, and thus indirectly win the day. The 6-inch guns in the Katori fired eight rounds in $52\frac{2}{5}$ seconds. The muzzle energy proved to be about 6500 foot-tons. Thus the Katori, with a great number of small guns, is unequalled in power by any ship now in commission. Her speed is also unique, for on her eight-hours' full-power trial she averaged 20.22 knots, as determined by four runs over a long deep-sea course on the Firth of Clyde. On the twenty-four hours' coal-consumption test, at three-fourths of the full power, the mean was 1.6 pounds per indicated horse-power per hour. As she is most effectually armored, the Katori is thus a worthy addition to the victorious navy of the Mikado, and appropriately comes from the works where Admiral Togo's flagship, the Mikasa, was constructed.—*Engineering.*

Short Notes

An automatic fuze setter is being issued to batteries armed with the new 18-pounder quick-firing gun. This ingenious contrivance, quickly and easily set to the length of fuze ordered, is then employed to set as many fuzes as required to this length. This it does with perfect accuracy and expedition, thus eliminating the chance of personal error so liable to occur in the heat of action.—*The Engineer, London.*

In the course of trials with the new quick-firing field gun it was found that the glints of light from the protecting shields make it unduly conspicuous; efforts are being made to find a suitable means for minimizing the reflection of the sun's rays. Deep rust indentations form the best cloak for iron and steel, but service traditions demand a conspicuous array of polished parts.—*Arms & Explosives.*

According to the German correspondent of the *Revue Militaire Suisse*, the Guard, the VIII., XIII., XIV., XV., XVI., and XVIII. Prussian corps and the II. Bavarian, all on the western frontier, are equipped with the new field material, dating from May first. It is not correct that accidents happened during tests nor in the service with this material. The new gun is almost exactly like the Krupp gun recently adopted in Belgium, except the breech mechanism, which is of the Ehrhardt type. But this fermeture and Krupp's are equivalent; both require but a single motion for opening or closing the breech. For aiming, the sight with level and goniometer and the

panoramic sight have been adopted. For the present the German battery will retain its six guns; the question of 4-gun batteries is being discussed in the press, but it is absolutely decided that the army corps will preserve its number of field guns, that is, 144 for 25 battalions, whether the batteries are of four or six pieces.

The *Esercito italiano* announces that in consequence of the comparative trials carried out with the 73 and 75 mm. R.F. guns, the Italian Permanent Commission of Inspectors of Artillery have concluded that "the advantages possessed by the material of 73 mm. with regard to mobility and management do not compensate for the inferiority of its ballistic power," and unanimously recommended the adoption of the Italian 75 mm. material. In compliance with this conclusion, the War Minister decided that the field artillery should be armed with the 75 mm. material, and in accordance with existing agreements, the first battery will be constructed by the Krupp firm and delivered in October next. The remaining material for replacing the heavy bronze 87 mm. gun will be constructed in Italy. The material of the R. F. 76 mm steel gun, M. 1900, which replaced the light bronze gun of the same caliber, will be altered to the newly adopted type. Thus the whole of the Italian field artillery will be provided with one material alone, and with identical ammunition.

BOOK REVIEWS

Moderne Feldkanonen (mit langem Rohrrucklauf). Von Roskoten, Hauptmann und Batteriechef im Mindenschen Feldartillerie-Regiment No. 58. 8 + 75 p. 22 il. 9½ x 6½. Oldenburg i. Gr. Gerhard Stalling, Verlagsbuchhandlung. 1906. Mk. 4.25.

This is a very complete work covering the details of modern field artillery material and accessories, and giving a large amount of statistical data on all the recently adopted field guns, etc., of various countries. It is written for officers of all arms, but a valuable feature and one intended for those who wish to pursue the subject more deeply, is the numerous notes and references to all the more important articles on field artillery questions that have lately appeared in the technical press.

The author's intention is to give only a "short review" of the types of modern field guns and the characteristic features of the long recoil system both as regards material and its employment in its technical and tactical aspects. This he has succeeded in doing concisely, yet with thoroughness, all questions connected with the new system being carefully and critically discussed.

The first part of the book is devoted to the general principles of the long recoil system, including recoil-checking arrangements, the shield, question of projectiles, sighting apparatus, methods of fire, caissons and limbers, organization and tactics. Copious notes quoting authorities show the extent of the author's researches and form an excellent guide for one interested in the literature of the subject.

Part II. is a compilation of all hitherto published data on long recoil field guns now adopted in Europe and America. It is comprehensive and accurate. In addition to the other excellent illustrations in the book, this part is supplemented by 15 photographic views of foreign field guns, including the U. S. model, 1902.

The book contains much that is of interest, and will be found very useful as a book of reference both for the data it contains and as a selected bibliography, as it were, of recent field artillery literature.

Der mechanische Zug mittels Damp-Strassenlokomotiven. Seine Verwendbarkeit für die Armee im Kriege und im Frieden. Von Otfried Layriz, Oberstleutnant z. D. 77 p. 29 il. 6 pl. 9½ x 6. E. S. Mittler und Sohn. 1906. Mk. 2.

Colonel Layriz, the well known writer on this subject, gives in this book an interesting discussion of the development of military motor tractors and their applications in war and in peace. Steam road locomotives for war purposes received their first service trials in the war of 1870-71. Starting from that time the author examines the successive improvements and progress made in their mechanical features and applications, citing examples of the advantages to be gained from their use as illustrated particularly in the Transvaal and Southwest Africa.

With the characteristic precision of German writings, the book treats of the various types that have been tried and found best for war purposes, discusses and describes the composition of trains and convoys, indicates the conditions that motor tractors should fulfil for their prompt and rapid movement on ordinary roads and across country where necessary, and cites many examples of their practical value in transporting troops and material, artillery, formation of armored trains, etc., etc. It is also shown they can be made to serve many useful applications as fixed engines: pumps, cranes for loading and unloading, clearing the ground in fortification work, digging trenches, etc.

Noting the wonderful development of the high-powered, speedy automobile, the author clearly shows that the requirements of mechanical traction for heavy loads under service conditions, are not so easily fulfilled. The automobile answers to some extent for personnel — specialized purposes— and as a rule only on good roads. The steam road tractor appears at present to meet best the demands of war service. In this connection the English War Office trials of 1898, 1899, and 1901 are noted, in which the steam vehicles did the best work under very severe conditions. At the same time there are great possibilities for military purposes of the internal combustion motor burning heavy oil.

The interest in this subject now being developed in all armies renders the book timely and of value. The illustrations are both numerous and interesting.

Cromwell. The Campaigns of Edge Hill, Marston Moor, Naseby, and of 1648 in the North of England. By Captain P. A. Charrier, Royal Munster Fusiliers. 22p. 23 maps. 11¼ x 8½. London. Relfe Brothers, Ltd., 6, Charterhouse Buildings, E. C. 6s. net.

Cromwell's qualities as a soldier are well illustrated in this terse account of his campaigns of Edge Hill, Marston Moor, Naseby, and in the north of England. The author asks the question: "Where did Cromwell acquire his genius for war? His mastery in leadership?" Without pretending to be able to solve this question, he notes the fact that all great leaders have received a thorough education in the art of war, and hence it is to be presumed that Cromwell's early training included a thorough grounding in this art. At any rate, we can make certain of his other qualities that make for success in life, and the influence of these is forcibly brought out in the discussion of his campaigns.

The author confines himself to taking up certain situations, discussing them and endeavoring to see what lessons may be drawn. A number of capital sketch maps greatly assist in following the text. It is made evident that Cromwell relied for the success of his army on its good order, its cohesion, rapidity of movement and the keeping of a reserve of horse to influence the final decision. We see the constant rallying of his troops for the next effort, the co-operation of his cavalry with other arms in the destruction of forces still on the field, and the quick pursuit to reap the fruits of victory. The battle rôle of his cavalry was such as is now conceived and preached in all war schools. Another secret of his success was keeping at all time a firm grip over the battle, which he never relaxed for even a moment. This and other lessons deduced by the author are still of the greatest value.

Discipline, decision, energy, self-control, coolness, perseverance and endurance, allied with knowledge, are distinctly the qualities that animated Cromwell and his men. One is also struck by the sound, practical common sense which imbued everything that Cromwell did. He left nothing to chance. There was no fuss, no irritability, no indecision. But with a capacity for prolonged and orderly efforts and imbued with the moral elements that make for victory, he displayed splendid proofs of leadership.

Organization and Tactics. By Arthur L. Wagner, late Colonel, Military Secretary's Department, General Staff, U. S. A. Ed. 7. Revised. 20+393 p. 8¾ x 6. Kansas City, Mo., Franklin Hudson Publishing Co. 1906. Cloth, $3.00.

Colonel Wagner's work is too well known in the service to need special notice or criticism here. In this edition careful revision has been made to bring the matter up-to-date and several changes have been introduced in the arrangement and treatment of the chapters. The author had in view, himself, the thorough revision of the book, but his untimely death necessitated placing the work in other hands. This has now been creditably performed by Captain Malin Craig, Captain Herbert J. Brees, and First Lieutenant L. A. I. Chapman, all of the 1st U. S. Cavalry, assisted by review and discussion, before publication, by the Department of Military Art of the Infantry and Cavalry School and Staff College.

The subject matter is brought up-to-date, including the Boer and Russo-Japanese wars. Chapter II. on Organization and Discipline is largely changed and is made to conform to the Infantry Drill Regulations and the Field Service Regulations, new tables on the Division instead of the Corps unit basis being inserted, including transportation. The chapters on the Characteristics of the Three Arms and the individual arms in attack and defense contain much new matter enunciating the principles of modern battle; except that no attempt is made at this time to revise the chapter relating to artillery in attack and defense due to the lack of complete data as to the tactical and technical handling of the new field artillery. Therefore for the main portion of this chapter there has been substituted a lecture prepared from all data available at present, by Captain O. L. Spaulding of the Artillery Corps, for use in the Infantry and Cavalry School and Staff College. Chapter VII. on the Three Arms Combined shows the result of careful study in introducing changes where necessary.

The historical chapters are grouped together and placed at the back of the book,—a decided improvement. They remain very much the same as in previous editions. It is rather surprising to read in a book with the imprint "1906", the remarks: "Since the Russo-Turkish war, there has been no conflict of sufficient magnitude to bring into use any considerable force of field artillery; and practical experience in the tactics of that arm virtually ceases with the year 1877." In another case also a note missed the revisers' eye: "engineers also serve in the seacoast defense, and have charge of the torpedo system". On the whole, though, the work of revision is well done, shows judicious selection in adding new matter and rearranging where changes seemed necessary, and will no doubt cause the book to retain its place as a military classic.

Jahrbuch fuer das Eisenhuettenwesen. (Ergänzung zu "Stahl und Eisen.") Ein Bericht über die Fortschritte auf allen Gebieten des Eisenhüttenwesens im Jahre 1903. Im Auftrage des Vereins deutscher Eisenhüttenleute bearbeitet von Otto Vogel. IV. Year. 16 + 464 p. il. 9¾ x 6½. Düsseldorf. Kommissionsverlag von A. Bagel. 1906. 10 Mk.

The present volume of this valuable reference book posseses the same characteristics as preceding ones with respect to comprehensiveness, systematic arrangement of subject matter and completeness of the extracts and references. The number of both the periodicals quoted and the references in the text has been increased. Certain headings have received most careful research, noticeable under (A), "General" and (G), "Installations." For example, particular attention has been devoted to the economics of the iron and steel industry: statistics; question of wages; relations of capital and labor, etc. Also researches pertaining to some of the allied industries in connection with foundry installations have been extended, and include such as railways and locomotives; cableways; loading arrangements, cranes and lifting magnets, condensers, steam plants, turbines and motors, heating and ventilation, etc.

As a reference book the volume undoubtedly affords abundant information on all departments of the metallurgical field, and should prove of great service to the specialist who desires to keep posted on the many recent developments in that line.

The Naval Annual, 1906. Edited by John Leyland and T. A. Brassey, A. I. N. A. 8+434 p. il. pl. 10 x 6½. Portsmouth. J. Griffin & Co. 2, The Hard. 15s net.

This volume of the *Annual*, the twentieth year of publication, contains several contributions of special interest and importance, in addition to the permanent features that characterize successive issues. Its contents are rather more varied than usual, but the volume is none the less interesting and useful in giving a faithful view of the various new questions as to systems of propulsion, relative speed, armament and distribution of armor, which are giving cause for much thought and not a little diversity of opinion among naval students.

