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ANNOUNCEMENT,

By this, the first issue of the Journal of the United States Artillery, is realized, we venture to believe, a hope long-cherished by the more progressive officers of the arm. It seems hardly necessary to-day to enter at length into the reasons for establishing an Artillery Review. What those reasons are is all but unanimously appreciated; justification of the step taken is hardly needed. But it may not be amiss briefly to sum up a few points that ought to engage the earnest attention of our officers. In no branch of the military service is progress so rapid, development so unexpected, as in the Artillery. Almost all the arts and industries are drawn upon to furnish in greater or less degree, their share in extending its sphere, in widening its applications. War grows more and more exacting in the requirements it makes of those who make its practical study their profession. True of all arms, this remark applies with peculiar force to our own, for it is in it especially that progress opens up an increasingly widening field. For us, the development of our artillery is of especial interest. The proper organization and administration of this arm is perhaps the great purely military problem that calls for solution in our land. For one great and essential difference exists between the war-conditions that this country may have to satisfy, as compared with those of other first-rate powers. So far as these are concerned, it is almost demonstrably certain that the theatre of any armed struggle into which circumstances may force us, will be our maritime borders. And this means that our artillery must be prepared for the duties that will then devolve upon it, not only as regards instruction of officers and men, but also as regards organization and administration.

These remarks perhaps make clear the object we hope in some measure to realize by the establishment of an Artillery Review. It will be devoted to the discussion of problems within the limits of our professional interests. As artillery literature is increasing day by day in volume and interest, so it will be the aim of the JOURNAL, in some sort to serve as a guide to those engaged in research and investigation.

Turning now to the more special consideration of our endeavor, we deem it to be a requirement of simple justice to state that the establishment of a professional paper has been made possible only by the generous encouragement and wise liberality of the Commanding Officer of the Artillery School. The nature and extent of the obligation under which the Artillery thus rests can be revealed only by experience. For the present we shall content ourselves by saying that to this wise action is it due that we of the Artillery at last possess a medium of inter-communication of our own, under our own control, and devoted with eye single to the interests of our arm.

The JOURNAL, for the present, will appear as a quarterly. It is temporarily under the editorial management of a committee of five, designated by the Staff of the School. Assuming that no one will question the soundness of making this the home of the JOURNAL, it remains but for us torecognize by acknowledging the probable existence of obstacles and difficulties, to be removed only by time, patience and experience. Hence, we bespeak in advance the kindly support of those who will be affected for good or evil by the success or failure of the enterprise, in which, whether willingly or unwillingly, we all have a common interest.

THE EFFECT OF WIND ON THE MOTION OF A PROJECTILE. *

By First Lieutenant JOHN W. RUCKMAN, First Artillery, U. S. A.

We know that wind influences, and, to a certain extent, controls the flight of a projectile, sometimes deflecting it from the plane of fire, sometimes retarding or accelerating its motion, but usually it combines these two effects, and causes the projectile to fall at a point some distance from that intended. We also know that this distance bears a certain relation to the velocity and direction of the wind. It is the purpose of the following discussion to determine this relation between these two elements, and other known quantities in the problem, in order that we may be able, under given conditions, to compute the above mentioned effects, and allow for them in aiming.

At the outset, considering it as a ballistic problem we find ourselves confronted with many difficulties, which, from an engineering point of view, do not enter into the wind problem. The engineer can allow sufficient strength in his structure to withstand the maximum effect which the wind may produce upon it. He can assume any coefficient of safety he chooses, and always allow a sufficient margin of strength, even when wholly ignorant of the laws of the wind's action. His structure being stationary, the wind produces pressures upon the surfaces and stresses within, all of which are similar to those with which he is constantly dealing. With the artillerist, however, it is different. He is required to send his projectiles direct to the point, and can allow himself no margin, one way or the other, the shot must fall neither short nor beyond, neither to the right nor to the left. Such rigid conditions require a perfect knowledge of the laws of the wind's action and the methods of computing its deviating effects.

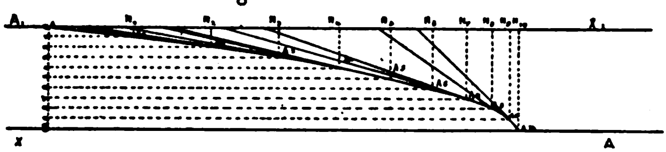
The engineer if required to determine the strength of the parts of his structure so that at all times and in all winds, it would have just sufficient strength to withstand the wind's force, would find himself dealing with a problem similar to our own.

Again, his problem is simply one of pressure, while ours, being essentially one of motion, embraces new and additional complications.

Since, in our case, both air and projectile are moving, the effect becomes that of their combined motions, and does not admit of separate treatment, so that we have in addition to the already difficult task of determining a trajectory in calm air, that of ascertaining it with the latter in motion.

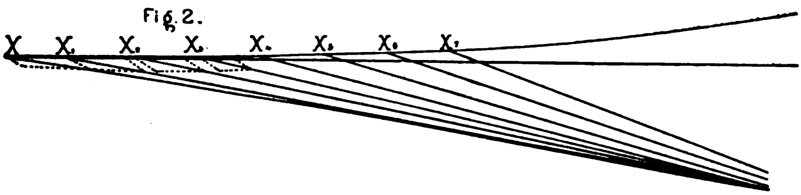
In order to determine what relations exist between the motion of air and projectile, we may consider the subject as one of relative motion. This may be done by supposing the projectile's velocity transferred to the air, and the *projectile* at rest. The air will then have its own motion (the wind), and that of the projectile ascribed to it. The air-particles will therefore strike the projectile along the lines of direction of these two motions. In the figure AX represents the plane of fire, and v_1, v_2, v_3, . . . the successive positions of the projectile at intervals of one second. A particle of air is assumed to be moving with the wind, perpendicular to AX, and is at A' when the projectile leaves the muzzle. In one second the projectile will be at v_1 and the particle of air at 1. But, if we assume the projectile at rest, and the velocity given to the air in the opposite direction, the particle and projectile will have approached each other by the distance of $v_0\,v_1$, and the projectile being at rest, the relative motion of the particle will be along $A'\,A'_1$, and the particle may be assumed to be at A_1, $A'\,N_1$ being equal to $v_0\,v_1$. At the end of the second unit of time, the air particle may be found at A_2, $N_1\,N_2 = v_1\,v_2$. The path of the particle will be that shown by A', A'_1, A_2, . . . , and at the instant of impingement will strike the projectile with a velocity and direction indicated by A_9A_{10}. If now the projectile be supposed to move from A' along A_1X_1 towards X_1 it follows from the construction that the tangents represent the directions of the resultant resistances at different points along the range.

Fig. 1.



This illustration assumes that the projectile is moving in the plane of fire, but when the direction of the wind makes an angle with this plane, the projectile, on leaving the bore, begins its side motion and departs more and more from this plane. We must, therefore, in treating the subject, take this side movement into account. The effect of this side movement is shown in figure 2 where we see the envelope to the resultant resistances, and the horizontal projection of the path.

Fig. 2.



The wind's velocity V_w is oblique to the plane of fire. Let the angle it makes with this plane be denoted by δ. The air-particles on this account impinge upon the projectile with a velocity V_w. At any point in the trajectory the air will also be impinging upon the projectile directly in front with a velocity equal to that in the projectile. Thus we see that the air has two motions: the one relative and in the direction opposite to that of the projectile, the other in the direction of the wind.

These two distinct velocities are *the components of a resultant velocity of impingement.*

This resultant velocity is easily determined. Construct a parallelogram upon the two component velocities of impingement. The diagonal of this figure gives the intensity and direction of the resultant. The resultant resistance to the projectile's motion acts along this line, and is oblique to the line of the projectile's motion. The angle between the direction of the projectile's motion and the resultant resistance we will here call *"the obliquity of the resultant."*

Thus disregarding all reactions of the air-particles among themselves, we consider the air as a moving fluid which impinges upon the projectile along a certain line and with a definite resultant velocity.

This principle of oblique resultant velocity and resistance briefly states the wind's effect upon a moving projectile.

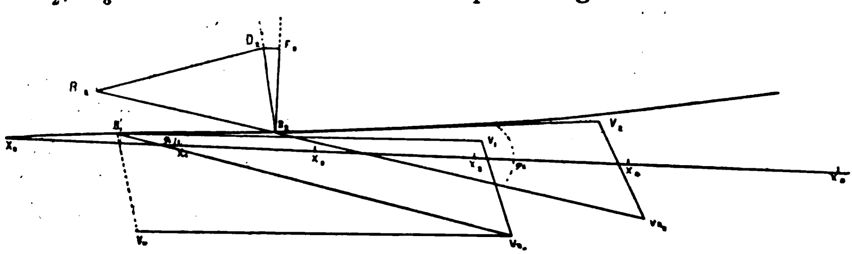
Taking this brief statement as a fundamental principle, we may now discuss the problem analytically and deduce the laws which govern the case, and point out the method of applying them practically to the problem before us.

Denote the projectile's remaining velocity by v and resultant velocity by V_R and we obtain from the parallelogram of velocities $V_R = \sqrt{v^2 + V_w^2 + 2vV_w \cos \delta}$. $Cos\ \delta$ will be positive when the wind's direction falls in the first or fourth quadrant, and negative when it falls in either of the other two. The resultant resistance being oblique to the projectile's motion has a component perpendicular to its path which acts as a deflecting force. Under the action of this component the projectile must depart more and more from the plane of fire.

In order to express the different quantities mathematically, let R be the general expression for the resistance and R_1, R_2, R_3, ... R_n the mean resistances over the 1st, 2d, 3d, ... nth hundred yards respectively.

Denoting the angle of obliquity by φ, then φ_1, φ_2, φ_3, ... φ_n will correspond to R_1, R_2, R_3 . . . . R_n . . . .

In Fig. 3 construct parallelograms of resultant velocities at B_1, B_2, B_3 . . . etc. The sides of the parallelograms are the corre-



sponding remaining velocities of the projectile and the constant velocity of the wind.

At B_2 the following relations are obtained: $R_2 cos(90°—\varphi_2)=B_2D_2$, and $B_2D_2 \cos\varphi_2=B_2F_2=P_2$, the deviating component at B_2. Again, $\cos(90°—\varphi_2)=\sin\varphi_2$, and $P_2=R_2 \sin\varphi_2 \cos\varphi_2$.

$Sin\ \varphi_2 \cos\varphi_2=\frac{1}{2} \sin 2\varphi_2$, and $P_2=\frac{1}{2}R_2 \sin 2\varphi_2$.

At B_3, similarly $P_3=\frac{1}{2}R_3 \sin 2\varphi_3$, and generally $P=\frac{1}{2}R \sin 2\varphi$.

As the wind is invariable in direction, and as P is constantly moving the projectile away from the plane of fire, the projectile, always moving tangentially to its trajectory, will be gradually changing its direction with respect to that of the wind.

Thus, if the wind be blowing perpendicularly to the plane of fire, the projectile's motion will soon make a small angle with that plane and δ will no longer be 90°.

Although this does actually take place in practice, the change will always be so small that it may be neglected; for the range must always be great compared to the deflection, and as the wind's velocity decreases the error will be less in the same proportion, and also from the cosine of the change being nearer unity.

If the lateral deviation be taken equal to one-tenth the range or an angle of departure whose sine is about .1, which is almost beyond the limit of possibility we have an angular departure of 5° 44′.

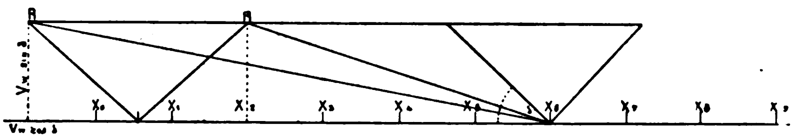
Sin 5° 44′=.09990. 0.09940, is $\frac{1}{2} \sin 2$ (5° 44′). And, 0.09990 —.09940 is equal to 0.0005. In this extreme case we see that $\sin\varphi$ and $\frac{1}{2} \sin 2\varphi$ differ only by 0.0005. It is, therefore, plain that for all values of φ and $\sin\varphi$, with which we have to deal in practice, $\sin\varphi$ may be substituted for $\frac{1}{2} \sin 2\varphi$ without appreciable error.

These illustrations show conclusively that in the following discussion the projectile may, be considered as always moving in, or parallel to the plane of fire, and the obliquity of the resultant may be found under the supposition that the wind's direction remains unchanged during the flight of the projectile.

Making the above mentioned substitution in $P=\frac{1}{2} R \sin 2\varphi$ we have $P=R \sin\varphi$ for the force which constantly carries the projectile away from the plane of fire.

Since the resultant resistance acts along the line of resultant velocity, and since the inclination of this line can always be determined, the retarding and deflecting forces can be computed.

From the parallelogram of velocities, Fig. 4



$Sin\ \varphi = \dfrac{V_w\ sin\ \delta}{\sqrt{v^2+V_w^2 \pm 2vV_w\ cos\delta}}$, or the deviating component of the wind's velocity divided by the resultant velocity. In this value of $sin\ \varphi$, v is the only variable. During the flight v continually decreases, and φ and $sin\ \varphi$ continually increase. The resulting resistance, being a function of some power of V_R, will decrease with v. Thus, we see that while the resultant resistance is decreasing with v, the angle of obliquity is increasing. The deviating component is always varying with the product of the two.

Substituting this value of $sin\ \varphi$ in $P=R\ sin\ \varphi$ we have

$$P=R\ \frac{V_w\ sin\ \delta}{\sqrt{v^2+V_w^2 \pm 2vV_w\ cos\ \delta}}$$

Placing $R'=K'(v)^u$, in which v is the velocity of the projectile at any time, K' may be constant and u variable, or u constant and K' variable. As the tables used in this discussion are constructed on the latter assumption, it will be followed here.

When the wind is blowing, the resistance will be a function of $\sqrt{v^2+V_w^2 \pm 2vV_w\ cos\delta}$, instead of v and since we have designated this by V_R, $R=K(V_R)^u$ and $P=K(V_R)^u\ \dfrac{V_w\ sin\ \delta}{V_R}=K(V_R)^{u-1}V_w\ sin\ \delta$.

Again from the same figure we have $R\ cos\ \varphi\ =\ K(V_R)^u\ cos\ \varphi=$
$K\ (V_R)^u\ \dfrac{(v \pm V_w\ cos\ \delta)}{\sqrt{v^2+V_w^2 \pm 2vV_w\ cos\ \delta}}$, or $R\ cos\ \varphi=K(V_R)^{u-1}(v \pm V_w\ cos\delta)$.

Comparing the values of P and $R\ cos\ \varphi$, or the deflecting and retarding forces, we observe that they are the same excepting the factors $(V_w\ sin\ \delta)$ and $(v \pm V_w\ cos\ \delta)$, which are the lateral and longitudinal components of the resultant velocity of impingement. Since V_w *sin* δ and V_w *cos* δ are the lateral and longitudinal components of the wind's velocity, *it follows that in the solution of the problem, we may resolve the velocity into its rectangular components.*

Since in all cases φ will be very small, we may place $\cos\varphi = 1$ and

$$\frac{P}{R} = \frac{V_w \sin\delta}{v \pm V_w \cos\delta}, \text{ or } P = R\frac{V_w \sin\delta}{v \pm V_w \cos\delta}.$$

DEFLECTION.

For the purpose of practical illustration let $\delta = 90$, $P = R\frac{V_w}{v}$. In this case the deflecting force and deflection are proportional to V_w.

Assume the following notation:

v_0 = initial velocity.

$v_1, v_2, v_3, \ldots v_n$, the remaining velocities at 1st, 2d, 3d, ... and nth hundred yards respectively.

$T_1, T_2, T_3, \ldots T_n$, the times of flight corresponding to $v_1, v_2, v_3, \ldots v_n$.

$t_1, t_2, t_3, \ldots t_n$, the intervals of time in which the projectile passes the sections corresponding to their subscripts.

$v'_1, v'_2, v'_3, \ldots v'_n$, the deflecting velocities impressed upon the projectile in the times t_1, t_2, t_3, etc.

$s'_1, s'_2, s'_3, \ldots s'_n$, the corresponding spaces.

$V'_1, V'_2, V'_3, \ldots V'_n$, and $S'_1, S'_2, S'_3, \ldots S'_n$, the total side velocities and spaces deflected in the times $T_1, T_2, T_3, \ldots T_n$.

From the nature of this notation $t_1 = T_1$; $t_1 + t_2 = t_2 + T_1 = T_2$; $t_3 + T_2 = T_3$; etc.

$v'_1 = V'_1$; $v'_1 + v'_2 = v'_2 + V'_1 = V'_2$; $v'_3 + V'_2 = V'_3$, etc.

$s'_1 = S'_1$; $s'_1 + s'_2 = s'_2 + S'_1 = S'_2$; $s'_3 + S'_2 = S'_3$, etc.

Let the range be divided into equal parts of 100 yards each, and the remaining velocities and the times of flight corresponding to each of these divisions be determined. The mean remaining velocity over any section is taken as the mean of the velocities at the extremities.

Knowing the mean remaining velocities at the middle points of the sections and the direction of the wind at each of these points the corresponding resultant velocities can be computed. From a range table giving remaining velocities, and times of flight, we can determine the deflection for any range. In $P = R\,\frac{V_w}{v}$, we have the relation between the deflecting and retarding forces; since these forces each act on the same mass for the same time, we may write the relation $v'_n = 2\,(v_{n-1} - v_n)\,\frac{V_w}{v_{n-1} + v_n}$; in which we substitute accelerations for the forces. All the quantities in the second member of this equation being known, gives us the value of v'_n, the side velocity impressed while the projectile is passing the nth. 100 yards of range. If we begin at the first 100 yards we have $v'_1 = 2(v_0 - v_1)\,\frac{V_w}{v_0 + v_1} = V'_1$, the side velocity at the end of 100 yards. $v'_2 = 2(v_1 - v_2)\,\frac{V_w}{(v_1 + v_2)}$ and $v'_2 + V'_1 = V'_2$ = side velocity at end of second 100 yards. Continuing this operation, we determine the values of V'_1, V'_2, V'_3, ... V'_n.