Among the special chapters of Part I. may be mentioned first the important contribution by Mr. J. R. Thursfield on "The Attack and Defense of Commerce", in many respects the most interesting and valuable in the book. He goes into the subject very thoroughly and shows the diminished danger to shipping in the conditions of the modern sea-going trade. The chapter gains in interest due to the fact that the problem with which it is directly concerned forms part of the British naval maneuvers of this year, which are intended to test on a large scale the new scheme elaborated for the protection of trade. Mr. John Leyland completes the account of the Russo-Japanese Naval Campaign from August 10, 1904, where Admiral Sir Cyprian Bridge closed last year. He tells of the subsequent events and gives a full description of the Battle of the Sea of Japan, not attempting to enforce its many lessons but his object being "to enable naval officers to discover the lessons of Tsushima for themselves."

The remaining chapters of Part I. deal mainly with technical matters and questions of naval policy that are of public interest: the turbine, the engineering question, problem of speed, naval reserves and sea training, and gunnery practice of the Fleet. These subjects are all treated comprehensively and in an instructive manner, in some cases both sides of the question being given. A short chapter on the Italian Navy and one on the Trafalgar Centenary and its Literature are also included.

The permanent features of the volume are maintained in the chapters on the British Navy, Foreign Navies, Comparative Strength, showing the progress at home and abroad, the lists of fighting vessels of all nations, diagrams of ships, ordnance and armor, ordnance tables, statistics, etc. They preserve the standard of excellence and accuracy for which the *Annual* is noted.

Part III. on armor and ordnance is by a new writer this year (name not given) and is not given the amount of space heretofore allotted to it. Two reasons are offered in explanation: The exhaustive completeness with which the subject has been treated for many years back, and the lack of any very notable development to record, added to the difficulties found in obtaining permission to use all the information necessary for a complete treatment of the subject. The author deals with the matter briefly, therefore, but the chapters constitute a good résumé of recent developments in ordnance and armor with interesting data as to late experiments with armor and projectiles.

Technisches und tagliches Lexikon. Ein Handbuch für den Verkehr mit dem Auslande. Von Oscar Klincksieck, Fregatten-Kapitän a.D. Berlin. Boll u. Pickardt, Verlagsbuchhandlung. 1906.

This is a new technical dictionary which judging from the first part we have received 48 pages, (A—Anschlag) gives promise of being a very satisfactory work and one possessing many excellent features.

It is intended especially for officers of the army and navy, officials of the merchant marine, consuls and other officials, specialists, etc., in their intercourse with English and French speaking people. It is to include, therefore, all words and phrases relating to seamanship, the military and naval services, general technical subjects, including transportation, political and consular services, shipbuilding, commerce and mercantile affairs, etc.

The arrangement of the dictionary is strictly alphabetical according to German words, with English and French equivalents. The matter is arranged in an eminently satisfactory manner for quickness and ease of consultation. First is given the word (followed by reference to other words of similar meaning in the dictionary), then this word in connection with short sentences, then the combinations of the word with prefixes or prefixed words, and finally with suffixes or words added; the arrangement being again alphabetical in each group. A system of numerical references also aids in finding variations of meaning readily. The English and French equivalents are well rendered and are quite fully given.

The dictionary is planned to be completed in about 17 parts, each of 48 pages, price 2 marks each. A feature that is announced is a complete alphabetical index of the English and French words used in the text, which will undoubtedly add to the practical value of the work as a means of translating into German.

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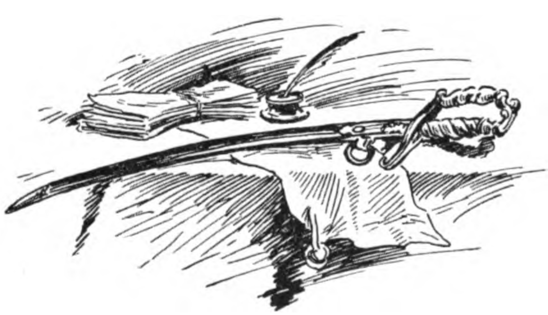

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PERIODICALS CITED

All the periodicals are preserved in the Artillery School Library, Fort Monroe, Va.
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ENGLAND.

Arms and Explosives.	[*Arms Expl.*]	*Monthly*
Effingham House, Arundel Street, Strand, London, W.C.		*Per year 7 s*
Army and Navy Gazette.	[*A. N. Gaz.*]	*Weekly*
22 Essex Street, Strand, London, W.C.		*Per year £1 12s 6d*
Canadian Military Gazette.	[*Can. Mil. Gaz.*]	*Semi-monthly*
Room 16, Trust Bldg., Ottawa, Canada.		*Per year $2.00*
The Engineer.	[*Engr. L.*]	*Weekly*
33 Norfolk Street, Strand, London, W.C.		*Per year £2 6d*
Engineering.	[*Engng.*]	*Weekly*
35-36 Bedford Street, Strand, London, W.C.		*Per year £2 6d*
The Engineering Times.	[*Engng. Times*]	*Weekly*
Orchard House, Westminster, London, E.C.		*Per year 21s 8d*
The Iron & Coal Trades Review.	[*In. Coal T. Rev.*]	*Weekly*
165 Strand, London, W. C.		*Per year 27s*
Journal of the Royal Artillery.		*Monthly*
Woolwich, England.	[*Jour. R.A.*]	*Single copy 2s 6d*
Journal of the Royal United Service Institution.		*Monthly*
Whitehall, London, S.W.	[*Jour. R.U.S.I.*]	*Per year 24s*
Journal of the United Service Institution of India.		*Quarterly*
Simla, India.	[*Jour. U.S.I. Ind.*]	*Per year $2.50*
Page's Weekly.	[*Page's Wkly.*]	*Weekly*
Clun House, Surrey Street, Strand, London, W.C.		*Per year 16s*
Photographic Journal.	[*Photo. Jour.*]	*Monthly*
66 Russell Square, London.		*Per year 12s*
Proceedings of the Institution of Civil Engineers.		
25 Great George Street, Westminster, London, S. W.	[*Proc. I.C.E.*]	
Proceedings of the Institution of Mechanical Engineers.		
Story's Gate, Westminster, London, S. W.	[*Proc. I.M.E.*]	
The Royal Engineers Journal.		*Monthly*
Chatham, England.	[*R. E. Jour.*]	*Single copy 1s*

Transactions of the Canadian Institute.
58 Richmond Street, [*Trans. Can. Inst.*]
Toronto, Canada.

Transactions of the Canadian Society of Civil Engineers.
Montreal, Canada. [*Trans. Can. Soc. C.E.*]

Transactions of the Institute of Naval Architects.
5 Adelphi Terrace, [*Trans. Inst. N.A.*]
London, W.C.

United Service Gazette. [*U.S. Gaz.*] — *Weekly*
43, 44 Temple Chambers. — *Per year £1 10s 6d*
London, E.C.

United Service Magazine. [*U. Serv. Mag.*] — *Monthly*
23 Cockspur Street, Charing Cross, — *Per year £1 1s*
London, S. W.

GERMANY.

Internationale Revue. [*Int. Rev.*] — *Monthly*
Beiheft (German) [*Int. Rev. Bhft.*] — *Per quarter 8 fr*
Supplement (French) [*Int. Rev. Suplmt.*]
Weintraubenstrasse 21, 1. Dresden-N.

Jahrbuecher fuer die deutsche Armee und Marine. — *Monthly*
Mohren Strasse, 19, [*Jahrb.*] — *Per year 24 M*
Berlin, W. 8.

Kriegstechnische Zeitschrift. [*Krg. Zeits.*] — *Ten numbers a year*
Koch Strasse, 68-71, Berlin, S. W. — *Per year 10 M*

Marine Rundschau. [*Rundschau*] — *Monthly*
Koch Strasse, 68-71, Berlin, S. W. — *Per year 8 M*

Militaer Wochenblatt. [*Mil. Woch.*] — *Semi-weekly*
Beiheft. [*Beiheft M. W.*] — *Per year 20 M*
Koch Strasse, 68, Berlin, S. W. 12.

Schiffbau. [*Schiffbau*] — *Semi-monthly*
Zimmerstr., 8, Berlin, S. W. — *Per year 20 M*

Stahl und Eisen. [*Stahl u. E.*] — *Fortnightly*
Jacobistrasse 5, Dusseldorf. — *Per year 24 M*

Ueberall. [*Ueberall*] — *Weekly*
Verlag: Boll und Pickardt, — *Per year M 23.60*
Georgenstrasse 23, Berlin, N. W.

Die Umschau. [*Umschau*] — *Weekly*
H. Bechhold Verlag, — *Per year M 21.20*
Frankfort A.M.

AUSTRIA.

Mitteilungen aus dem Gebiete des Seewesens. — *Monthly*
Pola. [*Seewesens*] — *Per year 17 M*

Mitteilungen ueber Gegenstaende des Artillerie und Genie-Wesens.
Getreidemarkt 9, [*Mitt. Art. G.*] — *Monthly*
Wien VI. — *Per year 20 M*

Organ der Militaer Wissenschaftlichen Vereine. — *8-14 numbers*
Strauchgasse No. 4 [*Organ*] — *Per year 20 K*
Wien I.

Zeitschrift des Oesterreichischen Ingenieur und Architekten Vereines.
Eschenbachgasse, No. 9. [*Zeitschr. I.A.V.*] *Weekly*
Wien I. *Per year 34 K*

FRANCE.

Le Genie Civil. [*Genie C.*] *Weekly*
6 Rue de la Chaussee d'Antin, Paris. *Per year 45 fr*

La Marine Francaise. [*Marine F.*] *Monthly*
26 Rue de Grammont, Paris. *Per year 30 fr*

Memoires et Compte Rendu des Travaux de la Societe des Ingenieurs Civils.
19 Rue Blanche, [*Memoires I.C.*] *Monthly*
Paris. *Per year 36 fr*

Memorial des Poudres et Salpetres. [*M. Poudres.*] *Semi-annually*
55 Quai des Grands-Augustins, Paris. *Per year 13 fr*

Le Monde Militaire. [*Monde*] *Fortnightly*
6 Rue de la Chaise, Paris. *Per year 7 fr 50*

Revue d'Artillerie. [*R. Art.*] *Monthly*
5 Rue des Beaux-Arts, Paris. *Per year 22 fr*

Revue de Cavalerie. [*R. Cav.*] *Monthly*
5 Rue des Beaux-Arts, Paris. *Per year 33 fr*

Revue du Cercle Militaire. [*Cercle*] *Weekly*
37 Rue de Bellechasse, Paris. *Per year 27 fr*

Revue du Genie Militaire. [*R. Genie M.*] *Monthly*
5 Rue des Beaux-Arts, Paris. *Per year 27 fr*

Revue d'Infanterie. [*R. Inf.*] *Monthly*
10 Rue Danton, Paris. *Per year 25 fr*

Revue Maritime. [*R. Maritime*] *Monthly*
30 Rue et Passage Dauphine, Paris. *Per year 56 fr*

Revue Militaire des Armees Etrangeres. *Monthly*
R. Chapelot et Cie., [*R.M. Etrang.*] *Per year 15 fr*
30 Rue et Passage Dauphine, Paris.

Le Yacht—Journal de la Marine. [*Yacht*] *Weekly*
55 Rue de Chateaudun, Paris. *Per year 30 fr*

ITALY AND RUSSIA.

Rivista di Artiglieria e Genio. [*R. Artig.*] *Monthly*
Tipografia Enrico Voghera, *Per year 20 L*
Via Astalli 15, Rome.

Rivista Marittima. [*R. Maritt.*] *Monthly*
Economo del Ministero della Marina, *Per year 25 L*
Rome.

Voyennyj Sbornik. [*Sbornik*] *Monthly*
Madezhcdinskoi Dom, No. 21, *Per year 4.80*
St. Petersburg, Russia.

NORWAY, SWEDEN, DENMARK.

Artilleri-Tidsskrift. [*Art. Tids.*] *Bi-monthly*
Artillerigarden Stockholm, Sweden. *Per year, U.S., $1.75*

Militaert Tidsskrift. [*M. Tids.*] *Bi-monthly*
Copenhagen, Denmark. *Per year, U.S., $2.50*

Norsk Artilleri-Tidsskrift [*N. Art. Tids.*] *Bi-monthly*
Christiania, Norway. *Per year $1.50*

Norsk Militaert Tidsskrift. [*N.M. Tids.*] *Monthly*
Christiania, Norway. *Per year, U.S., $2.50*

SWITZERLAND AND BELGIUM.

Allgemeine Schweizerische Militaer-Zeitung. *Weekly*
Basel, Switzerland. [*A.S.M. Zeit.*] *Per year 8 fr*

La Belgique Militaire. [*Belg. Mil.*] *Weekly*
Rue Albert de Latour 50, *Per year 12 fr 50*
Schaerbeck, Brussels.

Revue de l'Armee Belge. [*R.A. Belg.*] *Bi-monthly*
24 Rue des Guillemins, Liege, Belgium. *Per year 13 fr*

Revue Militaire Suisse. [*R.M. Suisse*] *Monthly*
23 Escaliers-du-Marche, Lausanne, *Per year 12 fr 50*
Switzerland.

Schweizerische Monatschrift fuer Offiziere Aller Waffen. *Monthly*
Frauenfeld, [*S. Monatschr.*] *Per year 5 fr*
Switzerland.

Schweizerische Zeitschrift fuer Artillerie und Genie. *Monthly*
Frauenfeld, [*S. Zeit. Art. G.*] *Per year 7 fr*
Switzerland.

SPAIN, PORTUGAL AND SOUTH AMERICA.

Annaes do Club Militar Naval. [*Ann. Club M.N.*] *Monthly*
43 Rua do Carmo, Lisbon, Portugal. *Per year $3.85*

Boletin del Centro Naval. [*Boletin*] *Monthly*
Florida 659, Buenos Aires, Argentine. *Per year $m/n 11.90*

Boletin del Ministerio de Guerra y Marina *Fortnightly*
Apartado de Correo 37 [*Bol. M.G.M.*]
Lima, Peru.

Liga Naval Portuguesa. [*Liga Nav.*] *Monthly*
95 Rua Garrett, Lisbon, Portugal. *Per year $4.50*

Memorial de Artilleria. [*M. de Art.*] *Monthly*
Museo de Artilleria, Madrid, Spain. *Per year $3.60*

Revista Cientifico-Militar. [*Cientifico*] *Semi-monthly*
Paseo de San Juan, 201, Barcelona, Spain. *Per year 40 fr*

Revista del Ejercito y Marina. [*R. Ejercito*] *Monthly*
Departamento de Estado Mayor,
City of Mexico.

Revista de Engenheria Militar. [*R. Engen. Mil.*] *Monthly*
27 Rua Nova da Almada, Lisbon, Portugal. *Per year 16 fr*

Revista General de Marina. [*R.G. Marina*] *Monthly*
Ministerio de Marina, Madrid, Spain. *Per year $4.45*

Revista de Marina. [*R. de Mar.*] *Monthly*
Casilla del Correo 976, Valparaiso, Chili. *Per year $10.00*

Revista Maritima Brazileira. [*R. Marit. Brazil*] *Monthly*
Rua Conselheiro Saraiva n. 12, *Per year $6.00*
Rio de Janeiro, Brazil.

Revista Militar. [*R.M. Brazil*] *Monthly*
Rio de Janeiro, Brazil.

Revista Militar	[*R.M. Bol.*]	*Monthly*
Colegio Militar, Avenida 12 de Diciembre, La Paz, Bolivia.		*Per year $3.00*
Revista Militar.	[*R. Mil. Por.*]	*Monthly*
262 Rua da Princeza, Lisbon, Portugal.		*Per year 2 $4.00 reis*

UNITED STATES.

American Journal of Mathematics.		*Quarterly*
Johns Hopkins University, Baltimore, Md.	[*Am. Jour. Math.*]	*Per year $5.00*
American Machinist.	[*Am. Mach.*]	*Weekly*
World Building, New York.		*Per year $3.00*
Army and Navy Journal.	[*A.N. Jour.*]	*Weekly*
93 Nassau Street, New York.		*Per year $6.00*
Army and Navy Register.	[*A.N. Reg.*]	*Weekly*
Washington, D.C.		*Per year $3.00*
Bulletin of the American Mathematical Society.		*Ten numbers per year*
University Heights, New York.	[*Bull. Am. Math. Soc.*]	*Per year $5.00*
Cassier's Magazine.	[*Cas. Mag.*]	*Monthly*
3 West 29th Street, New York.		*Per year $3.00*
Compressed Air.	[*Compr. Air*]	*Monthly*
26 Cortlandt Street, New York.		*Per year $1.00*
Electrical World.	[*Elec. World*]	*Weekly*
114-118 Liberty Street, New York.		*Per year $3.00*
Electrical Review.	[*Elec. Rev.*]	*Weekly*
13-21 Park Row, New York.		*Per year $3.00*
The Engineer.	[*Engr. C.*]	*Fortnightly*
355 Dearborn Street, Chicago, Ill.		*Per year $1.00*
Engineering Magazine.	[*Engng. Mag.*]	*Monthly*
140-142 Nassau Street, New York.		*Per year $3.00*
Engineering and Mining Journal.	[*Engng. Min. Jour.*]	*Weekly*
505 Pearl Street, New York.		*Per year $5.00*
Engineering News.	[*Engng. News.*]	*Weekly*
220 Broadway, New York.		*Per year $5.00*
The Iron Age.	[*Iron Age*]	*Weekly*
14-16 Park Row, New York.		*Per year $5.00*
Journal of the American Chemical Society.		*Monthly*
Easton, Pa.	[*Jour. Am. Chem. S.*]	*Per year $6.00*
Journal American Society of Naval Engineers.		*Quarterly*
Navy Department, Washington, D.C.	[*Jour. A.S.N.E.*]	
Journal of the Association of Engineering Societies.		*Monthly*
31 Milk Street, Boston, Mass.	[*Jour. Engng. Socs.*]	*Per year $3.00*
Journal of the Association of Military Surgeons.		*Monthly*
Carlisle, Pa.	[*Jour. Mil. Surg.*]	*Per year $3.00*
Journal of the Franklin Institute.		*Monthly*
Philadelphia, Pa.	[*Jour. Frank. Inst.*]	*Per year $5.00*

Journal of the Military Service Institution. *Governors Island, New York.*	[*Jour. M.S.I.*]	*Bi-monthly* *Per year $3.00*
Journal of the U.S. Cavalry Association. *Fort Leavenworth, Kan.*	[*Jour. U.S. Cav.*]	*Quarterly* *Per year $2.00*
Journal of the U.S. Infantry Association. *1800 F Street, N. W., Washington, D. C.*	[*Jour. U.S. Inf.*]	*Quarterly* *Per year $3.00*
Journal of the Western Society of Engineers. *1734 Monadnock Block, Chicago, Illinois.*	[*Jour. W. Engrs.*]	*Bi-monthly* *Per year $3.00*
Machinery. *66 West Broadway, New York.*	[*Mach.*]	*Monthly* *Per year $2.00*
Marine Review. *Cleveland, Ohio.*	[*Mar. Rev.*]	*Weekly* *Per year $3.00*
Mines and Minerals. *Scranton, Penn.*	[*Mines & Min.*]	*Monthly* *Per year $2.00*
Pennsylvania Magazine of History and Biography. *13 Locust Street, Philadelphia.*	[*Penn. Mag.*]	*Quarterly* *Per year $3.00*
Physical Review. *66 Fifth Avenue, New York.*	[*Phys. Rev.*]	*10 numbers per year* *Per year $5.00*
Popular Science Monthly. *Sub-station 84, New York City.*	[*Pop. Sc. Mo.*]	*Monthly* *Per year $3.00*
Popular Mechanics. *Journal Building, Chicago, Ill.*	[*Pop. Mech.*]	*Monthly* *Per year $1.00*
Proceedings American Institute of Electrical Engineers. *95 Liberty Street, New York.*	[*Proc. A.I. Elec. E.*]	*Monthly.* *Per year $5.00*
Proceedings of the American Philosophical Society. *104 South Fifth Street, Philadelphia, Pa.*	[*Proc. Am. Phil. S.*]	
Proceedings of the American Society of Civil Engineers. *220 West 57th Street, New York.*	[*Proc. A.S.C.E.*]	*Monthly*
Proceedings of the Engineers' Club of Philadelphia. *1122 Girard Street, Philadelphia, Pa.*	[*Proc. Eng. C. Phila.*]	*Quarterly* *Per Vol. $2.00*
Proceedings of Engineers Society of Western Pennsylvania. *410 Penn Ave., Pittsburg, Pa.*	[*Proc. Engrs. Soc.*]	*Monthly* *Per year $5.00*
Proceedings of the U. S. Naval Institute. *Annapolis, Md.*	[*Proc. Naval Inst.*]	*Quarterly* *Per year $3.50*
Review of Reviews. *13 Astor Place, New York.*	[*R. of Revs.*]	*Monthly* *Per year $2.50*
The Scientific American. *361 Broadway, New York.*	[*Scien. Amer.*]	*Weekly* *Per year $3.00*
Shooting and Fishing. *150 Nassau Street, New York.*	[*S. & Fish.*]	*Weekly* *Per year $3.50*

Technology Quarterly. [*Tech. Quart.*] *Quarterly*
Mass. Inst. of Tech., Boston, Mass. *Per year $3.00*

Transactions of the American Society of Civil Engineers.
220 West 57th Street, New York. [*Trans. A.S.C.E.*]

Transactions American Institute of Mining Engineers.
99 John Street, New York [*Trans. A.I. Min. E.*]

Transactions of the American Society of Mechanical Engineers.
12 West 31st Street, New York. [*Trans. A.S. Mech. E.*]

Transactions of the Society of Naval Architects and Marine Engineers.
12 West 31st Street, New York. [*Trans. N.A.M. Engrs.*]

Western Electrician. [*West. Elect'n.*] *Weekly*
510 Marquette Building, Chicago, Ill. *Per year $2.00*

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Exchange and Book Notices.

Beginning with the issue for January 6, 1906, the **Electrical World and Engineer** and the **American Electrician** are consolidated in one weekly appearing under the title "Electrical World," thus merging in one journal two of the foremost weekly and monthly electrical periodicals of the world. The publishers in their announcement acknowledge the cordial co-operation of those who have contributed so largely to the success of the two component journals, and with the larger opportunities now offered feel that they will be enabled more than ever to make the consolidated paper not only an essential factor in influencing electrical development, but absolutely indispensable to every progressive man in the field.

The following course of lectures in Mathematical Physics will be given at Columbia University, City of New York, by Hendrik Antoon Lorentz, Professor of Mathematical Physics in the University of Leiden—Lecturer in Mathematical Physics in Columbia University, 1905–6:

1. "The Theory of Electrons and its Application to the Phenomena of Light and Radiant Heat."
2. "General Principles; Theory of Free Electrons."
3. "Emission and Absorption of Heat."
4. "The Zeeman Effect. Propagation of Light in Ponderable Bodies."
5. "Optical Phenomena in Moving Systems."

The Lorentz lectures will be open without charge to teachers and advanced students in Physics.

Professor Joseph Larmor of Cambridge and Professor O. Lummer of Breslau have been invited to deliver the courses for 1906–7.

Any further details may be learned upon application to the Department of Physics.

Recent numbers of the **Aldershot Military Society Lectures** are the following:

No. 86. **Imperial Strategy.** By Colonel G. G. Aston, C.B., D.A.A.G., Staff College, Camberley.

No. 87. **Cavalry.** By Major-General H. J. Scobell, C.B., commanding First Cavalry Brigade.

We have received the first number of a new periodical, **Zeitschrift fuer das Gesamte Schiess- und Sprengstoffwesen,** which bids fair to be of great value and interest in its particular field. The developments in the manufacture of powders and explosives have become so numerous and interesting that the time seems propitious for having a publication devoted especially thereto, which shall serve as a central organ for all information and details relating to the subject. It is intended that the paper shall be international in character, including articles in the German, French and English languages; though naturally it is mainly German. It will treat not only of the manufacture and tests of powders and explosives but also will be devoted to their employment, in mining, blasting, naval and military applications, sport, pyrotechnics, etc.

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[Periodicals of December, 1905, January 1906.]

The Editor is Dr. Richard Escales of Munich, and his colloborators include the names of Bergmann, Bichel, Cranz, Gody, Lunge, Will, Sy, among many others.

The Zeitschrift appears twice a month; subscription per year, Mk. 26. Address, J. F. Lehmann's Verlag, Munich, Germany.

New Books

Der Schraubenverschluss mit plastischer Liderung und der Keilverschluss mit Hulsenliderung fur Geschutze. von J. Castner. 32 p. il. 11½ x 8¼. Berlin. Schiffbau, G. m. b. H. 1906. 1 Mk.