With these values and those of small t, we can in a manner similar to that just described find the values of S'_1, S'_2, S'_3, ... S'_n. Beginning with $\frac{V'_0 + V'_1}{2} = V'_{1m} = \frac{V'_1}{2}$; $\frac{V_1}{2}\,t_1 = s'_1 = S'_1$; $\frac{V'_1 + V'_2}{2} = V'_{2m}$ and $V'_{2m} t_2 = s'_2$; $s'_2 + S'_1 = S'_2$ and so on to S'_n.

We may also write:

$$\frac{P}{R} = \frac{M\frac{d^2s'}{dt^2}}{M\frac{d^2s}{dt^2}} = -\,\frac{d^2s'}{d^2s} = -\,\frac{dv'}{dv} = \frac{V_w}{v}$$

$$\int_{v'_0}^{v'} dv' = -V_w \int_{v_0}^{v} \frac{dv}{v}\,;\; v' - v'_0 = -V_w\left(\frac{\log v - \log v_0}{m}\right);\; v'_0 = 0$$

$v' = \frac{V_w}{m}\log\frac{v_0}{v}$, or more generally

The preceding discussion is perfectly general and therefore applies to all projectiles. The illustrations are taken from the Springfield Rifle for two reasons. (1) When this discussion was developed two years ago our practical knowledge of this gun was better than that of any other. (2) At that time it was impossible to obtain any reliable data relative to any other gun in our service.

Table Showing Practical Computation.

RANGE.	Remaining Velocities.	Mean Remaining Velocities.	Retardations per 100 yards.	Time of passing 100 yards trajectory.	Times of flight.	Side velocities in feet, impressed in passing 100 yards.	Side velocities impressed in time of flight.	Mean side velocity of projectile while passing 100 yards of trajectory.	Spaces in feet passed over in times "t," or during passage over 100 yard range.	Total spaces in feet passed over during the times "T": 10 mile wind.
	$V_0=1301$			t	T	v′	V′	V'_m	s′	S′
100	1161.25	1231.13	139.75	.2444	.2444	1.665	1.665	.832	.203	.203
200	1054.86	1108.66	106.39	.2740	.5184	1.408	3.073	2.369	.649	.853
300	983.22	1019.04	71.64	.2953	.8137	1.031	4.104	3.589	1.060	1.912
400	925.14	954.18	58.08	.3149	1.1286	.893	4.997	4.551	1.433	3.345
500	873.54	899.54	51.60	.3351	1.4637	.842	5.838	5.418	1.815	5.161
600	827.39	850.46	46.15	.3577	1.8214	.796	6.634	6.230	2.231	7.391
700	785.89	806.64	41.50	.3720	2.1934	.755	7.389	7.012	2.608	10.000
800	747.47	766.68	38.42	.3920	2.5854	.735	8.124	7.756	3.041	13.040
900	710.92	729.20	36.55	.4110	2.9964	.735	8.859	8.491	3.490	16.530
1000	676.17	693.55	37.75	.4330	3.4294	.735	9.594	9.226	3.995	20.528
1100	643.26	659.71	32.91	.4496	3.8790	.732	10.326	9.960	4.478	25.003
1200	611.67	628.21	31.41	.4842	4.3632	.733	11.059	10.692	5.177	30.181
1300	581.76	596.71	29.91	.5033	4.8665	.735	11.794	11.426	5.751	35.932
1400	553.32	567.54	28.84	.5286	5.3951	.735	12.529	12.162	6.429	42.360
1500	526.27	539.80	27.05	.5564	5.9515	.735	13.264	12.896	7.176	49.536
1600	500.50	513.38	25.77	.5843	6.5358	.736	14.000	13.632	7.965	57.501
1700	476.5	488.5		.6182	7.1450	.7350	14.727	14.360	8.877	66.247
1800	452.8	464.65	73.47	.6457	7.7907	.7350	15.462	15.095	9.746	76.100
1900	431.0	441.9		.6790	8.4697	.7350	16.197	15.830	10.748	86.848
2000	409.5	420.25		.7143	9.1840	.7350	16.932	16.565	11.832	98.680
2100	389.5	399.5	52.8	.7500	9.9340	.7350	17.667	17.300	12.974	111.654
2200	369.5	379.5		.7895	10.7235	.7350	18.402	18.035	14.238	125.892
2300	350.5	360.		.8333	11.5568	.7350	19.137	18.770	15.641	141.533
2400	332.0	341·25		.8772	12.4340	.7350	19.872	19.505	17.109	158.642
2500	319.0	325.5		.9229	13.3569	.7350	20.607	20.240	18.681	177.323

$$v' = \frac{V_w \sin\delta}{m} \log\left(\frac{v_0 \pm V_w \cos\delta}{v \pm V_w \cos\delta}\right).$$

When $\frac{1}{m}\log\frac{v_0}{v} = 1, v' = V_w, \log\frac{v_0}{v} = m; \frac{v_0}{v} = 10^m$ or $v = \frac{v_0}{10^m}$, but $10^m =$ Napierian base. Therefore, when the remaining velocity is equal to the initial velocity, divided by the Napierian base, the side velocity will be equal to the deflecting component of the wind's velocity.

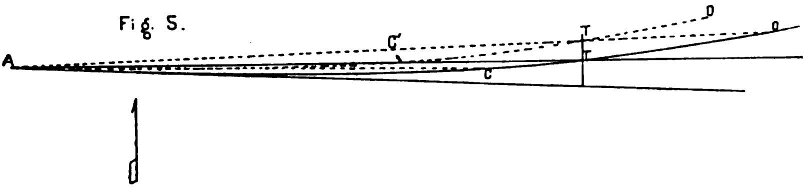
From the preceding table we observe that the deflection increases rapidly with the range. The first part of the curve may be approximately represented by the parabola $S' = .0000208X^2$ in which X is the range in yards and S' is given in feet. The computed velocities of S up to about 400 yards are a little greater than found by this equation, then a little less up to 1200 yards, after which they are again larger and the difference increases gradually. The wind curve could probably be accurately given by a parabola of variable parameter, or by the envelope to a series of parabolas, whose parameters vary according to some law depending on the conditions of the problem.

From what has just been said relative to the wind curve, it will be seen that we cannot hope, when the wind is blowing, to do good line shooting, unless we can accurately obtain the desired range. Thus, if, on account of wind, atmospheric conditions, or other causes, the gun must be elevated for 2500 or 2900 yards in order to strike the target at 2700, the side allowance on the sight must correspond to 2500 or 2900 yards as the case may be.

In firing at a target it is the worst kind of practice to "shoot low", to see where the shots are going, unless there is certainty of the bullet striking in range, near the target. If this does not take place, the point of impact will not only give no useful information, but will mislead; for it may appear to be a perfect line shot at the middle of the range, and yet from the form of the wind curve, would be away to one side if it fell at the range of the target. This is clearly shown in figure 5, (page 15.)

The gun, set correctly for wind deflection, is fired at A. The projectile follows the curve; if the elevation be too small, it strikes

Fig. 8.



A C T D = wind curve.

at *C*, to the right; if the elevation be correct, it will pass through the bull's-eye; but if the elevation be too great, it will pass directly over the centre of the target, and strike at *D* to the left. In this case, whether the impact appears to the right or left, no change should be made in the deflection leaf. A shot may be fired low and strike at *C'*, which is, apparently, a line shot; if however, it had attained the range of the target, it would have fallen at *T'*.

It is also shown by the table that the side velocities over each section are large at first, and their aggregate in the first instants of flight, or over the first sections of the range, is great compared to that of an equal range, further on.

From this we see that the wind's velocity and direction at the gun and along the first parts of the range, are of greatest importance and should be obtained with greatest care.

To illustrate, let us suppose the wind to die out when the bullet reaches 1000 yards on its way to 2500. At this instant the projectile is moving along the tangent to the wind curve, and as the wind no longer exists, there will no longer be any force to deflect it from its tangent plane, and the projectile will continue its motion in this plane. The value of the deflection at 2500 will be $S'_{10}+\frac{(S'_{11}-S'_{9})1500}{200}=S'_{10}+\frac{(S'_{11}-S'_{9})15}{2}=20.5254+63.5175=$ 84.043 feet, or about half the total deflection when the wind continues throughout the flight.

Resuming the equation giving the general value of $P=K(V_R)^{n-1}V_w \sin\delta$, we have $V_w=\sqrt{v^2+V_w^2+2V_w v\cos\delta}$, when the wind comes from any point in front of a normal to the plane of fire, and $V_R=\sqrt{v^2+V_w^2-2V_w v\cos\delta}$ when behind this normal. In the first case, the wind has a retarding component, in the second an accelerating component. From this we can see that P will be greater for retarding than for accelerating winds, and therefore in the same time for the former case, the deflection will be greater than in the latter. We also see that as $V_w \sin \delta$ is the deflecting component of V_w, and as the component is constant, the force and deflection will vary with this component; but as the function $K(V_R)^{n-1}$ is slightly affected by V_w being increased by retarding and decreased by accelerating winds we conclude that deflection will vary almost directly with $V_w \sin \delta$; increasing a little more rapidly than this factor for retarding winds, and a little less rapidly for accelerating winds.

The change in $K(V_R)^{n-1}$ due to a change in V_w will always be so small that we may assume that deflection in all cases will be practically proportional to the deflecting component of the wind's velocity.

The Fish-tail Wind.—By this we mean a wind whose capriciously varying direction makes at any instant but a small angle with the plane of fire, changing constantly and quickly from one side to the other, as does a fish's tail in swimming.

Doubtless this is the most troublesome wind to riflemen and gunners. And in such a wind it is almost impossible to obtain uniform results. The extreme changeability of its direction causes these well-known irregularities, but so far it never has been very clear why a change of a few degrees, when δ is small, should be so important, while the same change when δ is large is comparatively unimportant.

This apparent anomaly is clearly accounted for by the preceding theory, and is explained in the following manner. We have seen that deflections vary almost directly with $V_w \sin \delta$. Now, if V_w be constant and δ be variable, as in the case of the fish-tail wind, the greatest change in the $\sin \delta$, for equal increments or decrements of δ, take place when δ is near $0°$ or $180°$, or when the wind's direction is nearly coincident with the plane of fire. A few degrees change in δ, under such circumstances, will fully account for the apparent eccentricities of the shots.

To illustrate, let us suppose that we are firing with the Springfield Rifle at 1000 yards. The coefficient for the gun at this range is 2 feet. If $V_w = 25$ miles per hour, and makes an angle with the plane of fire of 10° to the right, the deflecting component will be 4.34 and the allowance 8.68 feet.

If the gun be set and aimed correctly and just before firing δ becomes zero, the shot will strike 8.68 feet to the right. The gun being corrected for this change in the next shot the wind may shift again, either to its former place or 10° to the left, and the shot will fall 8.68 feet to the left or right accordingly.

Having now determined the most important facts connected with the deflection of a projectile, the principal conclusions are:

1. The deflection of a projectile under the action of a side wind is not the result of wind-pressure, but of a kind of drifting motion, caused by a developed oblique resultant resistance.

2. Deflection is a ballistic problem and must be solved as any problem in exterior ballistics.

3. Deflection is a function of the remaining velocity of the projectile; any circumstance affecting this velocity changes the deflection.

4. Deflection is a function of the time of flight; and increases rapidly as the time increases.

5. For moderate winds, deflection varies directly with the wind's velocity; and in general, when $\tan \varphi$ may be substituted for $\sin \varphi$ without appreciable error, this law obtains.

6. In high winds, independent of any change in time of flight, deflection is greater for winds that retard than for those that accelerate; and in the former, it increases more rapidly, and in the latter less rapidly than the wind's velocity.

7. When the wind's direction falls near the plane of fire, changes in δ are of greatest importance, and cause irregular results.

8. Other things being equal, deflection varies inversely as the weight of the projectile.

9. Deflection varies with retardation of the projectile's velocity.

10. Deflecting components of the wind's velocity increase the resistance and time of flight. This results from the projectile being forced to follow a curve of double curvature, which is a path of greater resistance than a plane curve. Gravity affects the pro-

jectile's flight in the same way, but in a greater degree, giving the projectile a curved instead of a straight path. And as on account of gravity, we must aim above the object, so, on account of the wind, we must aim to one side to strike it.

LONGITUDINAL DEVIATION, OR CHANGES IN OR PARALLEL TO THE PLANE OF FIRE.

The discussion has so far been limited to the determination of effects perpendicular to the plane of fire. We now come to the changes which take place in the motion of a projectile in, or parallel to, this plane, and although such changes are less easily perceived, they are not less interesting and important.

We have already seen that $R\cos\varphi = K(V_R)^{n-1}\ (v \pm V_w \cos\delta)$, and that in all ordinary cases φ is so small that we may put $\cos\varphi = 1$ and $V_R = \sqrt{v^2 + V_w^2 \pm 2V_w v\cos\delta} = v \pm V_w \cos\delta$.

Under this supposition, we have $R = K(v \pm V_w \cos\delta)^n$ in which the equation for longitudinal resistance takes the same form as that for still air. We may therefore proceed in the same manner to compute the remaining velocities at different points of the range. Let $\overline{v}$ in this case denote the remaining velocity of the projectile at any time, $\overline{v_1}$, $\overline{v_2}$, $\overline{v_3}$, . . . $\overline{v_n}$, the remaining velocities corresponding to v_1, v_2, v_3, . . . v_n, (the remaining velocities in calm air. $\overline{v} \pm V_w \cos\delta$ will be the longitudinal component of resultant impingement.

Beginning the computation with $v_0 \pm V_w \cos\delta$ as an initial velocity, the values of $\overline{v} \pm V_w \cos\delta$ can be computed.

For retarding winds:

$(v_1 + V_w \cos\delta) - (\overline{v_1} + V_w \cos\delta) = v_1 - \overline{v_1}$, the loss due to wind in the first 100 yards of range. In similar manner we find $v_2 - \overline{v_2}$, $v_3 - \overline{v_3}, v_n - \overline{v_n}$, $\frac{v_1 - \overline{v_1}}{2} = v_1^\circ$ and $v_1^\circ\ t_1 = \Delta x_1 = \Delta X_1$, $\frac{v_2 - \overline{v_2}}{2} = v_2^\circ$; $v_2^\circ\ t_2 = \Delta x_2 + \Delta X_1 = \Delta X_2$.

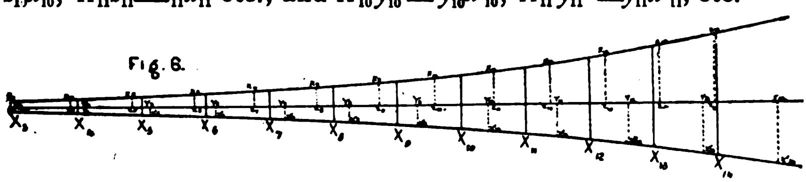
Proceeding in this manner, which is similar to that described in computing deflection we find the retardation for any range.

When the wind is accelerating $(\overline{v} - V_w \cos\delta) - (v_1 - V_w \cos\delta) = \overline{v_1} - v_1$, instead of $v_1 - \overline{v_1}$. It must be remembered that the values of t_1, t_2, t_3, . . . t_n, used are those found for the motion of the projectile in still air, while the values of $\overline{v} + V_w \cos\delta$ were found under the supposition that the projectile experience a resistance $R=K(v\pm V_w \cos\delta)^n$ instead of $K'(v)^n$. The projectile therefore instead of being at the end of the nth section, as in case of calm air, will be ΔX_n short or beyond it, as $V_w \cos\delta$ is plus or minus, and in order to obtain the true value of ΔX_n, a positive or negative quantity would have to be applied to the computed value.

If great accuracy were necessary and it became desirable to apply such a correction, its determination from the tables, if possible, would be difficult and laborious. At this point, the principles of graphics lend themselves in the most convenient manner to the solution of the question.

The construction of the curves of loss and gain in range due to retarding and accelerating winds is shown in Figure 6. The ordinates ot the upper curve give the loss in range due to the given retarding wind. The abscissas of the curve are, $X-\Delta X$ . . . . the corresponding ordinates are ΔX . . . . The ordinates of the resulting curve give the true loss in range for any value of X. The ordinates of the lower curve in like manner give the gain in range for corresponding values of X. The abscissas are, $X+\Delta X$ . . . . and the ordinates are ΔX . . . By construction, $X_{10}z_{10}=z_{10}x_{10}$; $X_{11}z_{11}=z_{11}x_{11}$ etc., and $X_{10}y_{10}=y_{10}x'_{10}$; $X_{11}y_{11}=y_{11}x'_{11}$, etc.

Fig. 6.



By applying the same principle the true curves of times of flight and deflection can be constructed.

ATMOSPHERIC CHANGES, BAROMETER AND THERMOMETER.