The Pressure of Explosives; Experiments on Solid and Gaseous Explosives. By J. E. Petavel. Reprint from the Proceedings of the Royal Society. London. Dulau & Co. 1905.

L'artillerie japonaise. Par M. C. Curey, capitaine d'artillerie. Paris. Berger-Levrault et Cie. 1905. 3 fr.

Schiessversuche mit einem neuen brisanten Sprengstoffe, angestellt in Schweden, 1903-1905. Von Andreas Holmgren. 14 p. il. 8¾ x 5¾ Stockholm. 1906.

Criteri d'impiego e metodi di condotta del fuoco seguiti dalle artiglierie da compagna dei due eserciti belligeranti nella guerra russo-giapponese. Luigi Giannitrapani, capitano d'artiglieria. 36 p. 9x5. Rome. Enrico Voghera. 1905.

The How and Why of Electricity. By Charles T. Child. Ed. 2 rev. New York. Electrical Review Publishing Co. 1906. $1.00.

The Siege of Port Arthur. By D. H. James. London. T. F. Unwin. 1905. 10s. 6d.

The Great Siege. The Investment and Fall of Port Arthur. By B. W. Noiregaard. London. Methuen & Co. 1906. 10s. 6d.

With Togo. The Story of Seven Months' Active Service Under His Command. By H. C. S. Wright. London. Hurst & Blackett. 1905. 10s. 6d.

Wedge fermeture, Ehrhardt system.—**Krg. Zeits.**, 10, 1905.
New high-power 15 cm. gun for the Reina Regente (system G. de Rueda).—**R.G. Marina**, February.
Development in naval artillery and armor.—**Seewesens**, 2, 1906.
The drawing of cartridge-cases for quick-firing guns.—**Mach.**, January; **Iron Age**, December 28; **Genie C.**, January 13.
Report of the Chief of Ordnance.—**Iron Age**, December 21.
Improved form of electric exploder for blasting.—**Engng. News**, January 25.
Battery commander's correction dial.—**Jour. R.A.**, December.
Small instrument for determining overs and shorts from the tug in coast artillery fire.—**R. Artig.**, October.
Particular form of slide rule (for artillery purposes).—**Jour. R.A.**, January.
Laying apparatus of the Russian field artillery.—**Mitt. Art. G.**, 12, 1905.
Barr and Stroud range finder.—**Art. Tids.**, 6, 1905.
Experimental automatic sight for field artillery.—**Krg. Zeits.**, 10, 1905.
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Shortening of the sight stem in telescopic sights.—**S. Zeit. Art. G.**, February.

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Present day developments in aerial navigation.—**S. Zeit. Art. G.**, February.
New experiments with the Lebaudy airship.—**Genie C.**, December 9.
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Proposed solution of the problem of flight.—**Scien. Amer. Suplmt.**, February 10.
Military ballooning.—**A.N. Gaz.**, January 27.
Notes on the use of military balloons.—**R.M. Suisse**, January.
Automobile engines considered from the operative point of view.—**Engng. Mag.**, January.
The armored automobile.—**A.S.M. Zeit.**, December 9.
The bicycle in the great European armies.—**Ueberall**, 12.
Automobiles.—**Scien. Amer.**, January 13 (special automobile number with many illustrations).
Motor car progress in France.—**Engr. L.**, December 29, January 5, 19.
Motor tractors for the war office.—**Engr. L.**, January 26.
Armored automobiles.—**Mitt. Art. G.**, 12, 1905.
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Ballistic effects of smokeless powders in guns.—**M. de Art.**, December.
Some problems in interior ballistics.—**S. & Fish.**, January 4.
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The independent line of sight for field guns.—**S. Zeit., Art. G.**, January.
Lessons on firing.—**R. Ejercito**, February.
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Field artillery fire.—**M. de Art.**, December.
Appreciation of distances; reconnaissance of objectives and of the ground.—**M. de Art.**, December.
Devices for measuring the angle of site.—**R. Art.**, December.
Note on various means capable of being used by artillery observers (observation of fire, etc.).—**R. Artig.**, December.

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Manufacture of nitrates by artificial nitre beds.—**Genie. C.**, December 9.
Report of the International Committee on atomic weights, 1906.—**Jour. Amer. Chem. Soc.**, January.
Rondinella's photo-printing machine.—**Jour. Frank. Inst.**, January.
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New application of photography for ballistic purposes.—**Krg. Zeits.**, 10, 1905.

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Provisional drill regulations for the Italian infantry.—**R.M. Etrang.**, January.
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New Italian field regulations.—**Mil. Woch.**, 4, 1906.
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On the theoretical examination of practice firing.—**Mitt. Art. G.**, 12, 1905.
Impressions of a foreign cavalry officer (instruction and training).—**A.N. Reg.**, December 30.
Competition results (Sea Girt; small arms).—**Jour. U.S. Cav.**, January.
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Military equitation; methods of instruction applicable to two years' service.—**R. Cav.**, November.
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Musketry : a few notions.—**U.S. Serv. Mag.**, January.
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A world's record (target of H. M. S. King Edward VII).—**A.N. Jour.**, December 23.

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Resonance in wireless telegraph circuits.—**Phys. Rev.**, December.
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New Massie space-telegraph system.—**West. Elect'n**, January 13.
Auxiliary telephone circuits.—**West. Elect'n**, January 20.
Wireless telegraphy in Switzerland.—**S. Zeit. Art G.**, January.
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Review of wireless telegraphy.—**Elec. Rev.**, January 13, 20.
Influence of the earth in wireless telegraphy.—**Elec. Rev.**, January 27.
Wireless telegraphy.—**M. Tids.**, January 1.
High potential discharges.—**Scien. Amer.**, January 27.
New electrical speed recorder.—**Jour. A.S.N.E.**, November.
Influence of electricity on power engineering.—**West. Elect'n**, December 30.
Electrical progress in 1905.—**West. Elect'n**, January 6.
Electrical engineering in 1905.—**Engr. L.**, January 5.
Applications of electricity in the Royal Gun Factory.—**Page's Wkly**, December 1.
Electricity in shipbuilding yards.—**Page's Weekly**, January 5.
Exposed circuit wiring.—**Elec. World**, January 6.
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Systems of electric motor driving.—**In. Coal T. Rev.**, December 8.
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Faults in induction motors.—**Engr. C.**, February 1.
A self-exciting alternator.—**Proc. A.I. Elec. E.**, January.
Starting alternating-current motors at full torque.—**West. Elect'n**, December 16.
Automatic control of rotary converters.—**West. Elect'n**, January 20.
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Changes and improvements in the Edison nickel-iron storage cell.—**Scien. Amer.**, January 27.
Deterioration in storage batteries.—**West. Elect'n**, February 10.
Storage batteries and their application to public institutions.—**Engng. Times**, January 18, 25.

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Boiler-house economy.—**In. Coal T. Rev.**, December 8; **Page's Wkly**, December 29.
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Classification and peculiarities of steam turbines.—**Jour. A.S.N.E.**, Nov.
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Attachment of turbine blades.—**Engng.**, December 15.
Tests of De Laval steam turbine.—**Engng.**, December 29.
Notes on steam turbines.—**Engng.**, January 5.
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Application of steam turbines to the propulsion of ships.—**Umschau**, December 9.
Government tests of lubricating oils.—**Iron Age**, January 25.
Treatment of water for steam purposes.—**Engr. C.**, December 15; **Engng. Times**, January 18.
Flow of steam through nozzles.—**Engng.**, Eebruary 2.
Power plants economics.—**Proc. A.I. Elec. E.**, January; **West. Elect'n**, February 3, 10.
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Comparison between torpedo boat and merchant marine engines.—**Scien. Amer.** Suplmt, February 10.
Liquid fuel for naval and marine purposes.—**Scien. Amer.** Suplmt, February 10.
Efficiencies.—**Elec. Rev.**, December 30; **West. Elect'n**, January 13; **Engng. Times**, January 25.
New developments in steam engine and motor construction.—**Mitt. Art. G.**, 12, 1905.
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Forms of concrete reinforcement.—**Iron Age**, January 11.
Testing of cast iron and other materials by the Ewing permeability bridge.—**Page's Wkly**, December 29.
Safe working strength of wire ropes.—**Engr. C.**, January 1.
Retempered mortar in concrete work.—**Engng. News**, January 11.
Design of high abutments.—**Engng. News**, January 11.
Power scraper for grading and excavating.—**Engng. News**, February 1.
Sea defenses (protection of shores).—**Page's Wkly**, December 1.
Structural steel dams.—**Page's Wkly**, January 5.

Mixing concrete.—**Engng. Min. Jour.**, January 20.
Shaft sinking in quicksand.—**Engng. Min. Jour.**, January 20.
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Experiments on the manufacture of white portland cement.—**Engng. News**, December 28.
Hair cracks, crazing or map cracks on concrete surfaces.—**Engng. News**, December 28.
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Types of modern dam construction.—**West. Elect'n**, December 23.
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Notable American railway bridges.—**Cas. Mag.**, January.
Experiments on road surfaces.—**R.E. Jour.**, January.
Recent improvements in piles.—**Engr. L.**, January 19, 26.
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Armored concrete.—**Scien. Amer.** Suplmt, February 10.
Behavior of materials of construction under pure shear.—**Engr. L.**, December 29; **Engng.**, December 22; **In. Coal T. Rev.**, December 22; **Page's Wkly**, December 22.
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Action of sea-water upon concrete.—**Engng.**, January 5.
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Attack and defense of Antwerp; siege of Port Arthur.—**Belg. Mil.**, December 17.
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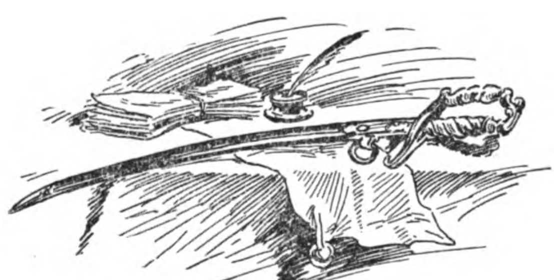

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ARTILLERY MATERIAL.

Exchange and Book Notices

Amongst the papers on electrical subjects indexed in this issue will be found some contained in recent numbers of the **Electric Journal**, a monthly periodical which has been added to the list of "periodicals cited" published with our January-February issue. The **Electric Journal** is composed almost entirely of original articles written by practical engineers, and which are not found in any other publication: a journal for young engineers, containing material suited to their needs and written in a form to meet their education and experience. Begun in January, 1904, it at once met with gratifying success, and the standing it has now secured is strong testimony that it has met a real need among many classes of electrical engineers.

The Electric Journal. [*Elec. Jour.*] *Monthly*
422 Sixth Avenue, Pittsburg, Pa. *Per year $1.50*

We cordially welcome the appearance of a new military periodical devoted to artillery matters,—**The Canadian Artillerist**, the Journal of the Canadian Artillery Association. The Staff of the Royal School of Artillery at Kingston has undertaken the publication of this journal to assist in carrying out the object of the Association, which is the development of gunnery skill and the dissemination of artillery knowledge throughout the Dominion of Canada with a view to the attainment of the greatest efficiency by the field and garrison artillery.

The journal is a well printed pamphlet of from 75 to 100 pages, with illustrations, and its contents give promise of fulfilling the object of the Association.

We offer it our best wishes for a long and prosperous life.

The Canadian Artillerist. [*Can. Artillerist*] *Quarterly*
Royal School of Artillery, Kingston, Ontario. *Single copy, 25 cents*

Die militaerische Welt, is another new military periodical, the first number of which—that for April 1906—we greet with this issue. It is an illustrated monthly, published in Vienna. In answer to the query as to the necessity for such a publication, the editor explains that Austro-Hungarian military publications are either official and technical or published by civilians and limited to particular interests. None appeal in a general, popular way to the people at large. "Die militaerische Welt" will undeavor to cover this field. It will contain short papers on all military questions, including field service, tactics, military geography and recent history, etc., of interest to all, and especially reserve officrs, who may wish to keep posted on recent developments and progress in general military matters. There is also a department of literature, including short stories, tales, and military biography. It is published by C. W. Stern, Verlagsbuchhandlung, Wien, I. Franzensring 16. Subscription price, 12 Kronen per year.

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AUTOMOBILES, AEROSTATION.

The balloon in warfare.—**U.S. Gaz.**, February 15.
Von Zeppelin's dirigible airship.—**Scien. Amer.**, March 3.
Some recent foreign flying machines.—**Scien. Amer.**, March 24.
The Lebaudy airship.—**R. Artig.**, December.
Road tractors.—**Ueberall**, 23.
New armored war automobiles.—**Scien. Amer.**, March 17.
Problems in motor-cars.—**Engng.**, February 16.
Automobile construction.—**Am. Mach.**, December 21, 28, January 4, February 8. 15.
Armored machine-gun automobile.—**R. Artig.**, January.
Future of the automobile.—**Cas. Mag.**, March.

BALLISTICS, RANGE FINDING AND POINTING.

Remarks on the experimental determination of the acceleration of the velocity of projectiles.—**Mitt. Art. G.**, 1, 1906.
New treatment of and new formulas of exterior ballistics of ogival projectiles.—**A.S.M. Zeit.**, December 30, March 3.
Effects of time-fuze fire.—**R. Ejercito**, March.
Density of the air.—**R.M. Bol.**, February.
Ballistics of ball and shot guns.—**S. & Fish.**, March 15.
The ballistic coefficient.—**Arms & Expl.**, February.
Dimensions of target for a given number of hits.—**Mitt. Art. G.**, 2.
An examination into the development of powder.—**Rundschau**, February.
Question of twist of rifling in naval guns.—**Seewesens**, 1.
Tables for calculating the power of penetration of armor-piercing projectiles.—**Boletin**, December.
Firing against balloons.—**Mil. Woch.**, 18.
Lessons on firing.—**R. Ejercito**, March.
The director (for aiming and laying field guns).—**Jour. R.A.**, March.
Indirect fire.—**Jour. U.S. Cav.**, April.
Note on the measurement of ranges with vertical base instruments, coast batteries.—**R. Artig.**, January.

CHEMISTRY, PHOTOGRAPHY.

Role of organic matter in nitrification.—**Genie C.**, March 10.
Nitrates from the air.—**Elec. Rev.**, March 24.
Artificial production of nitrates from the atmosphere.—**Engr. L.**, March 16.
Manufacture of artificial nitrates.—**Engng. Mag.**, April.
Electrical manufacture of nitrates in Norway.—**Elec. Rev.**, March 10.
The new heat test (explosives).—**Arms & Expl.**, March.
Report of the Committee on atomic weights.—**Jour. Am. Chem. Soc.**, March.
Novel blue printing apparatus.—**Mach.**, February.

A new technical index of value in the metallurgical field is the **Zentralblatt fur Eisenhuettenwesen,** edited by Dr. Fritz Bennigson, Berlin. This presents in classified form short references on all papers and articles pertaining to the iron and steel industry and allied subjects, appearing in the technical press throughout the world. A list of the important patents granted, and notices of new books are also added. A department will also be devoted to questions and answers and discussions. Published by the Berliner Union Verlagsgesellschaft m.b.H., Berlin W. 35; monthly, subscription price, Mk. 24.

Messrs Gale & Polden Ltd., have brought out new editions of the following manuals:

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Physical Drill with Arms made Easy, and Bayonet Fighting—giving many examples, with illustrations, of exercises similar to those of our Butt's manual, and of bayonet exercises.

The Soldier's Score Book for U. S. magazine rifle, model 1903, is the title of a convenient little book for keeping record of shots fired in rifle practice. It is designed and arranged by Captain Edgar T. Conley, 8th U. S. Infantry. About 55 pages are blank forms for the various kinds of fire; they show the targets, and suitable spaces are given for recording all information connected with the practice that may be of future use. Besides the score sheets the book contains several pages of useful information and pertinent suggestions to the marksman. These books are prepared for either the Springfield or Krag rifle, and are published by the Franklin Hudson Publishing Co., Kansas City, Mo. The price is thirty cents postpaid.

DRILL REGULATIONS, MANEUVERS AND PRACTICE.

New firing regulations for the Russian field artillery.—**R. Artig.**, November; **Mil. Woch.**, 28.
New field service regulations, English army.—**Mil. Woch.**, 15, 16.
The new infantry bullet and changes in the firing regulations.—**Ueberall**, 21.
Firing regulations for the Swiss infantry, 1905.—**S. Monatschr.**, February, March.
Outline of new drill regulations for the Swiss infantry.—**S. Monatschr.**, Feb.
The new German firing regulations.—**S. Monatschr.**, February, March.
The drill regulations.—**Mil. Woch.**, 24.
Critical study on the English Combined Training.—**R. Inf.**, February, March.
Proposed drill regulations for Colt's automatic machine gun cal. .30.—**Jour. U.S. Cav.**, April.
Remarkable new drill regulations for the French infantry.—**Jour. U.S. Inf.**, April.
The Kaiser-maneuvers in Germany, September, 1905.—**Jour. R.U.S.I.**, Feb.
Employment of infantry cyclists in the autumn maneuvers, 1905.—**A.S.M. Zeit.**, December 2.
Austro-Hungarian maneuvers, 1905.—**R. Ejercito**, March.
Maneuvers of the II. army corps, 1905.—**R.M. Suisse**, March.
The grand maneuvers of 1905.—**R. Inf.**, March.
Imperial German maneuvers in 1905.—**R.M. Etrang.**, February, March; **S. Monatschr.**, March.
Warlike maneuvers.—**A.S.M. Zeit.**, January 13.
Small maneuvers.—**Jour. U.S. Inf.**, April.
Chinese grand maneuvers, 1905.—**Mil. Woch.**, 10; **A.S.M. Zeit.**, February 10.
Army mobilization (maneuvers at Fort Sam Houston).—**A.N. Reg.**, Feb. 17.
Grand English naval maneuvers for 1906.—**A.S.M. Zeit.**, February 17.
Maneuvers of the English fleet.—**Ueberall**, 23.
Naval maneuvers.—**A.N. Gaz.**, February 17.
Maneuvers of the reinforced French Mediterranean fleet, 1905.—**Seewesens**, 1.
Coast artillery practice (allowance and cost).—**A.N. Reg.**, February 17.
Service class firing.—**Jour. R.A.**, March.
The war game applied to coast artillery fire.—**R. Art.**, February.
Field artillery practice against balloons.—**Mil. Woch.**, 11, 1906.
Firing practice of the coast artillery.—**R. Artig.**, November.
Service of artillery in the field.—**R. Ejercito**, March.
Graphical method of analysing coast defense practice reports.—**Jour. R.A.**, March.
Importance of the war game in the training of cavalry officers.—**Mil. Woch.**, 6, 1906.
Forced marches and endurance marches of a detachment of scouts.—**R. Cav.**, February.
Short term service and the preparation of cavalry for war.—**R. Cav.**, Feb.
Promotion of individual training in the infantry.—**Mil. Woch.**, 11, 1906.
Infantry cyclists in the maneuvers of the II. corps, 1905.—**R.M. Suisse**, March.
Marching of the French infantry.—**Jour. U.S. Inf.**, April.
Company rifle firing.—**Jour. U.S. Inf.**, April.
Instruction on infantry fire, Germany.—**R. Inf.**, February, March.
Target pistol shooting.—**Jour. U.S. Inf.**, April.

Hythe Musketry Course Made Easy, one of Gale & Polden's Military Series, contains a large amount of information in concise form on instruction in care of arms, instruction in aiming and firing, judging distance and observation of fire, with questions and answers and useful hints on various subjects connected with rifle practice. Will be found useful by riflemen. Price 1s.

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Training of the soldier.—**Mil. Woch.**, 27.
Physical culture and training in the army.—**Jour. U.S. Inf.**, April.
Target practice, American navy.—**R. Marit. Brazil**, December.

ELECTRICITY.

Experiments with wireless telegraphy for military purposes, Switzerland.—**A.S.M. Zeit.**, January 13.
First trials of wireless telegraphy.—**R.M. Brazil**, January.
Wireless telegraphy in southwest Africa.—**Scien. Amer.**, March 17.
Some novel developments in wireless telegraphy.—**Scien. Amer.**, March 17.
Progress in space telegraphy.—**Engng. Mag.**, February.
Telephone engineering.—**West. Elect'n**, March 3, 10, 17; **Elec. Rev.**, March 3, 10; **Elec. Jour.**, March.
Roussel's system of typewriting telegraphy.—**West. Elect'n**, March 17.
Orling-Armstrong system of wireless telegraphy and telephony.—**Elec. World**, December 30.
Transmitting distance in wireless telegraphy.—**Elec. World**, February 10.
Barclay printing telegraph.—**Elec. World**, February 24.
Review of telephone patents issued in 1905.—**Elec. Rev.**, February 3, 10.
Specifications for line wire.—**Elec. Rev.**, February 17.
Telephone system of the future,—the semi-automatic.—**Elec. Rev.**, March 10.
Regulation of wireless.—**Elec. World**, March 3.
Wireless telegraphy.—**Jour. R.A.**, March.
Wireless telegraphy by means of kites.—**Elec Rev.**, April 7.
Experiments on resonance in wireless telegraph circuits.—**Phys. Rev.**, March.
New types of electric lamps.—**In. Coal T. Rev.**, February 16.
Manufacture of arc lamp carbons.—**In. Coal T. Rev.**, March 16.
The field of electric direct-current service.—**Cas. Mag.**, April.
New German metallic-filament lamp.—**West. Elect'n**, March 3; **Elec. World**, February 17.
Wiring with wooden mouldings.—**Elec. World**, February 3.
New filament lamp.—**Elec. Rev.**, March 3.
Manufacture of incandescent lamps.—**Elec. Rev.**, March 10.
Conduit wiring for electric installations.—**Elec. Rev.**, March 17.
Cable splicing.—**Elec. World**, March 3.
Fuses.—**Elec. Jour.**, March.
Utilization of electricity in coast defense.—**Elec. World**, March 24.
Wiring with flexible conduit and armored cable.—**Elec. World**, April 7.
Protective apparatus.—**Elec. Jour.**, March.
Calculation of the flow of magnetic induction across any solenoid.—**R. Artig.**, November.
Measurement of currents of high frequency and of electric waves.—**R.G. Marina**, March.
Some recent electrical measuring instruments.—**Page's Wkly**, March 2.
Adjustment of the D'Arsonval galvanometer for ballistic work.—**West. Elect'n**, March 17.
International electrical units.—**West. Elect'n**, March 31; **Elec. World**, March 24.
Iron-cored alternate-current instruments.—**Elec. Rev.**, February 24; **Elec. World**, March 10.
Paper versus rubber insulation for electrical cables.—**Engng. News**, March 15.

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Field Artillery Training, 1906. Official. London. Harrison & Sons. 1906, 1s.

Les progres de l'artillerie de campagne moderne, par le général Rohne. Traduit de l'allemand par E. Frique, lieutenant-colonel d'artillerie. 86 p. O. Paris. Berger-Levrault & Cie. 1905. 2 fr. 50.

Influence du bouclier sur le developpement du materiel de campagne et sur la tactique de l'artillerie, par le général von Reichenau. Traduit de l'allemand par le capitaine L. Fossat. 75 p. O. Paris. Berger-Levrault & Cie. 1905. 2 fr.

Der mechanische Zug mittels Damp-Strassenlokomotiven. Seine Verwendbarkeit fuer die Armee im Kriege und im Frieden. Von Otfried Layriz, Oberstleutnant z.D. 77 p. 29 il. 6 pl. 9½ x 6. Berlin. E. S. Mittler und Sohn. 1906. Mk. 2.

Electric Wiring Diagrams and Switchboards. By Newton Harrison, instructor of electrical engineering in the Newark Technical School. 272 p. T. New York. Norman W. Henley Publishing Co. 1906. $1.50.

The Wiring Hand-book. By Cecil P. Poole. 85 p. 61 il. 8 x 4½. The McGraw Publishing Co. New York. 1906. $1.00.

Standard Telephone Wiring. By James F. Fairman. 91 p. 74 il. 7 x 4½. New York. McGraw Publishing Co. 1906. $1.00.

Care and Management of Electric Power Plants. Revised edition. By Norman H. Schneider. 290 p. 205 il. 7½ x 5. New York. Spon & Chamberlain. 1906. $1.50.

Electric Power Transmission. By Louis Bell. Ed. 4. 722 p. 9 x 6½. New York. McGraw Publishing Co. $4.00.

The Management of Accumulators. A Practical Handbook. By Sir David Salomons. Ed. 9. rev. 174 p. 38 il. 7½ x 5. New York. D. Van Nostrand Co. 1906. $2.50.