The fluctuations in temperature and pressure of the air must be noticed in our efforts to obtain the highest efficiency. $R'=K'(v)^n$ in still air, and when the wind is blowing, $R=K(v\pm V_w\cos\delta)^n$; $\frac{R}{R'}=\frac{K}{K'}\frac{(v\pm V_w \cos\delta)^n}{(v)^n}=$ to the ratio of the resistance in a calm to that in a wind. Making $V_w \cos\delta=14.667$ feet per second or 10 miles per hour, we can find the value of the ratio of $\frac{R}{R'}$ directly,

Retardations in Velocity in Feet Due to Retardating Winds. Springfield Rifle

Range.	10 mi.	20 mi.	30 mi.	40 mi.	50 mi.	Range.	10 mi.	20 mi.	30 mi.	40 mi.	50 mi.
100	2.84	5.72	8.55	11.37	14.11	1400	12.02	24.04	36.15	48.25	60.40
200	6.61	12.87	18.77	24.44	29.85	1500	12.13	24.31	36.52	48.75	61.07
300	8.90	17.83	26.78	35.75	44.75	1600	12.23	24.52	36.85	49.20	61.59
400	9.56	19.15	28.77	38.43	48.68	1700	12.32	23.73	37.18	49.65	62.16
500	10.10	20.25	30.43	40.60	51.46	1800	12.41	25.94	37.51	50.10	62.72
600	10.56	21.18	31.82	42.49	53.20	1900	12.49	25.15	37.84	50.55	63.28
700	10.88	21.99	32.80	43.82	54.86	2000	12.56	25.35	38.16	50.99	63.84
800	11.13	22.31	33.50	44.79	56.09	2100	12.61	25.55	38.41	51.40	64.36
900	11.32	22.69	34.10	45.52	57.03	2200	12.66	25.75	38.66	51.80	64.88
1000	11.48	23.07	34.55	46.16	57.76	2300	12.70	25.95	38.91	52.20	65.40
1100	11.67	23.33	35.03	46.79	58.56	2400	12.74	26.15	39.16	52.60	65.92
1200	11.76	23.57	35.41	47.29	59.19	2500	12.77	26.35	39.41	53.00	66.44
1300	11.88	23.80	35.77	47.76	59.79						

Accelerations in Velocity in Feet Due to Accelerating Winds. Springfield Rifle

Range.	10 mi.	20 mi.	30 mi.	40 mi.	50 mi.	Range.	10 mi.	20 mi.	30 mi.	40 mi.	50 mi.
100	2.94	5.82	8.72	11.66	14.31	1400	11.97	23.88	35.78	47.62	59.33
200	7.08	14.49	22.18	31.96	37.57	1500	12.12	24.17	36.38	48.15	60.03
300	8.83	17.61	26.35	35.04	43.50	1600	12.29	24.47	36.77	48.72	60.74
400	9.50	18.95	28.37	37.82	46.88	1700	12.46	24.77	37.16	49.29	61.45
500	10.08	20.09	30.07	40.04	49.70	1800	12.63	25.07	37.55	49.86	62.16
600	10.64	20.82	31.47	41.85	52.06	1900	12.80	25.37	37.94	50.43	62.87
700	10.86	21.63	32.37	43.05	53.56	2000	12.95	25.66	38.34	51.00	63.58
800	11.10	22.11	33.08	44.00	54.74	2100	13.00	26.09	38.87	51.62	64.30
900	11.27	22.48	33.65	44.75	55.70	2200	13.05	26.52	39.40	52.24	65.02
1000	11.44	22.80	34.13	45.40	56.50	2300	13.10	26.95	39.93	52.86	65.74
1100	11.58	23.08	34.55	45.98	57.25	2400	13.15	27.39	40.46	53.49	66.46
1200	11.72	23.38	35.38	46.56	57.98	2500	13.21	27.83	41.00	54.12	67.17
1300	11.92	23.63	35.59	47.07	58.63						

Table showing method of computing retardations in range due to a retarding wind of 30 miles per hour.

Range.	$v-\bar{v}$	v°	t	$v^\circ\ t=\Delta x$	ΔX feet	ΔX yards	True value ΔX in yards
0	.000						
100	8.55	4.275	.2444	1.045	1.045	.348	.348
200	18.77	13.660	.2740	3.743	4.788	1.596	1.618
300	26.78	22.775	.2953	6.725	11.513	3.838	3.933
400	28.77	27.775	.3149	8.746	20.259	6.753	6.969
500	30.43	29.600	.3351	9.919	30.178	10.059	10.407
600	31.82	31.125	.3577	11.133	41.311	13.770	14.292
700	32.80	32.310	.3720	12.019	53.330	17.777	18.488
800	33.50	33.150	.3920	12.995	66.324	22.108	22.988
900	34.10	33.800	.4110	13.892	80.217	26.739	27.972
1000	34.55	34.325	.4330	14.863	95.080	31.693	33.300
1100	35.03	34.790	.4490	15.621	110.701	36.900	38.952
1200	35.41	35.220	.4842	17.054	127.755	42.585	45.078
1300	35.77	35.590	.5033	17.912	145.667	48.556	51.571
1400	36.15	35.960	.5286	19.008	164.675	54.891	58.563
1500	36.52	36.335	.5564	20.217	184.892	61.631	65.978
1600	36.85	36.685	.5843	21.435	206.327	68.776	73.924
1700	37.18	37.025	.6182	22.889	229.216	76.405	82.535
1800	37.51	37.345	.6457	24.096	253.312	84.437	91.538
1900	37.84	37.675	.6790	25.581	278.893	92.964	101.253
2000	38.16	38.000	.7143	27.143	306.036	102.012	111.660
2100	38.41	38.285	.7500	28.714	334.750	111.583	122.734
2200	38.66	38.535	.7895	30.433	365.183	121.728	134.238
2300	38.91	38.785	.8333	32.321	397.504	132.501	147.279
2400	39.16	39.035	.8772	34.242	431.746	143.915	160.898
2500	39.41	39.285	.9229	36.255	468.001	156.000	175.332

from Prof. Greenhill's tables. With the value of this ratio we may in tables giving variations in density of air, or changes of temperature and barometer, find a corresponding value.

For example, with the Springfield Rifle $v_1=1161.25$ and $\bar{v}_1 + 14.667=1172.5$ and from Prof. Greenhill's tables of resistances, the corresponding values of R and R' on a circular inch are 5.49 and 5.32 lbs. respectively. $\frac{R}{R'}=1.032$ and we find in the temper-

Table of Atmospheric Equivalents in terms of 10 miles of Retarding Wind. Springfield Rifle

RANGE.	v	$\bar{v}+V_w cos\delta$	R'	R	$\frac{R}{R'}$	Mean value of $R \div R'$	Thermometer Equivalent of 10 miles of Wind.	Barometer Equivalent of 10 miles of Wind.
100	1161.25	1172.5	5.320	5.490	1.0320	1.0320	16°	1.''
200	1052.3	1060.5	3.22	3.4854	1.0824	1.0572	27	1.75
300	984.5	990.3	1.1964	2.2712	1.0341	1.0475	23	1.4
400	926.3	931.4	1.852	1.8827	1.0166	1.0413	20	1.3
500	874.67	879.2	1.5592	1.5858	1.0171	1.0364	17	1.1
600	828.4	832.5	1.3263	1.3450	1.0141	1.0327	16	1.
700	786.4	790.2	1.1635	1.1771	1.0117	1.0297	15	.9
800	747.3	750.9	1.0355	1.0458	1.0099	1.0272	13	.8
900	710.5	713.8	.9319	.9417	1.0105	1.0254	12.5	.8
1000	675.4	678.6	.8455	.8531	1.0091	1.0238	12	.7
1100	642.0	645.0	.7660	.7728	1.0088	1.0224	11	.7
1200	610.1	613.0	.6954	.7017	1.0084	1.0213	10	.6
1300	580.	582.33	.6339	.6388	1.0077	1.0202	10	.6
1400	550.3	553.0	.5728	.5784	1.0098	1.0195	9	.6
1500	522.5	525.1	.5184	.5246	1.0119	1.0190	9	.6
1600	500.5					1.0185	9	.6
1700	476.5					1.0181	9	.6
1800	452.8					1.0177	8	.5
1900	431.0					1.0175	8	.5
2000	409.5				1.0114	1.0171	8	.5
2100	389.5					1.0169	8	.5
2200	369.5					1.0167	8	.5
2300	350.5					1.0165	8	.5
2400	332.0					1.0163	8	.5
2500	319.0				1.0124	1.0171	8	.5

ature table that 44° Fahr. or 31 in. barometer corresponds to this ratio. From this we conclude that at 100 yards a fall in temperature from 60°, the standard, to 44°, or a rise in barometer from 30″ to 31″ is equivalent to 10 miles of retarding wind, or, 1.6° or .1 inch is equivalent to 1 mile of wind.

Proceeding in this manner for the second hundred yards, we find $\frac{R}{R'}$ for this range to be 1.0824, and the mean of this and the preceding value gives 1.0572 for the ratio, and 27° and 1.75 inches as the equivalent for 200 yards, and so on.

The accompanying table shows these results up to 2500 yards.

This table in connection with a knowledge of the longitudinal effect of a mile of wind for a given range, enables one to correct the sight for variations in the temperature and barometer.

We have now considered the deviating effect of the wind and atmospheric changes upon the motion of a projectile. Some of the results of this investigation as applied to the Springfield Rifle are embodied in the following consolidated table.

The following remarks may be of interest and practical value to those wishing to apply the principles upon which it is based. The table assumes that the components of the wind's velocity are known.

V_w is given in miles per hour, and $V_w \cos \delta$ and $V_w \sin \delta$ are its components, which, multiplied by their respective coefficients, give the allowance in yards.

Knowing from the proper instruments the variations in temperature and pressure, from the standard, the application of these equivalents is simple and can be made directly.

It must be remembered that similar changes in barometer and thermometer affect the flight of the projectile in opposite directions. The equivalent of temperature above and barometer below standard must be subtracted from the range, while temperature below and barometer above must be added. When they rise or fall together they tend to neutrallize each other; the differential effect, if important, must be applied with the sign of the greater.

Consolidated Table of Wind and Atmospheric Data. Springfield Rifle Calibre .45, Charge 70 grains, Bullet 500 grains.

RANGE.	REMAINING VELOCITIES.	TIMES OF FLIGHT.	WIND COEFFICIENTS.			ATMOSPHERIC CHANGES, (⅔ saturated with moisture.) Value equivalent to 10 miles retarding wind.	
			DEFLECTION, IN YARDS.	LONGITUDINAL. Retardation in yards.	LONGITUDINAL. Accelerating in yards.	THERMOMETER Standard 60° Fahr.	BAROMETER Standard 30 inches.
0	1301						
100	1161	.25	.01	.01	.01	16	1.
200	1055	.52	.03	.05	.05	27	1.75
300	983	.81	.06	.13	.13	23	1.4
400	925	1.13	.11	.23	.23	20	1.3
500	874	1.46	.17	.35	.35	17	1.1
600	827	1.82	.25	.47	.43	16	1.
700	786	2.19	.33	.62	.58	15	.9
800	747	2.59	.43	.77	.73	13	.8
900	711	3.00	.55	.93	.87	12.5	.8
1000	676	3.43	.68	1.11	1.04	12	.7
1100	643	3.87	.83	1.30	1.20	11.2	.7
1200	612	4.35	1.01	1.50	1.38	10	.6
1300	582	4.88	1.20	1.72	1.58	10	.6

THE DETERMINATION OF THE VELOCITIES OF PROJECTILES BY MEANS OF SOUND PHENOMENA.

BY CAPTAIN FERDINAND GOSSOT, OF THE FRENCH MARINE ARTILLERY.*

OBSERVED PHENOMENA.

In target practice, with velocities notably greater than that of sound in air (about 340 metres), an observer placed in the plane of fire notices what follows. At the epoch when the projectile passes near his position, he perceives an intense and very sharp sound, of inappreciable duration, and *apparently* coming from the projectile itself. This sound is followed by absolute silence. A few moments afterward the observer notices a second sound, this one being dull, of appreciable duration, and seeming to proceed from the battery.

Let us imagine placed in the plane of fire an interrupter with automatic re-establishment of the current, intended to work under the influence of a sudden variation of the atmospheric pressure. Let us put into the electric circuit a Schultz chronograph register. If the current-breaker is far enough from the gun (500 to 600 metres, about) it will work a single time at the instant of the projectile's passage. The re-establishment of the current with the devices employed, has as a rule, under these conditions been effected in 0.03 of a second; that is, long before the second sound could reach them.

This second noise, proceeding from the deflagation of the charge, advances with a constant mean velocity of 340 metres. It

* Translated with the permission of the author by 1st Lieutenant Cornélis De W. Willcox, 2d Artillery.

is concluded from this experiment that its intensity is too feeble to affect the apparatus arranged at 600 metres from the gun. Now under the action of the first sound observations have been made (or signals have been obtained) at a distance of 3000 metres from the gun. This first sound therefore sensibly maintains its intensity, while that of the second decreases very rapidly.

Let us suppose the interrupter brought to 100 metres from the piece. It is then established that the current after each shot is re-established in about a half second. From this we conclude that the noise of discharge lasts much longer than that due to the passage of the projectile. We shall in what follows, in order to simplify matters, designate the first sound as the *sound of the projectile*, and the second as that of the *piece*.

STATEMENT OF PREVIOUS INVESTIGATIONS.

These various phenomena have been successively investigated by:

Captain Jacob (*Mémorial de l'Artillerie de la Marine*, 3ᵉ *livraison*, 1886);

Captain Journée in 1887. The experiments and theories of this officer have been set forth by Colonel Sebert at a conference held by the Physical Society on the 20th of January, 1888.

Captain de Labouret (*Mémorial*, t. xvi., p. 369).

EXPLANATIONS OF PROFESSOR MACH.

Professor Mach, of the University of Prague, known by his photograph of a projectile in motion (*Revue d'Artillerie*, March, 1888, and *Mémorial de l'Artillerie de la Marine*, 3ᵉ *livraison*, 1889), explains this phenomenon as follows:

"The projectile moving with velocity greater than that of sound compresses the air in its front.

The wave accompanying the projectile is a single wave of detonation. This wave is *stationary* (without periodical variation of condensation for an observer traveling with the velocity of the wave). As it passes the ear the sharp noise of the explosion is heard *but once*. The whistling is caused by small variations in the motion of the air around the projectile, due to the rotation of the latter and to the irregularities of friction. But this is no longer the sharp and very intense sound produced by the stationary wave accompanying the projectile. The stationary wave is the same as that which would exist, were the projectile at rest and the air in motion in the opposite direction with a velocity equal to that of the projectile.

It is easy to see therefore that but one wave comes into play, as in the case of a bridge-pier setting up a wave in a river. I attribute the sound noticed by M. Journée to reflections of the wave mentioned by the clouds, the ground, etc., like the rolling of thunder due to the same cause.

There is further an ordinary spherical wave due to the discharge, that moves with the ordinary velocity. Distances could be measured by noticing the second instead of the first sound, which is possible if complete silence separates them." (Letter of May 13, 1890, to the author.)

If we denote by φ the complement of one-half the angle at the vertex of the wake produced by the moving projectile, Professor Mach admits the relation

$$\cos \varphi = \frac{a}{v} \quad \ldots \ldots \ldots \ldots (1)$$

in which,

$a =$ velocity of sound in air.
$v =$ velocity of projectile.

Hence, it follows that this equation has no meaning unless $v > a$.

In May, 1890, I addressed a note to the general inspection of the Marine Artillery proposing to make use of the phenomena described above, to mark the passage of the projectile by one or more fixed points, no matter what the angle of elevation. I developed briefly the calculations allowing the deduction from the observations, of the remaining velocity at any point of the trajectory, and consequently of either the I. V. or the coefficient of the atmospheric resistance, or the time of flight.

A circular dated June 19th, 1890, directed the Commission de Gâvre to make the proper experiments.

APPARATUS EMPLOYED.

If we wish to measure the velocity of a projectile at any point of its path, we place on each side of this point a frame fitted with wires forming part of electric circuits. In these circuits are connected up either the chronometer and the registrar of a Le Boulengé chronograph, or the Marcel Deprez register of the Schultz chronograph.

The projectile is aimed at the centre of the frames, and in its passage through them breaks the current. The chronograph used gives the interval of time θ between the rupture of the circuit or circuits at the first and second frames.

If $d =$ distance between them and $v =$ the mean velocity of the projectile, we have

$$v\,\theta = d \quad . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \quad (2)$$

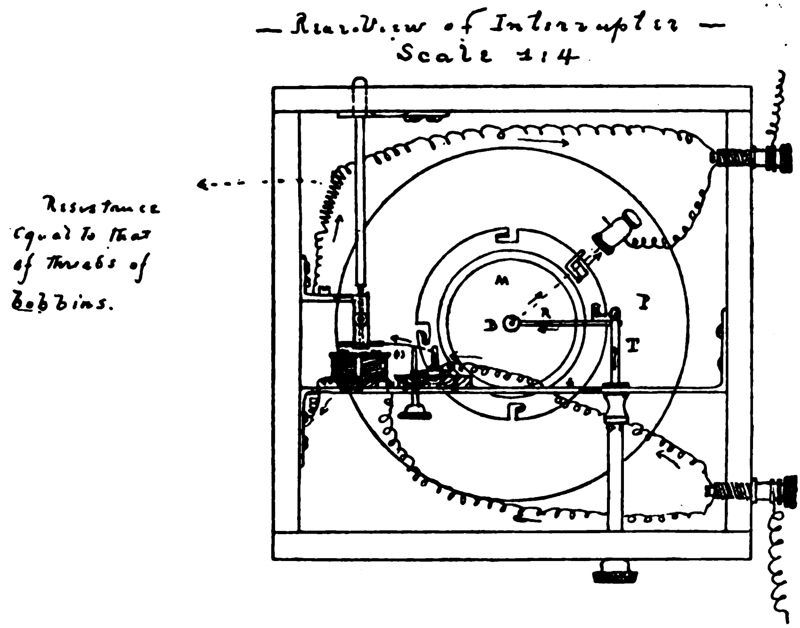
The frames act like current breakers precisely at the moment of passage of the projectile through the points where they are placed. In the new method now under investigation, it is no longer the projectile that breaks the current, but Mach's stationary wave. To effect this, we put in or near the plane of fire, two special devices whose relations to the chronograph are the same as those of the frames. Trial has been made of quite a number of devices. We shall describe in detail however, only the first apparatus built in 1888, in accordance with the suggestion of Captain Gerbault, and modified in 1890 by M. le garde d'artillerie Cousin. The modification consists in an arrangement intended to mark the passage of the current, which is in this apparatus broken by the vibration of a metallic membrane.

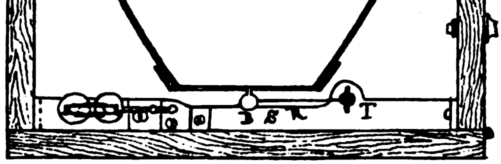
Current-breaking Vibrating Membrane.—The vibrating membrane is set up in the focus of a parabolic surface. It is from 0.2 to 0.3 of a millimetre in thickness and is made of tin or sheet-steel. The paraboloid is supported by a cubical box of wood. The upper surface of this box is parallel to the membrane, and carries a bar in which is drilled a nut for a screw whose blunt point may be brought in contact with the membrane. In the centre of the latter lies a small accurately made disk (*rondelle*) of platinum; the blunt end of the screw terminates in a lug of platinum. The screw and the membrane form part of an electric circuit that is closed when they are in contact, and broken when separated by the shock. A small electro-magnet in the circuit attracts, when closure takes place, a small tongue. This tongue flies back and leaves the magnet on the breaking of the circuit; by this means, the moment when the circuit is established is made known to the operator who is charged with the tightening of the contact-screw. The apparatus is so arranged that when reached by the wave of Mach the circuit is broken. To measure the interval between two successive breakings occurring in two neighboring apparatus, the LeBoulengé chronograph has in general been used. With the two interrupters very far apart, the Schultz chronoscope as modified by Messrs. Marcel Deprez and Sebert has been employed.

All the experiments to be described below except those of January 8, 1891, were made with the apparatus just described. Quite recently M. Cousin, garde d'artillerie, has succeeded after numerous and patient researches in making an interrupter whose working is perfectly satisfactory. A brief description will be given.

The device of M. Cousin consists of a paraboloid *P*, with a metallic membrane *M*, carrying at its centre a drop of platinum, and fixed in the focus of the paraboloid *P*. Against this membrane bears a light button *B* whose pressure is regulated by the spring *R*, caught in the split-rod *T*. This rod is furnished with a milled head, and turns with easy friction in a sleeve fixed to a support *S*.

The current passes into this support, the spring *R*, the button *B* and the membrane *M*. A very light shock acting on this membrane is wholly transmitted to the button *B*, which suddenly leaves the membrane and breaks the circuit. This is automatically re-established by means of the antagonistic spring *R*, so that after each shock the apparatus is ready to work anew. As compared with the one used until now this apparatus is of extreme sensitiveness. For example, the former has been made to work by striking a spade with a hammer. As soon as the source of sound is distant $2.^{m}5$, the old apparatus no longer works, while the new has given results for distances of the source of sound up to 25m.





The disjunctions obtained with the LeBoulengé chronograph have been satisfactory, without its being necessary to take special precautions for adjustment. In fact, it has been found enough to merely move the button *B* of the membrane by turning the milled head of the rod *T*, until a sharp noise indicated that contact was established.

Trials made with the Schultz chronograph have shown that under these conditions the circuit is re-established at the end of from o .2 to o'5, according to the adjustment. It is therefore indispensable to add to this apparatus when put in the circuit of a Schultz chronoscope, an arrangement securing a more rapid automatic re-establishment. M. Cousin has added a little device acting as a current-indicator, by means of which the current is re-established in o'.003 or o'004 after breaking.

This device consists of the current-indicator already described. When the circuit is broken the armature of the electro-magnet is drawn back by the antagonistic spring, and engages between the elastic tongues whose tension may be regulated by means of a thumb-screw. The contact thus obtained re-establishes the current by derivation. The tension is so regulated that at the moment of rupture due to the escape of the armature, the attractive force of the electro-magnet is not great enough to bring it back. In order that the apparatus be ready to work anew, the armature is set free by a metallic rod.

In order to secure more completely the re-establishment of the current, and to prevent a premature return of the armature, at the instant of its contact with the edges of the elastic tongues, M. Cousin has made the magnet and armature independent one of the other by insulating the support of the latter by means of an ebony plate. The intensity of the new current is maintained by the introduction into the circuit closed by the armature at the moment when the bobbin-circuit is broken, of a resistance equal to that of the bobbin.

OBJECT OF THE SUBSTITUTION OF THE PROPOSED METHOD FOR THAT OF THE TARGET-FRAMES.

The method of target-frames mentioned above, gives in all the cases to which it applies, excellent indications enjoying the great advantage of being among the most direct possible.

The deduction of the velocity v depends in fact, entirely upon knowing the distance d between the interrupter-frames, and the interval of time θ between the two breakings, the interval being given by the chronograph.

If we wish from the velocity v to pass to the initial velocity V_0, it is necessary to know besides, two other elements, to-wit: the distance x from the muzzle of the gun to the middle point of the space between frames; and the coefficient b of the resistance of the air for the projectile used—V_0 is then deduced from the relation

$$V_0 = v_x e^{bx} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

which supposes the resistance to vary with the square of the velocity. This coefficient b may be obtained from special tables, based upon the experiments made up to date on the atmospheric resistance. Now these tables have been computed for a mean projectile, and cannot apply to any projectile except through a coefficient λ, called the *coefficient of reduction*; b is then got from the formula,

$$b = \lambda . \frac{a^2}{p} . \sin \gamma . \Delta . f_H, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

in which

a=calibre.
p=weight.
γ=one-half ogival angle.
Δ=weight of a cubic metre of air.
f_H=function of the resistance, denoted by M. Hélie by $\frac{f(v)}{\sin \gamma}$.

In many cases this coefficient λ is not accurately known; it is then assumed equal to unity, and this assumption introduces no material error in the computation of V_0, provided v_x be measured at a distance x quite near to the muzzle (from 100m. to 200 m. for ogival projectiles).

When λ must be known, velocities are measured by means of the target frames at two points of the trajectory. We thus obtain two equations of form (3), leading to the simultaneous determination of V_0 and b or λ.

Now the methods of computation on which depends the preparation of ballistic tables, exact emphatically the determination of this element. This determination can be made directly only by experimentation on the law of the variation of the velocities of the projectile in its path. That sufficient accuracy may be reached in this investigation, it is necessary to deduce the coefficient of resistance for a very marked loss of velocity (about 100 metres), and if possible, to make two determinations of this coefficient in the same trajectory, in order to get a guarantee of its constant nature during the interval of velocity considered.

I shall now show what difficulties in these two classes of investigation are inherent in the method of target-frames.

Determination of Initial Velocities.—If V_0 be sought special firing is necessary. The angle of elevation can hardly be greater than 1° or 2°. Now in fire of this kind only one result is obtained—velocity; the other ballistic elements (ranges and times of flight) furnishing in this case, no check. When on the other hand the series of shots with a given calibre, necessary for the preparation of the tables has been completed, it must be admitted that the observed ballistic elements correspond to the velocity antecedently measured. Now in the present state of artillery experiments are very costly, especially with large calibres. Further, these experiments stretch sometimes over an interval of time so considerable—two or three months—that it is impossible during the period devoted to them, to guarantee as regards velocity, the constancy of the powder used.

If we add that in the marine artillery the frequent modifications of models in service, and of conditions of loading, result in reducing to a minimum the number of experiments serving as foundations for the corresponding variations in ballistic tables, we shall be driven to demand of this small number of experiments all the results they can yield; while on the other hand the application tion of the methods of calculation in vogue to-day, will become all the more trustworthy from the reduction in the number of unknown elements.

A method then, of deducing the initial velocity under *any angle whatever*, would permit on the one hand, the suppression of special fire for this purpose; and on the other, the concurrence of all ballistic practice in the determination of velocities, as well as the establishment of the changes undergone by the lot of powder used.

There would follow, economy and more accurate knowledge of the various ballistic elements belonging to a determined kind of fire.

Determination of Remaining Velocities.—I have mentioned above the necessity of knowing the coefficient of reduction.

In the present state of ballistic experiments, practice at ranges of from 2000 to 3000 metres, apparently necessary to carry out the programme laid down above, viz: the determination of remaining velocities at three points of a trajectory far distant from one another is very difficult, if not impossible, in view of the indispensably great height of the frames, to say nothing of the difficulty of hitting at long range, and of the resulting waste of projectiles.

A method which furnishes at a given point the record of the passage of a projectile, at no matter what height, is evidently free from these difficulties. By means of an apparatus like the Schultz chronoscope, such a method makes it possible to get as many remaining velocities along the trajectory as desired, as well as the time of flight between these points. Practice thus carried on at a range of about 3000 m. can be utilized to measure ranges and drift. Hence, from this point of view economy will result.

To sum this matter up: In offering this new method, I proposed to secure a substantial economy in practice carried on for the establishment of ballistic tables, by using one division of this practice to determine the coefficient of resistance and times of flight; and on the other hand, by making them all help in the determination of initial velocities. The two divisions thus saved can be thenceforth transformed into ballistic practice, and thus, for the same cost, notably increase the accuracy of tables.

It is a less direct consequence of this new method, that hereafter initial velocities can be measured in all practice under any angle whatever; this angle being fixed by the essential nature of the experimentation (as, in practice, when ricochets are avoided in order to recover the projectiles). We shall thus obtain by experiment the velocity heretofore sought by computation.

The amount of practice for determining velocity under very diverse conditions being thus largely increased, we shall have access to a wider induction for the study of the laws of the variation of velocity under the various conditions of practice. And so of the study of the laws of the resistance of the air—a study that must be undertaken to-day, in view of the high velocities developed by guns of the most recent model. It is this programme that I have endeavored to carry out in asking an examination of the methods whose details I shall now set forth.

DIVISION OF THE PROBLEM INTO TWO PRINCIPAL ONES.

From what has been just said the proposed problem may be divided into two chief ones, each involving special difficulties and special resources, and requiring the employment of different methods and apparatus.

Initial Velocities.—The measurement of initial velocities exacts the determination of only a single remaining velocity. I have said above that it is advantageous to measure this velocity near the piece. This advantage is still more marked in the new than in the old method. For, if it be intended that an interrupter be impressed on the passage of a projectile in its neighborhood, the distance from apparatus to projectile must not be too great, otherwise the intensity of the *sound of the projectile* would be too slight to work the interrupter.

Now, if the shot be fired at a high angle (20°–30°) it rises immediately to a great height; it is therefore necessary to put the interrupter near the piece in order to insure its working. Experiments have shown that a mean distance of 150 m. insured a good working of the interrupter, the projectile being fired under angles up to 26° from a gun of medium calibre (16 centimetres). This nearness to the piece results in the investigation of only that part of the trajectory stretching a short distance from the muzzle. The method of calculation may therefore be markedly more simple than in the general case.

The LeBoulengé chronograph, as modified by Bréger, is plainly pointed out as suitable for this measurement. It is extremely easy to work, and by one reading furnishes immediately the time of flight.

Remaining Velocities.—If it be proposed to determine several remaining velocities and times of flight, it is necessary to study the entire trajectory, involving more refined methods of investigation. The use of a chronograph reading continuously, is equally indispensable.

It may be remarked that in general the interrupters will not have to be altered. In fact, the elasticity of the membrane allows the re-establishment of the current in an extremely small interval of time; hence, all the interrupters may be strung on one and the same circuit working a single register of the Schultz chronoscope. No matter then how many velocities be measured, the number of wires is small and constant, which is not the case with the LeBoulengé, requiring four wires.

The distance of the interrupters from the muzzle is no longer now a hindrance to their working. For these instruments are actuated by the sound of the projectile, which will as a rule never pass more than 100 metres off. Fire of this sort must always be such as to secure a flat trajectory in order that the remaining velocity may not fall much below 400 metres about, a limit not to be transcended if good observations are desired.

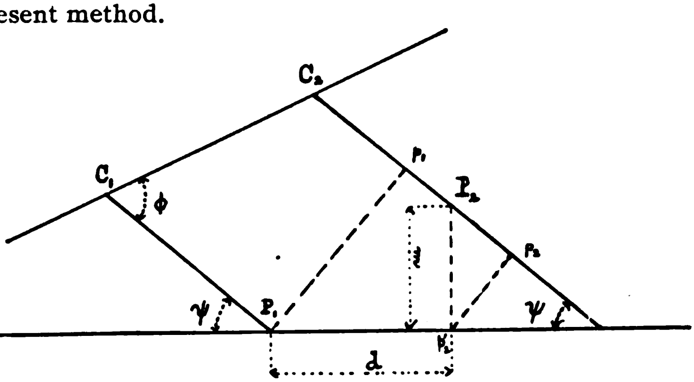
In actual practice, only the first of these problems has been exhaustively studied. I give the methods to be followed in order to combine the results of experiments bearing on the second. These last are too few in number to warrant a connected investigation.

ANALYTICAL INVESTIGATION.

Equation (2)

$$v\,\theta = d,$$

given above and relating to the target frames, has its analogue in the present method.



Let C_1 C_2 be the tangent to the trajectory; P_1 P_2 the positions of the two interrupters; d their horizontal distance apart; m their difference of level; P_1 C_1 and P_2 C_2 two right lines making with the tangent the angle φ defined by the equation

$$\cos\varphi = \frac{a}{v} \quad . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \quad (1)$$

The two points P_1 P_2 are supposed near enough to make this assumption legitimate. Mach's undulation is sensibly a right line normal to P_1 C_1. The time θ is that elapsed between the moments when this wave reaches P_1 and P_2 respectively. The interval p_1 P_2 will be passed over with constant velocity a; hence,

$$a\theta = p_1 P_2 = p_1 p_2 - P_2 p_2 = d \cos \psi - m \sin \psi.$$

If we put

$$\tan \zeta = \frac{m}{d} \quad . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \quad (5)$$

the preceding equation becomes

$$d \cos (\psi + \zeta) = a\theta \cos \zeta \quad . \; . \; . \; . \; . \; . \; . \; . \quad (6)$$

Call τ the inclination of the tangent to the trajectory, then

$$\psi = \varphi - \tau \quad . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \quad (7)$$

If we have $m = d \tan \tau$, (6) becomes

$$d \cos \varphi = a\,\theta \cos \tau,$$

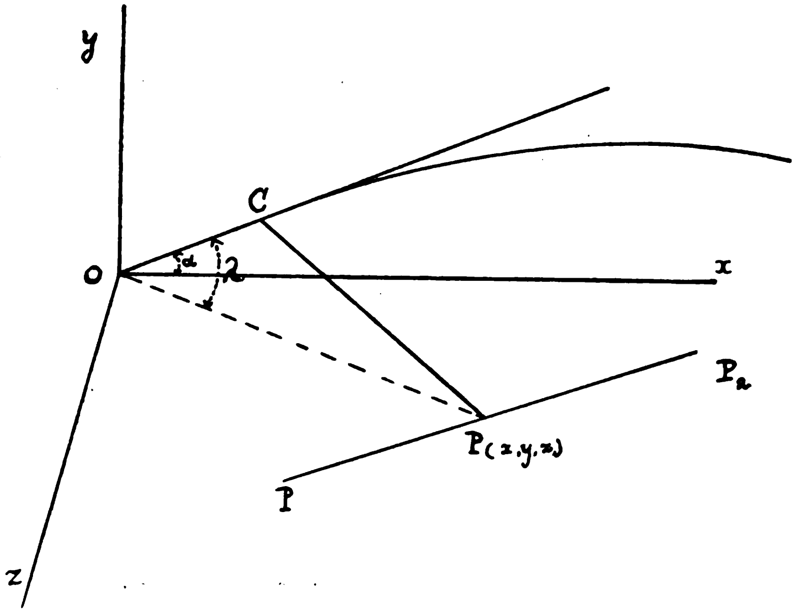
and in the case where the trajectory is flat enough to make $\cos \tau = 1$, we have

$$\theta v = d \quad . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \quad (2)$$

Hence, in this particular case the apparatus will work just as frames would at the same point. The same conclusion holds if $\tau = o$, *i. e.*, if the middle of the interval between the interrupters coincide with the summit of the trajectory; we shall see below how this condition may be realized.

A more general case may occur in which the two pieces of appatus are not in the plane of fire. For example, should it during a course of ballistic fire be expedient to change slightly the direction of fire without touching the apparatus, it is useful to be able to make use of their readings.

Let us consider three rectangular axes, having for origin the muzzle of the piece.



The axis Ox is horizontal and in the plane of fire. Let $O\,C$ be the tangent to the trajectory at the origin. We shall suppose the interrupters near enough to the muzzle to consider the elementary arc $O\,C$ as rectilinear. P_1 P_2 are the positions of the apparatus, P the mid-point of the right line P_1 P_2. Make x, y, z, the co-ordinates of P, λ the angle $C\,O\,P$, δ the distance $O\,P$; the same letters affected with the subscripts 1 and 2, will denote the corresponding elements of P_1, P_2.

When the apparatus—both pieces—are in the plane of fire, we have,

$$a\,\theta = d\cos(\varphi - \tau) - m\sin(\varphi - \tau);$$

We have to find the equivalent of this relation in the general case. The preceding formula expresses the condition that the projection of P_1 P_2 on $C\,P$ is traveled over with constant velocity in the time θ. From this property we deduce in the general case,

$$a\theta = \delta_2 \cos(\varphi - \lambda_2) - \delta_1 \cos(\varphi - \lambda_1) \quad . \quad . \quad . \quad . \quad . \quad (8)$$

This equation defines the angle φ. We must in the first place determine δ_1, δ_2, λ_1, λ_2. These elements are obtained by the ordinary formulas of analytical geometry. Thus

$$\left.\begin{array}{l} \delta^2 = x^2 + y^2 + z^2 \\ \delta \cos \lambda = x \cos a + y \sin a \end{array}\right\} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (9)$$

By writing λ, δ, x and y with suitable subscripts we shall obtain the desired elements. It is supposed that the co-ordinates of the apparatus have been measured on the field with reference to the chosen axes. In the particular case in which $z_1 = z_2 = o_1$, we obtain equation (1).