Seymour Vandeleur: The Story of a British Officer. Being a memoir of Brevet-Lieutenant-Colonel Vandeleur, D.S.O., Scots guards and Irish Guards, with a general description of his campaigns. By Colonel F. I. Maxse, C.B., D.S.O., Coldstream Guards. il. Maps. 10 x 7. New York. Longmans, Green & Co., 1906. $4.00.

Organization and Tactics. By Arthur L. Wagner, late Colonel, Military Secretary's Department, General Staff, U. S. A. Ed. 7. 20+393 p. 8¾ x 6. Kansas City, Mo., Franklin Hudson Publishing Co. 1906.

Five Years a Dragoon, and other adventures of the Great Plains. By Percival G. Lowe. 417 p. 8 x 6. Kansas City, Mo. Franklin Hudson Publishing Co. 1906.

The Russo-Japanese War. Japanese Official Reports, complied by M. Kinai. Vol. I. 7½ x 5. The Shimbashido, Tokyo, Japan.

Les flottes de combat en 1906. Par le commandant de Balincourt. Ed. 5. 984 p. 408 il. S. Paris. Berger-Levrault & Cie. 1905. 6. fr.

Balancers.—**Elec. Rev.**, March 10.
Deflection potentiometers.—**Elec. World**, March 17.
Electrical terminology.—**Elec. World**, March 17.
General Electric oscillograph.—**Elec. World**, March 17.
Distribution of magnetic induction and hysteresis losses in armatures.—**Elec. Rev.**, April 7.
Winding of direct-current armatures.—**Elec. Jour.**, January.
Induction in transmission circuits.—**Elec. Jour.**, February.
How to make a slide rule for wiring calculations.—**Elec. Jour.**, February.
Electrochemical calculations.—**Jour. Frank. Inst.**, February, March.
Capacity of mica condensers.—**Phys. Rev.**, February.
Half a decade of progress in electricity and magnetism.—**Cas. Mag.**, Feb.
Electricity in the foundry.—**Cas. Mag.**, March.
Speed characteristics and the control of electric motors.—**Engng. Mag.**, April.
Some features affecting the parallel operation of synchronous motor-generator sets.—**Proc. A.I. Elec. E.**, March ; **Elec. Rev.**, March 31.
Repulsion induction motors.—**Proc. A.I. Elec. E.**, February.
Single phase motor for general power purpose.s—**West. Elect'n**, March 3.
A self-exciting alternator.—**West. Elect'n**, March 17 ; **Elec. World**, February 10 ; **Elec. Rev.**, February 24.
Variable-speed operation of induction motors.—**West. Elect'n**, March 24.
New methods for motor control.—**West. Elect'n**, March 31.
Cooper-Hewitt single-phase converter.—**Elec. World**, February 10.
The magnetism in induction motors.—**Elec. World**, February 24.
Winding faults in induction motors.—**Engr. C.**, February 15.
Self-exciter alternators.—**Elec. Rev.**, February 17.
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Mercury arc rectifier for charging storage batteries.—**Scien. Amer.**, Feb. 17.
Some points relating to storage batteries and boosters.—**Elec. Rev.**, Feb. 3.

ENGINES, BOILERS, MECHANISM.

New type of marine fire-tube boiler.—**Mar. Rev.**, March 1.
Boiler compounds.—**Engng. Times**, March 8.
Boiler efficiency tests.—**Elec. World**, March 3.
Boiler house economy.—**Cas. Mag.**, March.
Gas engines as applied to electric driving.—**Engr. L.**, February 16.
Heat and internal combustion motors.—**Rundschau**, March.
Action of the cylinder walls in internal combustion engines (abstraction of heat, effect, etc.).—**Memoires I.C.**, November.
Efficiency of the gas engine.—**Scien. Amer.**, March 24.
Rankin Kennedy system of magneto ignition (for internal combustion engines).—**Engng.**, February 16.
The gas turbine.—**Engng. Mag.**, February.
Formulas and constants for gas engine design.—**Mach.**, February.
Combustion engines.—**Engr. C.**, February 15.

"Union" steam turbine.—**Genie C.**, March 3.
Development of the steam turbine.—**Page's Wkly**, February 16.
Zoelly steam turbine.—**Page's Wkly**, March 16.
Determination of the principal dimensions of the steam turbine with especial reference to marine work.—**Jour. A.S.N.E.**, February.
Test of a Curtis marine turbine.—**Jour. A.S.N.E.**, February.
Turbines.—**Ann. Club M.N.**, January.
Willis-Parsons turbines.—**Mach.**, March.
Steam consumption of reciprocating engines.—**Elec. World**, February 17.
The steam turbine situation.—**Elec. Jour.**, January.
The Kerr steam turbine.—**Am. Mach.**, January 18.
Internal combustion engines and steam engines applied to navigation.—**R. Maritime**, January.
Elastic connection of rotating masses and its influence on the mode of regulation of motors.—**Zeitschr. I.A.V.**, March 9.
Effect of admission pressure on the economy of steam turbines.—**Engng.**, March 2, 9.
Power house economies.—**Cas. Mag.**, April.
Investigation of the pressures upon the main bearings and crank pins of marine engines.—**Jour. A.S.N.E.**, February.
Suggestions for the care and operation of naval machinery in the engineer department, U.S.N.—**Jour. A.S.N.E.**, February.
Development of the application of steam turbines to the propulsion of ships.—**Memoires I.C.**, January.
Prime mover of the future.—**Jour. W. Engrs.**, February.
History of the marine turbine.—**Mach.**, February.
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New method of power production.—**R.E. Jour.**, March.
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Forced lubrication of small warship engines.—**Engr. L.**, March 9.
Engineering value of lubricating oils.—**In. Coal T. Rev.**, March 16.
Compound air compression.—**Am. Mach.**, February 1.
Balancing at high speeds.—**Am. Mach.**, February 22.
Speed-change gears.—**Am. Mach.**, February 15.
New steam valves.—**Engr. L.**, February 23.
Worm contact.—**Page's Wkly**, February 2.
Variable speed mechanisms.—**Mach.**, March.

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Resistance of materials to shear.—**Engng. Mag.**, February.
Report of test on a portland cement plant.—**Jour. W. Engrs.**, February.
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Note on the summation of stresses in certain structures.—**Am. Mach.**, January 11.
Remarks on foundations.—**Trans. A.S.C.E.**, lv.
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Anatomy of bridge work.—**Engng.**, March 16.
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New enlargements of the port of Antwerp.—**Genie C.**, March 17.
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Entrenching under fire.—**R.E. Jour.**, February.
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German fortifications on the Rhine.—**Monde**, December 30.
Advanced outlying works in fortress warfare.—**Mitt. Art. G.**, 2.
Japanese instructions for the tasks of infantry and engineers in the attack of fortified positions.—**Mitt. Art. G.**, 2.
Field fortification.—**R. Ejercito**, March.
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Ferro-silicon in the foundry.—**Engr. L.**, March 9.
Application of the dry air-blast in the manufacture of iron.—**In. Coal T. Rev.**, February 16.
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Piping in steel ingots.—**In. Coal T. Rev.**, March 16.
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The burning, overheating and restoring of steel.—**Engng. Min. Jour.**, February 24, March 3.
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MILITARY GEOGRAPHY.

Morocco.—**R. Mil. Por.**, February.
Orenburg-Tashkent railway.—**U. Serv. Mag.**, February.
Some strategic railways on the northwest frontier of India.—**U. Serv. Mag.**, February.
Development of the Kiao-Chau territory in the years 1904-05.—**Rundschau**, February.
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Notes on Greece and Turkey and the Greco-Turkish war of 1897.—**R.A. Belge.**, January-February.
Influence of command on the operations of cavalry.—**Cientifico**, February 25.
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The place of commanders in battle.—**Ueberall**, 21.
Burning of the frigate Nymph in 1757.—**R. Maritime**, January.
Nelson and the battle of Trafalgar.—**Rundschau**, March.
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Winter with the Russians in Manchuria.—**Jour. M.S.I.**, March-April.
German losses in southwest Africa.—**Ueberall**, 24.
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Experiences of the Russo-Japanese war; technical troops (balloons, telegraphy, projectors, etc.).—**Organ**, lxxii, 2.
Some lessons of the last war.—**Cientifico**, December 25, February 25.
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Truth of the battle of Sandepoo.—**Cercle**, March 3.
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The struggle for the command of the sea (Captain Daveluy's book on the Russo-Japanese war).—**R.G. Marina**, March.
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Law at the Infantry and Cavalry School.—**Jour. M.S.I.**, March-April.
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Torpedo for coast defense.—**Jour. M.S.I.**, March-April.
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Draft plan of a submarine battery of automobiles torpedoes for defense of a tidal river (armament, location, personnel and use).—**R.A. Belg.**, January-February.
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Military forces of Venezuela.—**Cercle**, February 24.
Reorganization of the general staff of the Argentine army.—**R.M. Bol.**, Feb.
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Sweden in 1905 (organization, etc.).—**N.M. Tids.**, 1, 1906.
The Chinese army.—**Jour. U.S. Cav.**, April.
Report of the Secretary of War, U.S.—**Mil. Woch.**, 27.
Future of the Royal engineers.—**A.N. Gaz.**, February 17.
Military cycling and the home army.—**Jour. R.U.S.I.**, February.
Royal Engineer duties in the future.—**R.E. Jour.**, February.
Organization of Royal Engineer units for employment with cavalry.—**R.E. Jour.**, February.
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Organic unit for machine guns.—**Jour. M.S.I.**, March-April.
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Engineers in the Russian army; present tendencies.—**R. Genie M.**, February.
Organization of civilian labor for defensive works in case of invasion at home.—**R.E. Jour.**, March.
Cavalry or mounted infantry.—**N.M. Tids.**, 2, 1906.
The signal corps with divisional cavalry; and notes on wireless telegraphy, searchlights, and military ballooning.—**Jour. U.S. Cav.**, April.
Von Lobell's annual reports on the changes and progress in military matters 1904.—**Jour. R.U.S.I.**, February, March.
Russian experience and opinion on lessons of the war: armament, equipment, service, etc.—**Mitt. Art. G.**, 1, 1906.
Effect of shortening the period of active service in the Russian army.—**Mil. Woch.**, 9, 1906.
Preparation for war.—**Organ**, lxxii, 2.
The British officer—his upbringing and its influence on his career.—**U. Serv. Mag.**, February.
Notes on the Russian infantry soldier.—**Jour. U.S. Inf.**, April.
Army reserves.—**Jour. U.S. Inf.**, April.
The United States army.—**Can. Artillerist**, December.
Moral and patriotic aspects of war and the relationship of the organized militia to the military power of the country.—**A.N. Reg.**, April 7.
Our soldier's pay as affecting desertion and re-enlistment.—**R. of Revs.**, March.
Our military deficency.—**A.N. Reg.**, March.
Enlisted man's contract with the government.—**Jour. M.S.I.**, March-April.
Philippine scouts in war.—**Jour. M.S.I.**, March. April.
Organization of Philippine scouts.—**Jour. U.S. Cav.**, April.
Practical attempt at barrack improvement.—**R. Art.**, January.
Researches on lightening the load of the infantryman and the improvement of his subsistence in the field.—**R. Inf.**, February, March.
Draft horses and the army.—**Jour. R.A.**, March.
Solution of a field ration problem.—**Jour. U.S. Inf.**, April.
Supply of small arm ammunition.—**Jour. U.S. Inf.**, April.
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Toleration of enteric fever by the army.—**Jour. R.U.S.I.**, March.
Efficiency of the hospital corps, with particular reference to the national guard.—**Jour. Mil. Surg.**, February.
Indentification system.—**A.N. Reg.**, April 7.
German naval budget, 1906.—**A.S.M. Zeit.**, January 6.
Decree of January 29 reorganizing the torpedo flotillas.—**Yacht**, February 17.
Annual reports of the U.S. Navy Department for 1904-05.—**Rundschau**, March.
Naval policy of Germany.—**U. Serv. Mag.**, March.
Ten years of naval administration.—**U. Serv. Mag.**, February.
Admiralty policy and the manning of the fleet.—**U. Serv. Mag.**, February.
The new French program: its financial dangers, uselessness of increasing the armored fleet, etc.—**Marine F.**, January-February.
Italian naval budget for the financial year, 1906-07.—**R. Maritt**, February (supplement).
The navy estimates, England.—**U.S. Gaz.**, March 8; **A.N. Gaz.**, February 24.
Engineering in the American Navy.—**Page's Wkly**, March 9.