For (2) may be written:

$$\begin{aligned} a\theta &= \cos \varphi \, [\delta_2 \cos \lambda_2 - \delta_1 \cos \lambda_1] + \sin \varphi \, [\delta_2 \sin \lambda_2 - \delta_1 \sin \lambda_1] \\ &= \cos \varphi \, [(x_2 - x_1) \cos a + (y_2 - y_1) \sin a] \\ &\quad + \sin \varphi \, [(x_2 - x_1) \sin a - (y_2 - y_1) \cos a] \\ &= (x_2 - x_1) \cos(\varphi - a) - (y_2 - y_1) \sin(\varphi - a). \end{aligned}$$

in which, $x_2 - x_1$ is the horizontal distance apart d of the apparatus, and $y_2 - y_1$ the vertical distance apart m.

a is substituted for τ in virtue of the accepted hypothesis of the rectilinearity of the trajectory from O to C. This particular case is very important in the sense that it is the one of the most frequent occurrence. It is to be noticed that the formula no longer depends on the absolute co-ordinates of the apparatus, but on their relative positions. We have here an important simplification, since it is in this case unnecessary to know the difference of level of the muzzle with reference to the interrupting membranes.

We may wish to find the condition that (1) will depend only on the relative positions of the two apparatus, that is, on the differences of their co-ordinates.

That formula may be written:

$$\begin{aligned} a\theta = \cos \varphi \, &[(x_2 - x_1) \cos a + (y_2 - y_1) \sin a] \\ &+ \sin \varphi \, [\delta_2 \sin \lambda_2 - \delta_1 \sin \lambda_1]; \end{aligned}$$

we also have,

$$\begin{aligned} \delta^2 \sin^2 \lambda &= \delta^2 - \delta^2 \cos^2 \lambda \\ &= x^2 + y^2 + z^2 - (x \cos a + y \sin a)^2 \\ &= (x \sin a - y \cos a)^2 + z^2. \end{aligned}$$

Put

$$z_1 = K(x_1 \sin a - y_1 \cos a)$$
$$z_2 = K(x_2 \sin a - y_2 \cos a);$$

then

$$\delta \sin \lambda = (x \sin a - y \cos a) \sqrt{\{1 - K^2\}}.$$

In this case $a\theta$ depends only on the differences $x_2 - x_1$, $y_2 - y_1$; that is, on the interval between the two groups and on their difference of level.

We have therefore after putting $K = \sin x$,

$$a\theta = (x_2 - x_1)[\cos \varphi \cos a - \cos x \sin a \sin \varphi]$$
$$-(y_2 - y_1)[\sin a \cos \varphi - \sin x \cos a \sin \varphi].$$

The coefficients of $x_2 - x_1$, $y_2 - y_1$, are respectively the cosines of angles ψ and ψ_1 of spherical triangles, so that we may write

$$a\theta = (x_2 - x_1) \cos \psi - (y_2 - y_1) \cos \psi_1$$

a form already met with.

The condition,

$$z = K(x \sin a - y \cos a)$$

asserts that the two apparatus are in the same plane with the right line OC.

Let us suppose that they are originally in the plane of fire, and at a difference of level such that we have

$$\frac{x_1}{x} = \frac{y_1}{y} = \frac{z_1}{z}$$

which supposes them and the gun in the same straight line. If we displace the plane of fire, the apparatus will remain very sensibly in the same place as $O\,C$; in this case, calling β the angle between the new and old planes of fire, and putting for the sake of compactness

$$\cot x = \cos \beta \cot \zeta \quad \ldots \ldots \ldots \ldots \quad (10)$$

as well as

$$\cos \lambda \sin x = \sin \zeta \cos (a - x) \quad \ldots \ldots \ldots \quad (11)$$

we reach the final equation

$$a\theta \cos \zeta = d \cos (\varphi - \lambda) \quad \ldots \ldots \ldots \quad (12)$$

Computation of the angle τ.—Equations (6) or (12) give the angle $\psi = \varphi + \tau$ to determine φ, whence we may deduce the velocity v by means of the equation

$$a \sec \varphi = v; \quad \ldots \ldots \ldots (1)$$

we must therefore compute τ. I shall give the general formulas leading to this computation.

We know that for velocities greater than 400 m., the resistance of the atmosphere may be supposed proportional to the square of the velocity. Further, in virtue of explanations already made, the trajectory may always be supposed very flat between the muzzle and the point C, either because C is very near the muzzle (as in the measurement of initial velocities), the firing taking place under any angle; or, because C being very far from the muzzle, this angle is small (6° to 7°).

In these two cases we may accept the hypothesis of Didion to facilitate the integration of the equations of motion. We shall even see that in the first case the trajectory may without difficulty be considered rectilinear between O and C.

These conditions premised, we have in the general case

$$u = a \cos \tau \sec \varphi \quad \ldots \ldots \ldots (13)$$

$$u_0 = u\Phi \quad \ldots \ldots \ldots (14)$$

$$\tan \alpha - \tan \tau = \frac{g x}{u_0^2}(1 + f) \quad \ldots \ldots \ldots (15)$$

$$y = x \tan \alpha - \frac{g x^2}{2 u_0^2}(1 + F) \quad \ldots \ldots \ldots (16)$$

in which,

x and y = rectangular co-ordinates of the point C.
x_0 = abscissa of P (half way between apparatus).
u = horizontal component of the velocity at C.
u_0 = horizontal component of the muzzle velocity.
$\tan \tau$ = angular coefficient of tangent at C.
$\tan \alpha$ = angular coefficient of tangent at origin.
Φ, f, F = modifying functions introduced by the resistance of the air into the equations *in vacuo*. These functions have the following values:

$$\Phi = e^z; \ 2\, z(1+f) = e^{2z} - 1$$
$$2\,(1+F)\, z^2 = e^{2z} - 2\, z - 1, \text{ and } z = b\,\beta\, x.$$

It is expedient to express the condition that C is on the right line CP; this condition gives from (16)

$$x \tan \alpha - \frac{g\, x^2}{2u_0^2}(1+F) = (x_0 - x)\tan \psi \quad \ldots \ldots \quad (17)$$

Eliminating u and u_0 between (13), (14) and (15), then between (15) and (17), we deduce

$$\sin(\alpha - \tau) = \frac{g}{a^2}\,\frac{\cos \alpha}{\cos \tau}\cos^2 \varphi \left\{ \frac{1+f}{\Phi^2} \right\} x \quad \ldots \quad (18)$$

$$1 - \frac{x_1}{x} = \left\{ \frac{1}{2}\,\frac{1+F}{1+f} \right\} \frac{\sin(\alpha - \tau)}{\sin(\alpha + \psi)}\,\frac{\cos \psi}{\cos \tau} \quad \ldots \quad (19)$$

with

$$x_1 = x_0 \frac{\sin \psi \cos \alpha}{\sin(\alpha + \psi)} \quad \ldots \ldots \ldots \ldots \quad (20)$$

x_1 being the approximate value of x obtained in taking as rectilinear the part of the trajectory comprised between O and C. For the elimination of u_0 between (15) and (17) leads to

$$\frac{x\,(\tan \alpha - \tan \tau)}{x\,(\tan \alpha + \tan \psi) - x_0 \tan \psi} = 2\,\frac{1+f}{1+F};$$

for $\tau = \alpha$, we have

$$x = x_0 \frac{\tan \psi}{\tan \psi + \tan \alpha} = x_0 \frac{\sin \psi \cos \alpha}{\sin(\alpha + \psi)},$$

a relation which may anyway be obtained directly without difficulty.

The computation will now be made as follows: By means of (20) the approximate value x_1 of x is determined; this value makes possible the evaluation of $\alpha - \tau$ by supposing in the second member of (18),

$$\tau = \alpha_1 \text{ and } \beta = \frac{1}{\cos \alpha},$$

Carrying into the second member of (19) the values of τ and of $x = x_1$, we get a more approximate value of x which allows us to return to the computation of τ by substituting for β the value

$$\beta = \frac{(\alpha) - (\tau)}{\tan \alpha - \tan \tau},$$

and for x its value just determined.

(a) designates symbolically the integral

$$\int_0^a \frac{d\tau}{\cos_2{}^3}$$

Calculation of V_0.—Having obtained final values for τ and x_1, we have v from the formula

$$a \sec \varphi = v,$$

and V_0 from

$$V_0 = a \sec \varphi \cos \tau \sec a \, \Phi \, . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \quad (21)$$

We may bring out clearly the values of the modifying functions peculiar to the law of the square; we have then

$$z = b \beta x,$$

$$\beta \sin (a - \tau) = \frac{g}{b a^2} \frac{\cos a}{\cos \tau} \cos^2 \varphi \, e^{-z} S h z \, . \; . \; . \; . \; . \quad (22)$$

or

$$\beta \sin (a - \tau) = \frac{g}{b V_0^2} \frac{\cos \tau}{\cos a} e^z S h z \, . \; . \; . \; . \; . \; . \; . \; . \quad (23)$$

Eq. (22) is used when ψ, Eq. (23), when V_0 is known. In the case where C is very near the muzzle we may write simply

$$z = b \beta x_1 = b x_0 \frac{\sin \psi}{\sin (a + \psi)} \, . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \quad (24)$$

the angle τ is deduced then by (22), in which we suppose as a first approximation, answering all purposes anyway: $\varphi = \psi + a$, $\tau = a$, $\beta = \sec a$. V_0 then comes from the equation

$$V_0 = a \sec \varphi \cos \tau \sec a . \, e^z \, . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \quad (25)$$

These calculations when so abridged are very short. They will nevertheless be made for only a single velocity, in general the mean of those measured. The differences between the successive velocities and the mean are obtained from the easily demonstrated differential equation.

$$\frac{d V}{d \theta} = - \frac{V_0 \tan \varphi}{\theta \tan \psi} \, . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \quad (25)$$

The second member being very sensibly constant during one experiment, it will suffice to prepare a table of the multiples of this quantity in order to get $d \, V$ from $d\theta$.

Influence of wind.—The velocity a of sound must be modified according to that of the wind. It is admitted that it becomes $a \pm W_1 \cos \psi$ according as the wind is rear or head. The preliminary calculations having been made before knowing W_1, the mean velocity will be suitably corrected by the formula

$$\frac{dV}{V} = -\frac{da}{a} \frac{\sin \tau}{\sin \psi \cos \varphi} \quad \ldots \ldots \ldots \ldots (27)$$

or, if $da = \pm W_1 \cos \psi$:

$$\frac{dV}{V} = \pm \frac{W_1}{a} \cdot \frac{\sin \tau}{\tan \psi \cos \varphi}.$$

This relation which supposes $m = o$, shows the feeble influence of da in the case of very flat trajectories, or whenever τ is near o (summit of the trajectory). This influence increases with the angle of projection. It will be therefore advantageous to make the determination of velocities only in comparatively calm weather. This rule, which ought anyway to apply to ballistic firing, will be always observed when velocities are measured.

Particular Cases.—Let us consider a few particular cases. Let it be proposed, the initial velocity being approximately known, to determine before firing, the mean distance, the interval between the pieces of apparatus or the time of flight θ. We shall suppose as approximately known, the mean distance x_0, in general from the lie of the land in the neighborhood of the piece or else because it is assumed outright.

The value of z being

$$z = b\, x_0 \frac{\sin \psi}{\sin (a + \psi)} = b\, x_0 \frac{\sin (\varphi - \tau)}{\sin \varphi},$$

let us in the second number make $\tau = a$, and $\varphi =$ value deduced from

$$a \sec \varphi = V_0.$$

This premised, we have

$$\sin (a - \tau) = \frac{g}{2b\, a^2} \frac{\cos^2 a \cos^2 \varphi}{\cos \tau} (1 - e^{-2z}) \quad \ldots (28)$$

$$\cos \varphi = \frac{a \cos \tau\, e^z}{V_0 \cos a} \quad \ldots \ldots \ldots \ldots \ldots (29)$$

The elimination of φ between the two equations gives

$$\sin(\alpha - \tau) = \frac{g}{2\,b\,V_0^2} \cos\tau\,(e^{2z} - 1) \;.\;.\;.\;.\;.\;.\; (30)$$

From this equation τ will be deduced by substituting in the second number for $\cos\tau$, $\cos\alpha$; then from (29) φ follows, and therefore

$$\psi = \varphi - \tau,$$

x_0 will then come from the equation.

$$z = b\,x_0 \frac{\sin\psi}{\sin(\alpha + \psi)} \;.\;.\;.\;.\;.\;.\;.\;.\;.\;.\;.\;.\;.\; (31)$$

and finally d or θ from the equation

$$a\theta \sec\psi = d.$$

We shall now suppose that initial velocities are measured under the conditions hitherto imposed by the use of target frames. This case will present itself whenever it is proposed to find a charge satisfying given conditions of velocity or pressure. In this case the velocity may change at each round. The special conditions of this kind of firing permit a simplification of this mode of calculation. We shall suppose the apparatus so arranged that $\tau = o$. Hence equation (30) becomes

$$2\sin\alpha = \frac{g}{b\,V_0^2}(e^{2z} - 1) = \sin 2\alpha \;.\;.\;.\;.\;.\;.\;.\; (32)$$

and in this particular case.

$$z = b\,x_0 \;.\;.\;.\;.\;.\;.\;.\;.\;.\;.\;.\;.\;.\;.\;.\;.\;.\; (33)$$

similarly

$$a\theta = d\cos\varphi,$$

whence

$$v = \frac{d}{\theta} \;.\;.\;.\;.\;.\;.\;.\;.\;.\;.\;.\;.\;.\;.\;.\;.\;.\;.\; (34)$$

The velocity v for $\tau = o$ (summit of the trajectory) is deduced then immediately from the height of fall measured by the chronometer. In view of the flatness of the trajectory, one may cause this velocity to correspond to the distance x_0, and the initial velocity is then calculated by the ordinary method.

This condition may be realized by equations (32) and (33). For x_0 is known, being given by the problem. From (33) we get z and from (32) the angle of projection α, corresponding to the velocity V_0 sought. It is indispensable that the apparatus be at the same level.

If the velocity be notably increased during the series of experiments, the angle of projection α will be modified by the differential formula:

$$d\alpha = -\left(\frac{1}{V_0} \tan 2\alpha\right) dV \quad . \; . \; . \; . \; . \; . \; . \; . \; . \; . \quad (35)$$

The quantity within parentheses may be calculated before the firing, and we shall then have the variation $d\alpha$ corresponding to a variation of 10 metres, for example, in the velocity.

Limiting Angle.—There exists for a given initial velocity an angle of projection that can not be exceeded if it be desired to register the remaining velocity of the projectile.

The formula

$$a\theta = d \cos \psi,$$

shows that if ψ is to be real,

$$\theta < \frac{d}{a}.$$

In the limiting case when $a\theta = d$, we have $\psi = o$, $z = o$, $\tau = \varphi = \alpha$, and hence

$$V_0 = a \sec \alpha.$$

In this limiting case the point C coincides with the muzzle. The interrupters then register the velocity of sound within the conditions of the experiment.

The limit fixed by the preceding equation may be passed by giving to the second interrupter a height greater than that of the first. Under ordinary experimental conditions, a difference of level of 4 metres between interrupters is admissible; this allows the imposed limit to be increased by about 5°. It must further be noticed that for an initial velocity of 400 metres to a velocity of sound, $a = 340$ metres we have

$$\alpha = 32° \text{ (about)}.$$

If V_0 is greater than 400 metres, a will be greater than 32°. We may then consider the method of measurement as applicable under all angles of fire employed by proving boards, for initial velocities greater than 400 metres.

In order to simplify computations by means of formulas (22) to (25), I have computed the tables below giving the logarithms of the functions

$$e^z \text{ and } f(z) = e^{-z} \, S h \, z.$$

Should these tables not be extensive enough, the computation of $f(z)$ will offer no difficulty if the table of hyperbolic functions given in the collection of Houël be used, As for the value of $\log e^z = M$, it may be found in any logarithmic table as a function of z. The tables of $\log(1+f)$ and $\log(1+F)$ given below, are from the treatise on ballistics by N. Wuich. The table of the values of a as a function of the temperature is taken from Rex's logarithmic table, and completed by interpotation.

[TO BE CONTINUED.]

OUR ARTILLERY ORGANIZATION.

By First Lieutenant W. A. SIMPSON, Adjutant, Second Artillery, U. S. A.

Our artillery has had practically its present organization for over seventy years, long enough for its merits and demerits to be well tested. In that time it has passed through two wars, besides Indian wars in which portions of it have been engaged. Throughout the greater portion of this period it has been practically infantry. In the organization act of 1821, it was provided that one company of each regiment should be organized and equipped as a company of light artillery; this was not done until nearly twenty years later. The service of the artillery was mainly as infantry in both periods of the Florida War. In the war with Mexico there were a few light batteries, and some siege artillery was employed; but the greater part of the service of the artillery was as infantry. During the War of the Rebellion the active field service of the regular artillery was almost, if not entirely, that of horse or field artillery. The batteries were scattered among the different armies, the battery,—never the regiment,—being the unit.

It may be well to consider briefly the working of the regimental organization in time of peace. I shall, naturally, have most in view my own regiment, with whose history I am most familiar, but its experience is not peculiar. What is true of the 2d is true, in the main, of all.