The naval debates.—Engng., March 9.
The French fleet.—Ueberall, 25.
British Admiralty policy and its consequences.—Engng. Mag., April.
General discussion on the French naval budget.—Yacht, March 17, 24.
Draft of the Italian naval budget, 1906-07, and the distribution of the fleet.—Yacht, March 17.
New organization of French naval forces.—Yacht, March 31.
Report on Olongapo (naval base).—A.N. Reg., February 24.
Promotion conditions among officers in the U.S. Navy.—Rundschau, Feb.
Desertions in the navy.—A.N. Reg., March 17.
Personnel of the navy.—U.S. Gaz., February.
Japanese navy medical service.—A.N. Jour., February 24.
Efficiency of the engineering personnel of the navy.—Engng. Mag., April.
Notes on service on board (daily routine, etc.).—Ann. Club M.N., January.

SMALL ARMS, EQUIPMENTS.

The new German rifle bullet.—Jour. R.U.S.I., February; R. Mil. Por. February; Mitt. Art. G., 2; R. Ejercito, March; R.E. Jour., March; A.N. Gaz., February 10; A.N. Jour., March 10; N. Art. Tids., 1, 1906; R.Art., January.
The French and German infantry rifles and their bullets.—A.S.M. Zeit., February 17.
Mannlicher automatic rifle, model 1904.—Mitt. Art. G., 2.
Mauser rifle, model 1891.—R.M. Bol., February.
The new gun sling.—A.N. Jour., March 8.
The cult of the bayonet.—U.S.Gaz., February 22.
New military bullets.—S. & Fish., March 22.
Ammunition for the German rifle, model 1898,—M. de Art., January.
United States army pistols.—Jour. U.S. Cav., April.
The Spitzer cartridge.—Arms Expl., March.
U. S. rifle, model 1903.—R. Art., February.
Field equipment Swedish army.—A.N.Reg., February 16.
Equipment of the Belgian foot soldier.—A. N. Reg., March 24.
The infantryman's load.—Monde, December 30, January 10.
New uniform of the Japanese army.—Monde, February 20.
The uniform question in Germany.—A.S.M.Zeit., December 2.
The infantry pack.—A.S.M.Zeit., February 3.
Portable tools in use in the Japanese army.—R. Genie M., February.
German infantry equipment.—R. Ejercito, March.
Bullet-proof shields.—R.E.Jour., March.
Common-sense vs. the bogus in uniform.—U. Serv. Mag., March.
Report of the cavalry board on various bits submitted for trial and report.—Jour. U.S. Cav., April.
Cavalry equipment.—Jour. U.S. Cav., April.
Field glasses for artillery.—Can. Artillerist, December.
Equipment of the Japanese soldier.—R. Artig., January.
Field equipment of the German foot soldier.—A.N.Reg., March 3.

STRATEGY, TACTICS.

Influence of limited theatres of war upon the character of the operations.—Mil. Woch., 17, 18.
Influence of Moltke's previously prepared strategy on the commencement of the wars of 1866 and 1870.—Mil. Woch., 25, 26.
Napoleon, Moltke, and the fortress.—Jahrb., January, February.

Study on the strategical employment of cavalry.—**R.A.Belg.**, Jan.-Feb.
Tactical employment of pack artillery.—**Jour.R.U.S.I.**, February.
Attack of shielded batteries.—**Mil. Woch.**, 7, 1906.
The employment and the method of fire of the field artilleries of the two belligerent armies during the Russo-Japanese war.—**R. Artig.**, November.
A 75 mm. battery under fire of German artillery: vulnerability of the elements in rear of the line of batteries.—**Cercle**, February 24, March 3, 10.
Tactics in use by artillery.—**R. Art.**, January.
Employment of the 75 mm. gun in the field.—**Jour. R. A.**, March.
Firing and tactical instruction for field and horse artillery.—**R. Artig.**, December.
Lessons of the war as regards artillery action.—**R. Artig.**, December.
Tactical employment of field artillery.—**M. de Art.**, February.
Primary conditions for the success of cavalry in the next European war.—**Jour.R.U.S.I.**, February, March.
Letters to Plok (cavalry tactics).—**R. Cav.**, February.
Role of cavalry in modern war.—**Jour.M.S.I.**, March-April.
Cavalry in modern warfare.—**U. S. Gaz.**, March 8.
German infantry attack of 1902.—**Cercle**, March 10.
Some considerations connected with the formations of infantry in attack and defense.—**Ald. Mil. Soc.**, 88.
Infantry combat in the Russo-Japanese war.—**R. Ejercito**, March.
Elements of infantry attack.—**U. S. Gaz.**, March 15.
Notes on the Russo-Japanese war; infantry in battle.—**R.M.Etrang.**, March.
Infantry fire tactics.—**Jour. U. S. Inf.**, April.
Formal considerations on the battle of Mukden (compared with the drill regulations).—**Mil. Woch.**, 9, 1906.
Initiative in commanders of troops.—**R. Mil. Por.**, February.
Methods of combat prescribed in the new French drill regulations.—**Organ**, lxxii, 2.
Columns of march on the battlefield.—**S. Monatschr.**, February, March.
The war game.—**R. A. Belg.**, January-February.
Some principles of general tactics for fleet actions.—**R. Maritime**, January.
Considerations on the naval battle of Tsushima.—**R. Mil. Por.**, February.

SUBMARINES, TORPEDO BOATS, WARSHIPS.

General Crozier on submarines.—**A. N. Reg.**, February 24.
Expert opinion on submarines.—**A. N. Jour.**, March 10.
The Lake submarine.—**A. N. Jour.**, March 17.
Development of underwater craft.—**Page's Wkly**, March 16.
Submarine boats.—**Seewesens**, 1.
Strategical and tactical duties of submarines.—**Seewesens**, 3.
Conclusions as to submarines.—**Jour.A.S.N.E.**, February.
Value of the submarine.—**A. N. Reg.**, March 3.
Submarine navigation.—**Pop. Sc. Mo.**, March.
Apparatus for supplying air to submarine torpedo boats.—**Compr. Air**, Feb.
Detonation of submarine mines by means of sound waves.—**Scien. Amer.**, February 24.
Modern destroyers.—**Boletin**, December.
Petrol torpedo boat.—**R. G. Marina**, March.
Torpedo boat destroyer Wear.—**Engr. L.**, March 9; **Yacht**, March 31.
Triple screw motor torpedo boat.—**Scien. Amer.**, March 3.

New turbine torpedo for the U. S. navy.—**Jour.A.S.N.E.**, February.
Future of torpedo craft.—**Cas. Mag.**, February.
English troop ship Dufferin.—**Yacht**, February 24.
Battleship Dreadnought.—**Ueberall**, 23, 24 ; **A. N. Gaz.**, February 10 ; **R. G. Marina**, March ; **Scien. Amer.**, February 24, March 10 ; **Page's Wkly**, February 16 ; **Engng.**, February 9 ; **Engr. L.**, February 16.
Expert opinion on the Dreadnought.—**A. N. Jour.**, March 17.
Launching of the Dreadnought.—**Mar. Rev.**, February 8.
British naval construction in 1905.—**Memoires I. C.**, January.
English scout Attentive.—**Yacht**, March 24.
German cruiser Hertha.—**Yacht**, February 17.
German troopship Borussia.—**Schiffbau**, March 14.
Trials of the Erzherzog Karl and Sankt Georg.—**Seewesens**, 1.
Sidelights on the French fleet.—**Rundschau**, February.
The new fleet ; battleships of the line.—**Yacht**, February 24.
The French navy.—**Engng.**, March 16.
Fleets of Argentine, Chili, and Brazil in the last two years.—**Rundschau**, February.
New warships for the Brazilian navy.—**R. Marit. Brazil**, December.
Necessary qualities in new battleships.—**R. Marit. Brazil**, December.
Our 16,000 ton battleships.—**A. N. Jour.**, March 24.
Armored cruiser Tennessee.—**Scien. Amer.**, March 17.
Mounting the 12-inch guns of the Connecticut.—**Scien. Amer.**, March 24.
U. S. battleship Rhode Island.—**Jour.A.S.N.E.**, February.
U. S. battleship Louisiana.—**Jour.A.S.N.E.**, February.
Increase of the navies of France and Germany.—**Yacht**, March 10.
Cruisers of the future.—**R. G. Marina**, March.
Displacement of battleships.—**R. Marit.** Brazil, November.
The cruiser.—**Schiffbau**, February 28.
Armaments of warships.—**Engng.**, February 16.
Modern warships.—**A. N. Reg.**, March 17 ; **U. S. Gaz.**, February 22 ; **Engng.**, February 23, March 2.
On the production of smoke by warships.—**R. Maritime**, January.
Battleship-cruiser of M. Chas. Bos.—**Yacht**, March 3.
Influence of the depth of water on the speed of ships.—**Genie C.**, March 3 ; **Jour.A.S.N.E.**, February.
Raising of the Russian ships at Port Arthur and Chemulpho by the Japanese.—**Rundschau**, March.
Salvage of the Variag.—**R. G. Marina**, March.
German instructions for the preservation of ships.—**R. Marit. Brazil**, December.
A specialty in coal bagging (for coaling warships).—**In. Coal T. Rev.**, March 2.
Damaged Russian warships at Port Arthur.—**R. Artig.**, December.
Question of turbines in various navies.—**R. G. Marina**, March.
On the use of internal combustion motors for the propulsion of warships.—**Schiffbau**, February 28, March 14.
New dry dock at Nagasaki.—**Mar. Rev.**, March 8.
Official tests of electrically-operated bulkhead doors.—**A. N. Reg.**, March 31; **Elec. World**, March 17.
Large floating docks.—**Genie C.**, March 17, 24.

MISCELLANEOUS.

Germany's present military position compared to that of other foreign powers.—**A.S.M.Zeit.**, January 13.

Political and economic problems in Canada.—**Rundschau**, February.

New elements of war and general instruction in the army.—**Cientifico**, February 25.

Belgian nationality and neutrality.—**Belg. Mil.**, March 4.

The heavy howitzer in modern warfare.—**Jour. R. A.**, March.

Notes on a heavy draft horse for artillery.—**Mil. Woch.**, 9, 1906.

Relative importance of cavalry and mounted infantry.—**U. S. Gaz.**, March 1; **A. N. Gaz.**, February 24.

Employment of signals in passing orders for a battery in action.—**Jour.R.A.**, March.

The mechanical conveyance of orders.—**R. E. Jour.**, February.

Apparatus for visual signaling in daytime.—**Jour.M.S.I.**, March-April.

Submarine signaling.—**R. Marit.** Brazil, November.

Submarine explosions.—**Arms Expl.**, February, March.

Hutted hospitals in war.—**R. E. Jour.**, February.

Use of dogs in war.—**U. S. Gaz.**, March 1.

Works of the Maryland Steel Co.—**Cas. Mag.**, March.

Wounds by artillery projectiles, hand grenades and land mines in the war in Manchuria.—**Jour. Mil. Surg.**, February.

Military hygiene of water.—**Jour. Mil. Surg.**, March.

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ARTILLERY MATERIAL.

Exchange and Book Notices.

With the number for May, 1906, **Compressed Air** makes its appearance in a larger and more attractive form. The field of compressed air has broadened so materially within the last few years and its uses have become so innumerable that there is ample scope for an enlarged magazine devoted to this subject. The editors have endeavored, therefore, to produce a magazine which will cover thoroughly the entire field of compressed air in all its applications. It is now published by the Kobbé Company, 90-92 West Broadway, New York; subscription price, $1.00 a year.

In its issue for May 31st, the **United Service Gazette** makes mention of its first anniversary under its present management. A little over a year ago this paper passed into the hands of a new proprietorship, an entire change of staff was made, and many improvements effected in the appearance and make-up of the publication. An active, vigorous policy with a view to raising its standard, bringing it up-to-date in every way, and the introduction of several special features, have been most successful in making it now an attractive and readable service paper.

The Nth Foot in War, is the title of a little book by Captain M. B. Stewart, U. S. A., recently published by the Franklin Hudson Publishing Co. It relates the experiences of the regiment during the Spanish-American war from the time of "off to war," through the Southern camps and in Cuba, until it reaches home again. The story is well told and sets forth graphically and entertainingly many details and incidents of that brief but trying campaign.