The batteries of a regiment are seldom all stationed at the same post under direct command of its colonel. The 2d Artillery, with the exception of a short time about 1838, has never had all its batteries together unless collected for transportation on a change of station. Not only is it true that seldom has more than a fraction of the regiment served at the same post together, but this fraction has rarely exceeded one-third.

As might be expected the position of regimental commander does not imply great powers of command. A thorough search of the army regulations fails to show him to be vested with any real authority. Paragraph 216 says: "He should continually labor for the instruction and efficiency of his regiment; he should encourage among his officers harmonious relations and a friendly spirit of emulation in the performance of duty. His timely interference to prevent disputes, his advice to the inexperienced, and immediate censure of any conduct liable to produce dissension in the regiment or to reflect discredit upon it, are of great importance in securing and maintaining its efficiency. In such efforts he is entitled to the assistance of every one of his subordinates."

Paragraph 217 makes the colonel superintendent of instruction of the officers under his control. This function was really due to his position as post—not regimental commander, and the recent order in regard to the establishment of officers' lyceums, makes it directly the function of the post commander.

Paragraph 221 gives the colonel authority to inspect batteries of his regiment not at headquarters—when he can get an order from higher authority to do so. If he finds anything to criticise he can report it to higher authority, as any other inspector could. He is not invested with any authority over these batteries. If he finds the time allotted to drill, for instance, insufficient, he cannot order it to be increased. That would be an infringment of the prerogatives of the post commander. Should the post be garrisoned entirely by batteries of his regiment and commanded by one of his field officers, he could still give no orders as to the drills, &c., to be carried on. No matter how desirous the colonel might be that the batteries thus stationed should reach a certain standard, he could do nothing by his own orders to effect such a result. The post commander would be the man who would be held responsible, and not the regimental commander.

The colonel appoints the non-commissioned officers of his regiment. As a captain is justly held responsible for the discipline and efficiency of his battery and for the instruction of his non-commissioned officers, it would be manifestly unfair not to allow him to select them; and as a matter of fact it is very rarely that the recommendations of a battery commander as to his non-commissioned officers are not concurred in. This power of the colonel's is then, almost nominal.

The colonel makes recommendations for transfer of officers to and from Fort Monroe, and the light batteries and between foot batteries. These recommendations being made, the War Department is at liberty to concur in them or not. The colonel selects his regimental staff and non-commissioned staff officers. Certain reports are forwarded through him to higher authority. These are about all the powers of a colonel. If there is any real, substantial command of a regiment of artillery, a command due to the grade of colonel and not to an assignment as post commander, I cannot find what it is. Even if all the batteries of a regiment were stationed at headquarters they would only be a collection of batteries; they might as well belong to different regiments; they would not form a unit, for military command, for any but infantry purposes. The same remarks to a certain extent would apply to a regiment of infantry or cavalry, separated at different posts, but not to one collected. It is designed to act in time of war as a unit, under command of its colonel, and could be tactically instructed as such a unit in time of peace. All regimental instruction would have a definite object and would be utilized in time of war.

If the evils of regimental organization for the artillery existed only in time of peace, this article would not be written. What does history show as to its efficiency in time of war? It would be laughable were it not deplorable.

In the War of the Rebellion the battery was the unit. The regiment had its batteries scattered over the whole theatre of operations, from the Potomac to the Gulf. There was no approach to a regimental organization for active service, nor to a fraction larger than a battery. Was a battalion or brigade of light artillery formed, it was composed of the batteries most convenient, no two of the same regiment, and commanded generally by the senior captain or some other officer assigned, without any reference to or thought of the regiment to which he belonged. The fact that no two of the batteries belonged to the same regiment, was of no greater importance than the fact that the regiments forming a division of infantry were not all from the same state. There was no semblance of any legitimate sphere of action for any regimental field officer of artillery except the colonel, —no command that he could claim by virtue of his rank. I say, except the colonel; he still commanded his regiment. How? If he were old, infirm, utterly incapacitated for active service, he remained at regimental headquarters, established at some distant fort, far from the scene of active operations, and, assisted by the regimental staff, received the battery monthly returns at very irregular intervals, depending upon the state of activity of the batteries, consolidated them, and forwarded the regimental return with other regimental papers to the Adjutant General. They no doubt exercised in addition, important functions which had to be done by some one, but these were exercised as post or district commanders, under perhaps volunteer commissions, and their garrisons were composed of volunteers. Had they been younger and in good physical condition, they would have been corps or army chiefs of artillery (if they served with the artillery at all) and would have been doing legitimate artillery work—but they would then have been carried on the regimental returns as on detached service, and I do not know who would then have commanded the regiments.

All who read the Military Service Institute Journal know the views on the subject of Generals Hunt and Tidball, who were distinguished artillery officers, served throughout their military career in that arm, and always had its best interests at heart.

If then, the regimental organization for the artillery is poor in peace and absurd in war, why should it be continued? I ask this question with all due deference to the late Honorable Secretary of War, who in his report for 1891, page 13, says in reference to the artillery, "From a purely military standpoint the organization of this arm is not defective."

Now let us consider how the artillery as a whole has fared under its present organization. All orders in regard to its instruction and practical work emanate from Headquarters of the Army. Until quite recently there has been no one in authority who seemed to concern himself at all about the efficiency of artillery as artillery. There was no general scheme of artillery target practice and no concern for armament or fortification. Our forts were not improved and no attention was paid or effort made to get a modern armament. The artillery was employed in any kind of duty but artillery duty. The personnel became expert in the use of the Springfield rifle, which is the last weapon they would be called upon to use in a general war, and knew but little about their own arm. Much of the artillery was stationed for years at posts where there was no artillery matériel but a reveille gun. The spectacle was seen of men serving whole enlistments without seeing a cannon other than the above mentioned field-piece, and of a captain of artillery, serving almost constantly with his regiment who, up to the year of our Lord 1890, had never seen a seacoast gun fired.

Latterly we have seen some improvement, owing to the fact that we have now a commander-in-chief who has paid some attention to the artillery. What has been done shows how much more could be done, and how much better had we a corps organization and an energetic chief. General orders for artillery instruction and practice have been issued. Detailed orders were to be issued by regimental commanders, giving chances for want of uniformity. Each division inspector carried out his own ideas as to details, and they differed in their views as to the construction to be placed on the general orders from the Adjutant General's Office. Should a change occur in the command of the army, we might have for a successor some one who took no interest in the arm, and then might drift back to the old condition of things, under which it was possible for artillery officers to serve fifteen or twenty years with their regiments, and never see a shot fired at a target from a battery of position.

I have thought that had we long ago had a corps, with a chief at the seat of government we should be to-day in much better condition. I think so still. But it has occurred to me that there is a much more potent cause than bad organization for our backward condition to-day with respect to heavy artillery.

Whatever the general nature of a war, the part taken in it by sea-coast defenses is, as the name shows tactically defensive. In the war of 1812 British fleets sailed along our coasts without molestation from the land. They sailed up Chesapeake Bay and had Washington at their mercy. The result was that after the war the question of sea-coast defense was a burning one, and there were planned and built the Forts Warren, Adams, Hamilton, Monroe, etc., which were models in their day and thought to be impregnable. They must have cost, what, compared to the resources and wealth of the country then, would be a sum greater than the most ardent advocate of sea-coast defense would dream of asking for to-day. In our Indian wars they were not needed. Our war with Mexico was carried on in the enemy's country. Our last war, terrible struggle as it was, was fought with an enemy having no navy, and our sea-ports were never thought to be in danger. So our forts, strong as they were when built, are no better absolutely, and a thousand times worse relatively, to-day, because they have not in all these years been proved to be be necessary.

Now, things are changing. People are beginning to realize that our sea-ports need defending, and that adequate defense cannot be improvised at short notice. If we get these defenses we want a proper personnel. We need a corps organization, with a chief, a central head. He would be at army headquarters, at the seat of government. I regard this one thing as above all most important. With a representative head to look after our interests, to recommend proper legislation, to insist and keep on insisting on proper armament, modern guns and modern ammunition, everything else would follow.

A corps organization, with due proportion of field officers, directly responsible to the chief, would be flexible and adjustable without friction, to any system of sea-coast defense. As it is now, commanders of adjacent forts are independent of each other. Any one of our important harbors would have several forts, batteries or turrets. One might require two batteries, another three, another four, larger ones many more batteries to defend them. The regimental organization would not work as well as the corps organization. The senior officer should command all the works that would cooperate in the defense. If a small work in the harbor was garrisoned by two batteries, it would be the appropriate command of a major. The more important the work the higher the grade. Each captain would command his battery and have charge of a group of guns. The chain of command would run right up from the captain to the post commander, to the harbor commander, to the chief, who would have the same relation to the commander-in-chief that a chief of artillery of an army in the field has to the commander of that army.

The light and horse artillery should have a distinct organization of their own. There is much more similarity in the functions of mounted artillery and cavalry, than between mounted and sea-coast artillery. Their kinds of work and spheres of action are entirely different. If we had a modern defensive system and a modern armament, with all its expensive and complicated accompaniments, any officer would have all the work he needed to perfect himself in their use, and having attained some degree of proficiency, it would be folly to detach him and send him for a tour of duty with a light battery, or *vice versa*.

This is a very large subject and cannot be thoroughly treated in an essay. I hope this paper though, will have some effect in turning the attention of artillery officers to the subject, and in helping to convince them that what we want is a corps organization with a chief of artillery, and a permanent divorce of the personnel of sea-coast from field and horse artillery. The latter, on account of the smallness of the army cannot be hoped for, but the former I think can, if the artillery think it necessary, and will work for it with a united front.

RANGE TABLES FOR THE 12-INCH CAST-IRON B. L. MORTAR.

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

The following range tables for the 12-inch cast-iron B. L. mortar, which has been adopted for the defence of our more important harbors, have been prepared in advance of complete experimental data, to serve as aids for studying the best means of using these mortars in action. Seventeen tables are given for as many different ranges. Beginning with an extreme range of five miles, the other ranges decrease by a regular difference of one-fourth of a mile (440 yards) to the inferior limit of one mile. For each of these ranges the tabular argument is the angle of elevation which, beginning at 30°, increases by a constant difference of 2½ degrees up to 60°. These tabular differences both of range and elevation are so small that the quantities depending upon them—muzzle velocity, time of flight, angle of fall, striking velocity and energy—can be accurately determined for intermediate values of the arguments, by proportional parts, as in a table of logarithms.

These tables show at a glance that to provide for the various ranges which it may be necessary to employ between the limits of five miles and one mile several different muzzle velocities are required; and the selection of the most suitable of these muzzle velocities and the preparation in advance of the proper charges to secure them are matters of the first importance. The following table easily prepared by interpolation from the range tables, is given merely as an illustration of the changes required in the muzzle velocity as the range decreases. Various other similar tables can be constructed by taking muzzle velocities corresponding to 60°, or any other elevation—though 45° is probably on the whole the best angle for mortar firing, except for short ranges.

But whatever charges may be decided upon, it is of vital importance that they give the required muzzle velocities with the least possible variations; since a given variation of muzzle velocity in mortar firing produces a much greater variation in range than the same variation does in direct fire. For example the tables show at once, by interpolation, that for a range of 3 miles, a variation of 100 yards in range is produced by variations of from 8 to 9 foot-seconds in the muzzle velocities, varying slightly with the elevation;—while for the same range a variation of 10 f. s. in the muzzle velocity of a 12-inch projectile fired from the new B. L. rifle with a muzzle velocity of 1975 f. s., would cause a variation in range of only 43 yards.

Table of muzzle velocities and angles of elevation corresponding to different ranges.

RANGE (miles)	MUZZLE VELOCITY	ANGLES OF ELEVATION			
		°	′	°	′
5	1030	45			
4¾	"	53	32	34	36
4½	"	57	30	30	34
4¼	936	45			
4	"	54	22	33	49
3¾	"	58	39	29	31
3½	836	45			
3¼	"	55	33	33	00
3	766	45			
2¾	"	56	24	32	04
2½	692	45			
2¼	"	57	39	31	00
2	611	45			
1¾	"	59	06	29	40
1½	566	60			
1¼	513	60			
1	456	60			

The theoretical drift of the projectiles to be fired from these mortars (which are 2½ calibres long), is given in the following table for a few ranges and elevations:

TABLE OF DRIFT.

RANGE (miles)	DRIFT TO THE RIGHT IN YARDS, AT ELEVATIONS OF:—		
	30°	45°	60°
5	107	258	778
4	84	197	755
3	60	143	440
2	40	95	288

These computed deviations agree fairly well with those observed at Sandy Hook by the Ordnance Board in 1885–6, while firing similar (but lighter) projectiles from a M. L. rifled mortar of the same calibre and length of twist as those we have been considering*. The change in azimuth necessary to correct the drift for any range and elevation can easily be computed from a complete table of drift, which however it is hardly worth while to prepare at present. The only necessary uncertainty in pointing mortars is due to the effect of the wind in drifting them from the plane of fire and in increasing or diminishing the range. The wind effect might, indeed, be approximately determined and provided for if we knew in advance its mean direction and velocity for the entire range. These data are difficult to procure for long ranges even in direct fire; and in mortar firing they seem to be entirely beyond our reach.

We know that the direction and velocity of the wind at the surface of the earth give no indications, generally, of what they are at a height of one or two miles; and these altitudes must be considered in laying mortars for ranges exceeding three or four miles. Take an extreme case: To attain a range of five miles with an elevation of 60°, the 12-inch projectile would reach an altitude of 12600 feet; and during forty seconds of its flight would be more than a mile high. Taking into account the powerful but unknown currents to which the projectile may be subjected during this

*Report of Chief of Ordnance for 1886.

comparatively long interval, it is apparent that any prediction of where it will strike the ground must be pure guess work.

In view of what has been said the following procedure recommended by General Abbot, is probably the best available:* "The Captain would take his station at a point from which he could see the enemy engaged at some work, as, for example, at countermining in our mined channel. From his chart and a position-finder he would determine the elevation, charge and azimuth for a trial shot. Giving his orders by telephone, he would watch the splash of the shell, and, estimating the deviation, would give orders for the second shot accordingly. Having succeeded in dropping one shell in close vicinity to the enemy, he would order the whole battery to adopt the same elevation, charge and azimuth, and to fire by volleys of four or of sixteen mortars, as seemed best."

RANGE 5 MILES. (8800 YARDS.)

Angle of Elevation φ	Muzzle Velocity V	Time of Flight T	Angle of fall ω		Striking Velocity v_ω	Total striking energy per inch of shot's circumference E_1	Vertical striking energy per in. of shot's circumference E_2
°	f. s.	"	°	'	f. s.	f. t.	f. t
30	1102	32.3	35	09	855	84.8	28.2
32.5	1078	33.9	37	49	847	82.7	31.1
35	1059	35.5	40	27	840	81.3	34.2
37.5	1045	37.2	43	02	835	80.2	37.4
40	1035	38.9	45	35	832	79.7	40.7
42.5	1030	40.7	48	06	832	79.7	44.2
45	1030	42.5	50	35	836	80.4	48.0
47.5	1034	44.4	53	02	844	81.9	52.4
50	1042	46.4	55	28	857	84.5	57.3
52.5	1055	48.6	57	53	871	87.0	62.5
55	1073	50.9	60	16	887	90.5	68.2
57.5	1097	53.4	62	37	906	94.6	74.7
60	1128	56.1	64	58	931	99.8	82.0

*Defence of the Sea-Coast of the United States, by General H. L. Abbot, U. S. Army. New York, D. Van Nostrand, 1888.

RANGE 4¾ MILES. (8360 YARDS.)

φ	V	T	ω		v_ω	E_1	E_2
°	f. s.	″	°	′	f. s.	f. t.	f. t.
30	1069	31.4	34	55	841	81.4	26.7
32.5	1046	33.0	37	35	830	79.3	29.5
35	1027	34.6	40	12	823	77.9	32.5
37.5	1013	36.2	42	48	819	77.2	35.6
40	1004	37.9	45	21	817	76.8	38.9
42.5	1000	39.6	47	52	817	76.8	42.3
45	1000	41.4	50	21	820	77.4	45.9
47.5	1003	43.3	52	49	827	78.8	50.0
50	1011	45.2	55	15	838	80.8	54.6
52.5	1023	47.3	57	40	851	83.3	59.5
55	1040	49.5	60	04	866	86.3	64.8
57.5	1063	51.9	62	26	885	90.1	70.8
60	1093	54.6	64	47	909	95.1	77.8

RANGE 4½ MILES. (7920 YARDS.)

φ	V	T	ω		v_ω	E_1	E_2
°	f. s.	″	°	′	f. s.	f. t.	f. t.
30	1035	30.5	34	41	825	78.3	25.4
32.5	1013	32.0	37	20	814	76.1	28.0
35	995	33.6	39	57	806	74.6	30.8
37.5	982	35.2	42	33	801	73.9	33.7
40	973	36.8	45	06	799	73.4	36.8
42.5	969	38.5	47	37	799	73.4	40.1
45	969	40.2	50	07	802	74.1	43.6
47.5	972	42.0	52	35	809	75.3	47.4
50	979	43.9	55	01	818	77.1	51.7
52.5	990	45.9	57	26	830	79.3	56.3
55	1007	48.1	59	51	845	82.1	61.4
57.5	1030	50.5	62	14	864	85.9	67.2
60	1058	53.0	65	35	887	90.5	73.9

RANGE 4¼ MILES. (7480 YARDS.)

φ	V	T	ω		v_ω	E_1	E_2
°	f. s.	"	°	'	f. s.	f. t.	f. t.
30	1001	29.6	34	26	808	75.1	24.0
32.5	979	31.1	37	05	797	73.1	26.6
35	962	32.6	39	42	788	71.5	29.2
37.5	949	34.1	42	17	782	70.4	31.9
40	941	35.7	44	51	779	69.8	34.7
42.5	937	37.3	47	22	779	69.8	37.7
45	936	39.0	49	52	782	70.4	41.1
47.5	939	40.7	52	20	788	71.5	44.8
50	946	42.6	54	47	797	73.1	48.8
52.5	958	44.5	57	13	808	75.2	53.2
55	974	46.6	59	38	823	77.9	58.0
57.5	995	48.9	62	01	842	81.6	63.5
60	1022	51.4	64	23	864	85.9	69.8

RANGE 4 MILES. (7040 YARDS.)

φ	V	T	ω		v_ω	E_1	E_2
°	f. s.	"	°	'	f. s.	f. t.	f. t.
30	966	28.6	34	11	789	71.6	22.6
32.5	945	30.0	36	50	778	69.6	25.0
35	928	31.5	39	27	769	68.0	27.4
37.5	916	33.0	42	02	762	66.8	29.9
40	908	34.5	44	36	758	66.1	32.6
42.5	904	36.1	47	08	759	66.2	35.6
45	903	37.7	49	37	762	66.8	38.8
47.5	906	39.4	52	05	768	67.9	42.2
50	913	41.2	54	33	776	69.3	46.0
52.5	924	43.1	56	59	787	71.3	50.1
55	940	45.1	59	24	801	73.9	54.7
57.5	960	47.3	61	48	819	77.2	59.9
60	986	49.8	64	11	840	81.3	65.8

RANGE 3¾ MILES. (6600 YARDS.)

φ	V	T	ω		v_ω	E_1	E_2
°	f. s.	"	°	'	f. s.	f. t.	f. t.
30	931	27.7	33	57	768	67.9	21.2
32.5	910	29.1	36	35	757	66.0	23.4
35	894	30.5	39	12	748	64.4	25.7
37.5	882	31.9	41	47	741	63.2	28.0
40	874	33.4	44	20	737	62.5	30.5
42.5	870	34.9	46	52	737	62.5	33.3
45	870	36.4	49	22	740	63.0	36.3
47.5	873	38.0	51	51	746	64.0	39.5
50	879	39.8	54	18	754	65.4	43.1
52.5	890	41.6	56	44	764	67.2	47.0
55	905	43.6	59	10	778	69.6	51.4
57.5	925	45.8	61	35	795	72.6	56.3
60	949	48.1	63	59	815	76.4	61.7

RANGE 3½ MILES. (6160 YARDS.)

φ	V	T	ω		v_ω	E_1	E_2
°	f. s.	"	°	'	t. s.	f. t.	f. t.
30	895	26.7	33	43	747	64.2	19.8
32.5	875	28.0	36	20	735	62.1	21.8
35	859	29.4	38	56	726	60.6	23.9
37.5	848	30.8	41	31	720	59.6	26.2
40	840	32.2	44	04	716	59.0	28.6
42.5	836	33.6	46	36	716	59.0	31.1
45	836	35.1	49	06	718	59.2	33.9
47.5	839	36.6	51	35	723	59.9	36.9
50	845	38.3	54	03	730	61.2	40.1
52.5	855	40.1	56	30	740	63.0	43.8
55	869	42.0	58	56	754	65.4	48.0
57.5	888	44.1	61	21	770	68.3	52.6
60	911	46.3	63	46	789	71.6	57.6

RANGE 3¼ MILES. (5720 YARDS.)

φ	V	T	ω		v_ω	E_1	E_2
°	f. s.	″	°	′	f. s.	f. t.	f. t.
30	857	25.7	33	28	725	60.5	18.4
32.5	839	27.0	36	05	713	58.5	20.3
35	824	28.3	38	40	704	57.0	22.3
37,5	813	29.6	41	15	697	55.9	24.3
40	806	30.9	43	48	693	55.3	26.5
42.5	802	32.3	46	20	693	55.3	28.9
45	801	33.7	48	50	695	55.6	31.5
47.5	804	35.2	51	19	699	56.2	34.2
50	810	36.9	53	48	705	57.2	37.2
52.5	819	38.6	56	16	715	58.8	40.6
55	832	40.4	58	42	728	61.0	44.5
57.5	850	42.3	61	08	744	63.7	48.8
60	872	44.5	63	34	762	66.8	53.6

RANGE 3 MILES. (5280 YARDS.)

φ	V	T	ω		v_ω	E_1	E_2
°	f. s.	″	°	′	f. s.	f. t.	f. t.
30	819	24.6	33	12	701	56.6	17.0
32.5	801	25.8	35	49	689	54.7	18.7
35	787	27.1	38	24	680	53.2	20.5
37.5	777	28.3	40	58	673	52.1	22.4
40	770	29.6	43	32	669	51.5	24.4
42.5	767	30.9	46	04	669	51.5	26.6
45	766	32.3	48	34	671	51.9	29.1
47.5	768	33.8	51	04	674	52.3	31.7
50	774	35.4	53	33	680	53.2	34.4
52.5	782	37.0	56	01	690	54.7	37.6
55	795	38.7	58	28	702	56.8	41.2
57.5	812	40.6	60	55	717	59.2	45.2
60	833	42.7	63	21	735	62.1	49.6

RANGE 2¾ MILES. (4840 YARDS.)

φ	V	T	ω	v_ω	E_1	E_2
°	f. s.	″	° ′	f. s.	f. t.	f. t.
30	780	23.5	32 57	676	52.6	15.6
32.5	763	24.7	35 33	664	50.8	17.1
35	750	25.9	38 08	655	49.4	18.8
37.5	740	27.1	40 43	648	48.3	20.5
40	733	28.3	43 16	644	47.7	22.4
42.5	730	29.6	45 48	643	47.6	24.5
45	730	30.9	48 18	645	47.9	26.7
47.5	732	32.3	50 49	648	48.3	29.0
50	737	33.8	53 18	654	49.2	31.6
52.5	745	35.4	55 46	662	50.5	34.5
55	757	37.0	58 13	674	52.3	37.8
57.5	773	38.8	60 41	688	54.6	41.5
60	793	40.8	63 08	706	57.4	45.6

RANGE 2½ MILES. (4400 YARDS.)

φ	V	T	ω	v_ω	E_1	E_2
°	f. s.	″	° ′	f. s.	f. t.	f. t.
30	740	22.3	32 41	650	48.6	14.2
32.5	724	23.4	35 17	637	46.8	15.6
35	711	24.6	37 52	628	45.4	17.1
37.5	701	25.7	40 26	622	44.5	18.7
40	695	26.9	42 59	618	33.9	20.4
42.5	692	28.1	45 30	617	43.8	22.3
45	692	29.4	48 01	618	44.0	24.3
47.5	694	30.7	50 32	621	44.3	26.4
50	699	32.1	53 02	626	45.1	28.8
52.5	707	33.6	55 30	635	46.3	31.6
55	718	35.2	57 58	646	48.2	34.6
57.5	733	37.0	60 26	659	50.2	37.9
60	752	38.8	62 54	675	52.5	41.4

RANGE 2¼ MILES. (3960 YARDS.)

φ	V	T	ω		v_ω	E_1	E_2
°	f. s.	"	°	'	f. s.	f. t.	f. t.
30	698	21.1	32	26	621	44.4	12.8
32.5	683	22.2	35	01	609	42.7	14.1
35	671	23.3	37	36	600	41.4	15.4
37.5	662	24.4	40	10	594	40.6	16.9
40	656	25.5	42	43	590	40.1	18.4
42.5	653	26.7	45	14	589	40.0	20.1
45	652	27.9	47	45	589	40.0	21.9
47.5	654	29.1	50	16	592	40.2	23.8
50	659	30.3	52	46	597	41.0	26.0
52.5	666	31.7	55	15	605	42.2	28.5
55	677	33.3	57	43	616	43.7	31.2
57.5	691	35.0	60	12	628	45.4	34.2
60	708	36.7	62	40	642	47.4	37.4

RANGE 2 MILES. (3520 YARDS.)

φ	V	T	ω		v_ω	E_1	E_2
°	f. s.	"	°	'	f. s.	f. t.	f. t.
30	655	19.9	32	11	589	40.0	11.3
32.5	640	20.9	34	46	578	38.5	12.5
35	629	21.9	37	20	570	37.4	13.7
37.5	621	22.9	39	53	564	36.5	15.0
40	615	24.0	42	26	559	35.9	16.4
42.5	612	25.1	44	57	557	35.7	17.8
45	611	26.2	47	28	557	35.7	19.3
47.5	613	27.3	49	59	560	36.1	21.1
50	617	28.5	52	29	565	36.8	23.1
52.5	624	29.8	54	58	573	37.9	25.3
55	634	31.3	57	27	583	39.2	27.8
57.5	647	32.8	59	56	595	40.7	30.4
60	663	34.2	62	25	607	42.5	33.3

RANGE 1¾ MILES. (3080 YARDS.)

φ	V	T	ω		v_ω	E_1	E_2
°	f. s.	″	°	′	f. s.	f. t.	f. t.
30	609	18.6	31	57	554	35.3	9.9
32.5	596	19.5	34	31	544	34.1	10.9
35	586	20.5	37	04	536	33.1	12.0
37.5	578	21.4	39	37	530	32.3	13.1
40	572	22.4	42	10	525	31.7	14.3
42.5	569	23.4	44	41	523	31.5	15.5
45	568	24.4	47	12	523	31.5	16.9
47.5	570	25.5	49	42	525	31.7	18.5
50	574	26.6	52	12	530	32.3	20.2
52.5	581	27.8	54	42	537	33.2	22.1
55	590	29.2	57	11	546	34.3	24.2
57.5	602	30.6	59	40	557	35.7	26.5
60	616	32.2	62	09	569	37.3	29.1

RANGE 1½ MILES. (2640 YARDS.)

φ	V	T	ω		v_ω	E_1	E_2
°	f. s.	″	°	′	f. s.	f. t.	f. t.
30	560	17.1	31	42	516	30.6	8.5
32.5	549	18.0	34	14	506	29.5	9.4
35	540	18.9	36	47	498	28.6	10.3
37.5	533	19.7	39	21	492	27.9	11.3
40	527	20 6	41	53	488	27.4	12.3
42.5	524	21.5	44	24	486	27.2	13.4
45	523	22.5	46	55	486	27.2	14.6
47.5	524	23.5	49	25	488	27.4	15.8
50	528	24.6	51	55	492	27.9	17.3
52.5	535	25.8	54	25	498	28.6	18.9
55	543	27.0	56	54	506	29.5	20.7
57.5	553	28.3	59	24	516	30.6	22.6
60	566	29.6	61	53	527	32.0	24.8

RANGE 1¼ MILES. (2200 YARDS.)

φ	V	T	ω		v_ω	E_1	E_2
°	f. s.	″	°	′	f. s.	f. t.	f. t.
30	508	15.6	31	26	474	25.9	7.0
32.5	498	16.4	33	58	464	24.8	7.7
35	490	17.2	36	31	457	24.0	8.5
37.5	483	18.0	39	04	452	23.5	9.2
40	478	18.8	41	37	448	23.1	10.0
42.5	476	19.6	44	08	446	22.9	11.0
45	475	20.5	46	38	446	22.9	12.1
47.5	476	21.4	49	08	448	23.1	13.2
50	479	22.4	51	38	451	23.4	14.4
52.5	484	23.5	54	08	456	23.9	15.7
55	492	24.6	56	37	463	24.7	17.2
57.5	501	25.8	59	07	472	25.7	18.9
60	513	27.0	61	36	483	26.8	20.8

RANGE 1 MILE. (1760 YARDS.)

φ	V	T	ω		v_ω	E_1	E_2
°	f. s.	″	°	′	f. s.	f. t.	f. t.
30	454	13.9	31	09	427	21.0	5.6
32.5	443	14.6	33	42	419	20.2	6.2
35	435	15.3	36	14	412	19.6	6.8
37.5	429	16.0	38	47	407	19.1	7.5
40	425	16.8	41	20	404	18.8	8.2
42.5	423	17.5	43	51	403	18.7	9.0
45	423	18.3	46	21	403	18.7	9.8
47.5	424	19.1	48	51	404	18.8	10.7
50	426	20.0	51	20	406	19.0	11.6
52.5	430	20.9	53	50	410	19.4	12.7
55	437	21.9	56	20	417	20.0	13.9
57.5	446	23.0	58	49	425	20.8	15.3
60	456	24.1	61	18	435	21.8	16.8

THE CHILEAN NAVY.

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

The following notes include information relative to the Chilean Navy that is of interest to artillerists:

"In October 1884, the Government of Chile appointed a naval commission under the presidency of Rear Admiral Latorre, to determine the naval requirements of the state, and to devise a programme of new constructions, having in view the latent developments and designs in England, France and Germany."*

The commission recommended the construction of *one armored vessel, two protected cruisers, two gun vessels and two torpedo boats.*

The first three of these were built in France; the cruisers have been, and the battle ship will be delivered probably in a very short time. The torpedo vessels were built in England (Laird Bros.), and took part in the recent civil war, doing good work for the Balmacedists.

Including the above, the armored and protected vessels of Chile are as follows:

Capitan Prat—Battle Ship.

Dimensions.—Length, 328 feet; beam, 60 feet 8 inches; displacement, 6091 tons; draught, 21 feet 9 inches.

Speed.—17 knots under ordinary and 19 under forced draft; steaming radius 7000 miles at 10 knots.

Armor.—The protection for the hull consists of a complete steel water line belt over 6 feet 5 inches wide, with a maximum thickness of 11.8 inches; a complete protective deck, and a light central redoubt 3.94 inches thick and 134 feet long. All armor of Creusot steel*.

Armament.—Four 24 cm. (9.45 in.) Canet B. L. R., mounted in barbette turrets; eight 4.72 inch Canet R. F. G., in pairs in closed turrets; four 57 mm. and four 47 mm. R. F. G.; six Hotchkiss R. C.,; seven Maxim machine guns and four Canet torpedo tubes.

The four 24 cm. guns are arranged singly after the French system, in contradistinction to the English method of grouping the guns in pairs.

*Naval Intelligence Annual.

These rifles are of 40 calibre length, and the contract specifications require a muzzle velocity of 2400 f. s. with a projectile weighing 374 lbs. Smokeless powder will be used.

The turrets have Canet central loading tubes so the guns may be loaded in any position, and both guns and turrets may be worked either by electricity or hand.

A Fiske range-finder completes the outfit, and at last account the *Capitan Prat* was waiting only for this attachment before leaving for Chile.

Presidente Pinto and Presidente Errazuriz—Protected Cruisers.

Dimensions.—Length, 268 feet; beam, 35 feet 9 inches; displacement, 2080 tons; draught, 14 feet 5 inches.

Speed.—17 knots natural and 19 knots forced draft; steaming radius, 4500 miles at 12 knots.

Armor.—Both these cruisers are completely protected; thickness of steel not known, but probably about three or four inches.

Armament.—Four 15 cm. (5.91 in.) and two 12 cm. (4.72 in.) 36 calibre Canet B. L. R.; four Hotchkiss R. F. G. of 57 mm.; four 37 mm. H. R. C.; two 11 mm. Gatlings and three torpedo tubes.

The first of these cruisers completed the speed trials a little over a year ago with very satisfactory results, viz:—17.8 and 18.4 knots respectively, under natural and forced drafts.

The speed trial of the other cruiser was made last spring, but the results are not yet published.

Like those of the *Capitan Prat*, the guns and turrets may be worked either by hand or electricity.

Almirante Lynch and Almirante Condell—Torpedo Vessels.

Displacement.—735 tons.

Speed.—*Lynch* 21.22 and *Condell* 20.3 knots on speed trial; steaming radius, 2500 miles at 11 knots.

Armor.—Conning tower forward of 1-inch steel; steel hood aft to protect steering gear, torpedo apparatus, &c.; steel upper deck with oak sheathing; hatches protected from plunging fire by steel plates. A steel plating extends two-thirds ofthe length of the vessel protecting its vitals. There are forty-five water tight compartments.

Armament.—Five above water, powder impulse, Canet tubes, two on each side and one in the bow on the main deck; three 14-pounders; four 3-pounder Hotchkiss R. F. G., and several machine-guns.

This completes the list of vessels so far delivered under the Latorre contracts.

It will be remembered that the *Blanco Encalada* was attacked by these two torpedo vessels and sunk by a torpedo from the *Lynch*. Both torpedo vessels were injured but are now reported as in good condition.

Of the old Chilean Navy the following are either armored or protected:

Almirante Cochrane—Battle Ship.

Dimensions.—Length, 210 feet; beam, 45 feet 9 inches; displacement, 3560 tons; draught, 19 feet 8 inches.

Speed.—13 knots; steaming radius, 1900 knots at 10 knots per hour.

Armor.—Nine inches of iron at the belt and 8 inches of iron to protect the battery.

Armament (recently renewed).—Five 8-inch 14-ton Armstrong B. L. R.; a number of Hotchkiss 57 mm. R. F. G. and 37 mm. R. C. (revolving cannon). A sixth 8-inch gun may have been added, as the plan originally called for that number. This vessel was launched in 1875.

The Huascar—Monitor.

Dimensions.—Length, 300 feet; beam, 35 feet; displacement, 1800 tons; draught, 15 feet 6 inches.

Speed.—Twelve knots per hour.

Armor.—Four and one-half inches iron at belt, and 5½ inches on turret.

Armament.—Two 10-inch 12½-ton Armstrong M. L. R. and two 40-pounders.

This vessel was captured in the war with Peru, and at that time lost one of her guns by its recoiling overboard. The condition of this ship at present is not known.

Esmeralda—Corvette.

Dimensions.—Length, 270 feet; beam, 40 feet; displacement, 3000 tons; draught, 18 feet 3 inches.