In **Five Years a Dragoon ('49 to '54) and Other Adventures on the Great Plains**, Mr. Percival G. Lowe relates his experiences as a dragoon campaigning on the great plains amongst the wild tribes of Indians from the Missouri River to the Rocky Mountains and from Dakota to Mexico, giving many interesting incidents of army life on the western frontier fifty years ago. Most of the stories here told have been published in the "Journal of U. S. Cavalry Association"; the interest with which they were received and the encouragement and approval given the author have induced him to reproduce in book form these recollections of his active, varied career in the frontier days of western life.

They constitute a plain, straightforward narrative of many interesting scenes and stirring incidents connected with the early days of western army posts, Forts Kearney, Laramie, Leavenworth, Riley, etc., the Kansas war, Cheyenne expedition, and other Indian campaigns, etc., covering in all, as soldier and citizen ever engaged in some active enterprise, fifty-six years of frontier life.

Guns and their functioning.—**Ueberall**, 27, 32.
Ordnance for land service.—**Trans. A.S. Mech. E.**, xxv., 1904.
Brown wire-wound gun.—**R.M. Brazil**, February.
Carl Cronstadt and his rapid-fire guns.—**Art. Tids.**, 1 & 2, 1906.
Manufacture of cartridge cases for quick-firing guns.—**Proc. I.M.E.**, October-December, 1905.
Some shop methods of the American and British Manufacturing Company (manufacture of ordnance material).—**Am. Mach.**, April 5.
Report on the work done by the 1st section of the *Escuela Central de Tiro* during the year 1905. (Mainly about artillery matters, tests of material, etc.).—**M. de Art.**, March.
A retrograde step (14-inch guns for coast defense).—**Scien. Amer.**, May 5.
Shortening of the sight stem with telescopic sights.—**Krg. Zeits.**, 1, 1906.
Sighting apparatus with independent line of sight.—**Mitt. Art. G.**, 3.
Works of Messrs. Barr and Stroud (range finders).—**Engng.**, May 4.
Naval range-finder.—**R. de Mar.**, February.
Zeiss stereoscopic range-finder.—**R.G. Marina**, April.
Thc Grubb sight.—**R.M. Bol.**, May.
Naval artillery.—**R. Maritt.** March (Supplement).
Wire-wound guns.—**Krg. Zeits.**, 1, 1906.

AUTOMOBILES, AEROSTATION.

Ballooning.—**Jour. M.S.I.**, May-June.
The Wright aeroplane and its performances.—**Scien. Amer.**, April 7.
Development of aerial navigation for military purposes in Europe.—**Scien. Amer.**, April 21.
Further development of motor ballooning in France.—**Mil. Woch.**, 38.
Balloons in war.—**Belg. Mil.**, April 29.
Aerial navigation in its military importance with reference to the introduction of dirigible airships in the French service.—**Ueberall**, 34.
Parseval balloons.—**Belg. Mil.**, May 27.
Russian field balloon parks.—**R. Genie M.**, April.
Flying machines experimented with in Europe in 1905.—**R. Art.**, March.
Automobile construction.—**Am. Mach.**, March 8, 15, April 12.
The armored military motor car.—**Mil. Woch.**, 30; **Krg. Zeits.**, 2, 1906.
Velocipedes.—**Engng. Times**, April 5.
Combined long and short range automobile searchlight.—**Scien. Amer.**, April 7.
The automobile in war.—**R.E. Jour.**, April.
The Daimler motor car works.—**Engr. L.**, May 4.
Automobilism in tho Austro-Hungarian army.—**R.M. Etrang.**, April.
Motor tractors for military purpases.—**S. Zeit. Art. G.**, May.
Steam, oil, and electric automobiles.—**Engng. Times**, April 26.

BALLISTICS, RANGE FINDING AND POINTING.

Ballistics of ball and shot guns.—**S. & Fish.**, March 29.
Correction of tables for coast artillery fire.—**M. de Art.**, March.
Study on exterior ballistics.—**Ann. Club M.N.**, February.
History of exterior ballistics at the Commission de Gâvres.—**R. Maritime**, March.
Notes on the computation of range tables.—**Mitt. Art. G.**, 4, 1906.
Kinematical theory of shooting.—**Krg. Zeits.**, 6, 1904.

Messrs. G. P. Putnam's Sons announce that they have accepted the agency for the United States of **The University Press** (The Pitt Press) of Cambridge, England, and from July 1, 1906, will be prepared to fill orders for these. Correspondence is invited with instructors, students, the general public, and the trade. Messrs. Putnam will be ready to send to those interested, copies of the new general catalogue of the Cambridge Press publications, and will also be glad to forward them regularly the quarterly bulletin of the Press.

The **Revista Cientifico-Militar** is issuing a History of the Russo-Japanese War, appearing in supplements of from 16 to 24 pages. Twenty-two of the pamphlets have been issued to the present time. They constitute a detailed account of the operations on land and sea, and the numerous illustrations add to the interest of the narrative.

"**Team-Work in War**" is the title of a handsome reprint from the **Journal of the U. S. Cavalry Association**, being an abstract of a lecture by Major Geo. O. Squier, Signal Corps, delivered at the U. S. Signal School, Fort Leavenworth. Likening a modern battle in many respects to that of a foot ball game on a large scale, the author quotes the rules of the game and shows that they apply in principle almost without change to the conduct of modern battle, the dominant feature being the necessity for the development of "team-work" to its highest efficiency in order to win the game. The professional task before the army at present is to apply to the utmost the principle of combination of effort to a single purpose in the shortest possible time. The United States has now the three arms of the service, each of which compares favorably with the same arm in any other army. We have efficient regulations for the training of each of these arms separately, but we have as yet reached no full appreciation of the results to be attained by the complete co-operation and support of the different arms of the military service operated as a gigantic *war-team.*

The Craftsman for July is a very attractive number containing several papers of timely interest and value. "Building a New City", the leading article, deals with the reconstruction of San Francisco according to Mr.

Considerations on the influence of the position of the center of gravity of projectiles on the trajectory.—**Krg. Zeits.**, 3, 1906.

Pressure of explosions: experiments on solid and gaseous explosives.—**Engng.**, March 30; **In. Coal T. Rev.**, May 25.

Calculation of muzzle velocities by means of impulsometers.—**R. Maritt.** April.

Efficacy of shrapnel fire.—**R. Artig.**, February; **M. de Art.**, April.

Direction of fire of a battery by means of visual signals.—**R. Artig.**, Feb.; **M. de Art.**, March.

Firing against balloons.—**Cientifico**, March 25.

Indirect fire.—**M. Tids.**, April 1.

Technic and firing methods of the Netherlands artillery.—**Art. Tids.**, 6, '05.

CHEMISTRY, PHOTOGRAPHY.

Photographic reproduction of blue prints.—**Engng. News**, April 12.

Spectro-photography and its technical applications.—**Photo. Jour.**, April.

Technical photography.—**Proc. Engrs. Soc.**, May.

DRILL REGULATIONS, MANEUVERS AND PRACTICE.

The drill regulations.—**Mil. Woch.**, 29, 32, 37, 41.

Study on infantry drill regulations.—**R.M. Bol.**, April, May.

Reform of infantry drill regulations.—**Mil. Woch.**, 34.

Changes in the German drill regulations for infantry.—**A.S.M. Zeit.**, Mar. 17.

Critical study on the English Combined Training.—**R. Inf.**, April, May.

New French firing regulations.—**S. Monatschr.**, May; **R.M. Bol.**, May.

Japanese technical service regulations.—**Krg. Zeits.**, 1, 1906.

Draft of new firing regulations for infantry, and the new ammunition, Germany.—**Krg. Zeits.**, 2, 1906.

Notes on the maneuvers of 1905.—**R.M. Suisse**, April.

Italian grand maneuvers of 1905.—**R.M. Etrang.**, April.

The grand maneuvers in 1905.—**R. Inf.**, April, May.

French criticism of the Swiss autumn maneuvers.—**S. Monatschr.**, April.

German Imperial maneuvers of 1905.—**S. Monatschr.**, April, May.

Grand maneuvers of the English fleet.—**R. G. Marina**, April.

English naval maneuvers, 1906.—**A.S.M. Zeit.**, March 24; **Rundschau**, April.

Grand naval maneuvers in 1905.—**R. de Mar.**, January.

Field artillery fire technic during maneuvers.—**Mil. Woch.**, 31.

Siege artillery training.—**A.N. Gaz.**, April 7.

Lessons on firing.—**R. Ejercito**, May.

Exercises on the service of artillery in the field.—**R. Ejercito**, May.

Course of coast artillery firing, 1905.—**M. de Art.**, April.

Report on firing practice of heavy and siege artillery at the camp of Carabanchei.—**R.G. Marina**, April.

Rational execution of artillery gunnery practices.—**Mitt. Art. G.**, 4, 1906.

French experiences with rapid-fire field material.—**Art. Tids.**, 6, 1905.

Target for naval practice.—**R. de Mar.**, January.

Notes on naval target practice.—**R. de Mar.**, January.

Improvement in naval gunnery.—**U. S. Gaz.**, May 17.

Cavalry training.—**U. Serv. Mag.**, May.

A maneuver cavalry division under war conditions.—**Beiheft M.W.**, 4, 1906.

Cavalry scouting during the marches to grand maneuvers.—**Mil. Woch.**, 39.

School of grouped cavalrymen.—**R. Cav.**, March.

Burnham's plans. It will be remembered the substance of this project was published in the *Craftsman* for January, but the demand for it has been so great that it has been decided to reprint the greater part of it showing exactly what were the plans accepted only a few months before the destruction of the city.

Amongst other articles may be mentioned "Russia Behind the Veil", an inquiry as to "are we unsympathetic to this vast unfamiliar country"; "Boat Life in Japan"; "The Riddle of the Tall Building", has the sky-scraper a place in American architecture? "A Co-operative Village for Working people"; "What is Architecture", a study of the American people of to-day. Several other interesting articles pertaining to art and crafts and the usual *Craftsman* departments complete the number.

Study of a cavalry maneuver by echelons.—**R. Cav.**, April.
Short term service and preparation of cavalry for war.—**R. Cav.**, March.
Peace training of cavalry for war.—**Sbornik**, February.
Musketry training in the army.—**U. Serv. Mag.**, May.
How to make rifle practice a success.—**Jour. M.S.I.**, May-June.
Musketry instruction in the German army.—**R.M. Suisse**, April.
Bayonet fighting.—**Mil. Woch.**, 35.
Infantry battle firing.—**Mil. Woch.**, 36.
Instruction on infantry fire, Germany.—**R. Inf.**, April, May.
Preparatory instruction in collective fire.—**R. Mil. Por.** March.
New French firing regulations for infantry.—**M. Tids.**, April 1.
Service target practice range on the maneuver grounds of the railway and telegraph regiment.—**Mitt. Art. G.**, 3, 1906.
Revolver practice at home and abroad.—**S. & Fish.**, May 3.
Target revolver shooting.—**S. & Fish.**, May 17.
Field training for the United States army.—**Jour. M.S.I.**, May-June.
Importance of drill grounds.—**Mil. Woch.**, 40.
Application of the lessons of the Russo-Japanese war in the English army. —**A.S.M. Zeit.**, March 31.
Preparation in time of peace of commanders of troops to use their initiative.—**R. Mil. Por.**, April.
Physical training and its advantages.—**Mil. Soc. Ireland**, April 6, 1906.
Saber fighting in the Swiss army.—**A.S.M. Zeit.**, May 19.
Rules for conducting the naval war game.—**Boletin**, January-February.
British naval target practice.—**R. de Mar.**, March.
Movable platform for practicing gunners before firing.—**R. de Mar.**, March.
New U. S. naval rifle range.—**S. & Fish.**, May 3.
Naval target ranges at Guantanamo.—**A.N. Reg.**, May 26.

ELECTRICITY.

Paper versus rubber insulation for electric cables.—**Engng. News**, March 15.
How to improve telephony.—**Engng.**, March 23.
The Bell tetrahedral kite in wireless telegraphy.—**Scien. Amer.**, April 21.
Collins' system of wireless telegraphy.—**West. Elect'n**, April 14.
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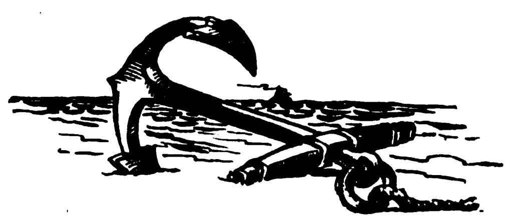

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