Speed.—18.2 knots; steaming radius, 2200 knots at 10 knots per hour.

Armor.—Hull of steel; deck protected throughout by one inch of steel.

Armament.—Two 10-inch 25-ton and six 6-inch 4-ton Armstrong B. L. R.; two R. F. and six machine guns; three fish torpedo dischargers.

Magellanes.

Dimensions.—1230 tons displacement and 14 feet 9 inches draught.

Armor.—Composite gun vessel.

Armament.—One 7-inch B. L. R; one 64-pounder and 3 launching tubes. (This old ship has quite a fighting record.)

Abatao.

Composite vessel of 1050 tons displacement and draught of 15 feet 6 inches; carries three 8-inch, two 70-pounder and four 40-pounder Armstrong B. L. R.

O'Higgins.

Wooden vessel carrying three 7-inch and four 40-pounder B. L. R (Armstrong).

Pilcomayo.

Wooden ship (formerly *Peruvian*) carrying two 70-pounders and two 40-pounders (Armstrong).

Besides sail and merchant vessels, some of these acquired by ex-President Balmaceda, there are five gun boats of 7 to 10 knots; eleven first class torpedo boats 90 tons displacement, 100 feet long and speed of 22 knots; two second class torpedo boats of 40-tons displacement, 50 feet long and of 18 knots speed.

The despatch vessel *Amazonas* closes the list.

In this connection it will be of interest to note the capacity of our proposed sea-coast guns, Lieutenant Berry's chart of penetrations*, Captain Ingall's Handbook of Problems, and the following data furnish all that is necessary for ascertaining the ranges at which these guns, would be effective against such armor as that noted above.

The formulæ for steel penetration pre-supposes the use of armor piercing projectiles, such as the Holtzer forged steel or the Firminy projectiles.

The Carpenter projectile (Firminy process) is now manufactured in this country and promises to do well, so it is hoped that when the guns are ready the armor-piercing shot will not be wanting.

†PROPOSED ARTILLERY FOR U. S. SEA-COAST DEFENSE.

CALIBRE.	WEIGHT OF PROJECTILE (LBS).	MUZZLE VELOCITY.	
8″	300	1935 f. s.	Type gun undergoing test.
10″	575	1940 f. s.	Type gun undergoing test.
12″	1000	1940 f. s.	Now being tried at Sandy Hook.

Corresponding naval guns have projectiles a little lighter with a little greater muzzle velocity.

*See November number of the Journal of Military Service Institute.

†Ordnance construction note No. 53, May, 1890.

BOOK NOTICES.

FORTIFICATION:—Its Past Achievements, Recent Development and Future Progress, by Major G. Sydenham Clarke, C. M. G., Royal Engineers. London: John Murray, Albemarle Street, 1890, pp. xiv, 306.

The purposes of the author cannot be better stated than in his own preface. "The objects which the writer has kept in view may be briefly summed. It has been sought in the first place, to arrive at a just estimate of the war achievements of Fortification.

"Beginning with the sieges of Marlborough and Eugene, the history of Fortification in the Peninsula, the Crimea, the Russo-Turkish campaigns of 1828–9 and 1877–78, the Danish War, the American War of Secession, and the Franco-German War, are sketched in broad outline, and the general results criticized and compared. The evolution of the defense is traced down to the present day, and the many and various recent proposals are discussed in the light of such experience as is available. The principles which it is maintained should guide future progress, in view of the latest development of arms, are then defined.

"In the large portion of the work which deals with coast defense, prominence is given to the great practical experiment carried out at Alexandria in 1882, No secure basis on which to rest coast defense can be found without a careful study of the capabilities and disabilities of the modern ship of war. The evolution of armored navies is, therefore sketched, and a selection of types of British and foreign vessels is given. Appendices are added, in which the principal details of the armored ships of France and Russia are tabulated."

In accordance with the foregoing plan the first seven chapters are devoted to a comparative study of what fortification has done in the past, as a basis for what it may be expected to do in the future. In Chapter VIII a summary is given of recent proposals to meet the present conditions; in Chapters IX and X the author discusses the effect of the modern development of arms, magazine rifles, high angle fire, quick firing and machine guns, smokeless powder, high explosives, etc., and argues that the basis of the defense of a position should be infantry redoubts, supported by a powerful artillery kept altogether outside of them, and supplemented by a field force carrying on the outpost duties, and manning field defenses guarding the intervals. In submitting his case the author says:

"The principles which it has been sought to lay down, require in their practical application a higher standard of organization, both of men and matériel, than has usually been accorded to the defense. Fort building is not necessarily fortification, and lavish expenditure upon non-essentials can never atone for the absence of real preparation for war. The very elaboration and cost of the conventional defenses have tended to induce neglect of real requirements, and to foster the dangerous belief that any troops, commanded in any fashion, will suffice as garrisons. While, therefore, the tactics and organization of the attack have received much study, the conduct of the defense has been too generally left to chance, and the opinion of Frederick the Great, that everything depends upon the genius of the commander, rarely finds practical recognition.

"It is necessary to withdraw fortification from the dim realms of occultism into the light of common sense; to fling mere theory to the winds, and to seek a basis in the teaching of war alone. Then will the science emerge from the clouds of uncertainty which have too long obscured it.

"The principles which it has been sought to lay down may be expressed in a few words. The fortification which has given the most brilliant results in the past has been that of the soldier, not the professor. Take the best of that fortification, and carefully preserving all that conferred such great advantages upon it, add everything which time, both for labor and thought, renders possible. A Plevna thus completed, properly armed and fully organized, will fulfil all the requirements of defense; and, whatever may be the advances in the weapon of attack, can never become either so hopelessly inadequate or so difficult to renovate, as now are most of the masterpieces of the school men."

In the foregoing extracts the author gives us in his own words what he has wished to do.

In the remaining six chapters the evolution and principles of coast defense are discussed; the evolution of ships of war, their capabilities and vulnerabilities. Sfax, Alexandria; types English, French, Italian, Russian; functions of coast defense, armament, high-angle fire, quick-firing guns, distribution, dispersion, invisibility, mountings, magazines, parapets, lights, torpedoes, pneumatic gun, submarine mines, position-finding.

"No attempt has been made to lay down hard and fast rules. A 'typical defense' cannot be formulated, since the ruling conditions, hydrographic and topographic, differ widely, and each case must be considered on its own merits.

"While science has conferred great benefits upon coast-defenses, it has made new demands upon the defenders. To control and direct to the best advantage the various elements which go to the modern defense of a port is no easy task. An organization carefully developed in peace time, and a training at once thorough and all embracing, are more than ever needed. Failing such an organization and training, the full use of the powerful weapons which scientific progress has placed at our disposal is not merely debarred, but in the complication of these weapons there lies danger. The fighting organization of the port must be as complete as is that of the ship of war."

In his preface the author recognizes that some of his strictures upon the "théoriciens" may seem iconoclastic, and pleads necessity as his justification. For any apparent lack of dignified treatment, his manifest professional earnestness seems a very wide cloak. The book is attractive in form and substance; the illustrations throw light on the text; an excellent index completes the whole. This work is worthy of careful study.

J. D. B.

WAR—Reproduced with amendments from the article in the last edition of the "Encyclopædia Britannica," to which is added an Essay on Military Literature, and a list of books with brief comments, by Colonel F. Maurice, R. A., Professor of Military Art and History, Royal Staff College, pp xi, 155. London, MacMillan & Co., 1891.

Our thanks are due Colonel Maurice for reprinting with additions his article "War," from the ninth edition of the Encyclopædia Britannica. That article is too well known to need special mention here. All students of the military art, however, will be glad to have it in the compact and handsome book now before us. It is the additions chiefly that invite brief remark. These, barring a few changes in the original article, consist of an essay on military literature, followed by an annotated list of the more important works of military art and history in French, German and English, published since the time of Napoleon I.

For the essay itself we have nothing but praise. Clear and direct, it has a wider reach than is implied in its title. It is a guide, not merely in the choice of military works, but what is far more important, in the proper method of study of such works. It distinguishes the mere acquisition of information from the results that ought to follow acquisition, and that alone give life to information. This distinction in our opinion is too often lost light of, and yet upon its observance depends the benefit flowing from the study of military history. It is hardly possible to set the matter in a clearer light than by the following words of the author: "It is necessary in each separate case first to ascertain what the facts really were; secondly, to endeavor to ascertain what the causes were that led to the facts; and thirdly, to endeavor to draw sound conclusions for the future from the sequence of the facts upon the causes."

Lack of space forbids notice of other interesting features. It is gratifying however, to our professional pride, to find the author acknowledging the great benefit to be derived from a careful study of our civil war. He goes so far as to attribute in part, the success of the Germans and the reverses of the French, to the fact that the former had heeded while the latter ignored the lessons of this war.

Of similar interest to us are the remarks made by the author on the indifference of the English nation to its military affairs. For these remarks apply, *mutatis mutandis*, to our own people. What this indifference, possibly inherited by us, certainly emphasised by our supposed isolation, has cost in blood and treasure, is but too well known to the service.

The author expects his list of military works in the appendix to provoke criticism. It sins indeed, but chiefly by omission. For instance, the subject of coast-defense is unrepresented; but perhaps the list is intended to include only works of general application, besides those bearing on military history proper. Our war with Mexico is not even mentioned, and yet it is as worthy of study as most of the minor British wars since 1815, a full list of which is given. Mr. Ropes's careful studies are not included among the works bearing on the Waterloo campaign. Under "Fortification" we find no mention of the excellent work of MM. Plessix and Legrand-Girarde; while under "Maps and Atlases" we certainly have a right to expect some notice of the "Schlachten Atlas des Neunzehnten Jahrhunderts." Another omission is of an entirely different kind. Colonel Maurice declines to give the title of a memoir of D'Erlon's, because, having tried for many years and failed to get it, he thinks it would be of no service to his readers.

With one or two exceptions the defects mentioned are of slight importance, and all could be easily corrected in a second edition. They do not detract materially from the excellence of one of the most useful professional publications of the past year.

C. De W. W.

A Course of Instruction in Ordnance and Gunnery, by Captain Henry Metcalfe, Ordnance Department, U. S. Army, Instructor of Ordnance and Gunnery, U. S. M. A. Second edition, New York, John Wiley & Sons, 1891.

When Benton's ordnance and gunnery was first published, its excellence as a text-book was at once established. For many years the growth of artillery science had been relatively slow, consisting more in the improvement of old than in the introduction of new methods. Guns were all but universally smooth-bore muzzle loaders, small in calibre and easily manufactured. Gunpowder was the only explosive, and before General Rodman's classic researches, almost fixed in type. Steel was either unknown, or looked on with suspicion. In short, arms of precision with all they imply were unknown, and the present development of artillery science unthought of.

Under these conditions, it was possible for a single text-book to present both fully and accurately, the state of artillery science. It was possible in a single work not only to deduce principles, but also to describe their application with sufficient fulness to subserve most purposes of reference. And this was made all the easier from the simplicity of prevailing construction and appliances and from the limited choice of materials available.

To-day, however, it is for obvious reasons, a task of no ordinary difficulty to write a text-book of ordnance. A dilemma immediately presents itself. If, in a course limited by time and other considerations, certain branches of the subject be treated with a fulness commensurate with their importance, the remaining branches must necessarily suffer. If, however, all branches are represented, then they all suffer. A choice must be made, and when this choice is limited by the requirements of the Military Academy, we do not see how it can fall upon the second alternative. We cannot reasonably expect to-day any text-book to fill the place once occupied by Benton. Yet this is what Captain Metcalfe has tried to do by his treatise on Ordnance and Gunnery. The attempt is made in the small compass of thirty chapters, (600 odd 12mo pages) to cover the subject of artillery science as it exists to-day, to the extent of leaving no important branch of it unrepresented. In our opinion, this is attempting too much. In the praiseworthy desire to make the course complete, as defined above, thoroughness has been to a great degree sacrificed, in the sense that but little time is left for any branch.

If it be the object of the course in Ordnance and Gunnery at the Academy, in ten months to touch upon gun construction, armor, projectiles, exterior and interior ballistics, probabilities of fire, gun-carriages, explosives, gunpowder, metallurgy and all the other subjects that to-day go to make up what we have called artillery science, then it may be admitted that Captain Metcalfe's book will fulfil this purpose perhaps as well as any that could be got up.

But the purpose of instruction at the Academy now as always, is to give training rather than information, with the condition introduced that the training furnished shall put it in the power of the cadet to acquire in the future the professional information that he is expected to have. In our opinion this purpose is lost sight of when cadets are made to follow a course like that outlined in the work under review. The subject of Ordnance and Gunnery is too tremendous to be covered in the time represented by one hundred recitations. It would be far better to select, and give thorough training in, the fundamental branches of the subject, leaving to post graduate study the duty of working up the remaining branches according to the requirements of the respective arms of the service.

The course of Ordnance and Gunnery as shaped in the work we are considering, is however in marked advance over that of immediately preceding years. At the time we speak of, it was not only not up to the general standard of the Academy, but it was bad in itself. The text was Benton patched up in a vain attempt to bring it up to modern requirements. For the parts omitted were substituted others by different hands, resulting in a lack of unity, and of system. The instruction in ballistics proper, as a distinct element of the general subject, was almost *nil.*

Siacci's method having been adopted almost the world over, cadets were still solving trajectories for spherical shot, by Didion's Tables, while not unduly neglecting such professional matters as the color of ammunition boxes, and the constituents of the bullet lubricant to four places of decimals. Sarrau and Siacci were not so much as mentioned in the section-room; and there was the less excuse for this, as Siacci's method had been made known, first, by Lieutenant Mitcham in the report of the Chief of Ordnance for 1881, and two years later by the now well known work of Captain Ingalls, while Sarrau's Researches had been published in 1884 by the Naval Institute

In noticing Captain Metcalfe's book, our object has been more to consider its relations to the department of which it forms the text, than the book itself. We cannot help expressing our surprise however at the complete omission of Siacci's method. Further comment is made unnecessary by the circular printed in the foot-note*. We do not see either how the sections on drift and wind can be of much benefit to any one. They amount to barely more than the bare statement that such things exist. The formula for the permanent angle of indication is addressed to the gun-maker, not to the gun-user; while that for wind merely recites that the wind effect depends on the velocity and direction of the wind, and gives the impression that to allow for wind is altogether a very simple matter.

Under explosives, it is a clear deduction from the remarks on potential, that a lump of coal is not only an explosive but one of the best. The author apparently has arrived at the same conclusion, for we find anthracite coal in the same list with dynamite and nitroglycerine. It is surprising to find only nitroglycerine, gun-cotton, and their derivatives mentioned as the principal compound explosives. The formulas given for detonation by influence are altogether misleading. Any one who has ever witnessed this phenomenon is acquainted with its extreme capriciousness, and yet we have before us categorical formulas, without a single limiting circumstance or condition.

Text-books are almost necessarily compilations. In the one before us, the obligations under which the author rests, seem in many cases to deserve more specific recognition than is conveyed by the list of works consulted. The plates accompanying the text are admirable. It would be hard to find a text-book so fully, so clearly, so *really* illustrated.

C. DeW. W.

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*HEADQUARTERS U. S. MILITARY ACADEMY,

West Point, N. Y., November 21, 1891.

CIRCULAR }
No. 35. }

The Secretary of War has approved the recommendation of the Academic Board that "Practical Operations in Gun Construction," and "Sea Coast Guns in the U. S. Service," by Captain *L. L. Bruff*, Ordnance Department, Instructor of Ordnance and Gunnery, be substituted for certain matter of equivalent amount in *Metcalfe's* Ordnance and Gunnery. Also that *Ingalls'* System of Exterior Ballistics, so far as applicable, be substituted for *Niven's* Method as now taught, the text to be prepared by the Department of Ordnance and Gunnery.

BY ORDER OF COLONEL WILSON:

J. M. CARSON, JR.,
2d Lieutenant 5th Cavalry,
Adjutant.

OFFICIAL:

2d Lieutenant 5th Cavalry,
Adjutant.

SERVICE PERIODICALS.

Revue d'Artillerie.

OCTOBER, 1891.—A study of the effects of the high-explosive shell of the German field-artillery.

This is a shell (*spreng granate*) filled with some high explosive. Issued to the German field-artillery in 1890, it is intended especially to reach, thanks to the great dispersion of its fragments, troops sheltered in trenches or by parapets. A double-action fuze is fitted to it, the time fuze being employed against troops, after the range has been determined in the ordinary manner with ordinary powder shells. It is predicted for this projectile that it will cause a rapid evacuation of any epaulment, trench, or field-parapet against which it is used.

Réglette for field-artillery. Employment and destruction of foreign artillery material—German field-artillery.

A description of foreign artillery material and service, from the point of view of its use or destruction by the French.

Note on the tactical concentration of artillery fire. Naval gun-carriage for 14 c. gun, built by MM. Schneider & Co., for the Spanish Navy. Notes and book reviews.

NOVEMBER, 1891.—Sketch of a manual for the regulation of field-artillery fire in war. The object proposed is

First.—To simplify the rules as much as possible in order to facilitate their application to war.

Second.—To leave them so general, as to preserve a certain degree of flexibility of application.

Third.—To reduce to a minimum the time necessary to regulate the fire.

Employment and destruction of foreign artillery material—Austrian. R. F. guns of large calibre.

Begun in July, continued in September and finished in this number.

Notes.

DECEMBER, 1891.—Plan for fire direction in the German field-artillery,

Gives only general principles on which rests fire control, leaving particular applications to be determined by circumstances.

Employment and destruction of foreign artillery material—Italian field-artillery. Austrian 8 mm. repeating carbine, model 1890. Importance of smokeless powder in war.

(translation from Russian.)

Properties of new powder; immediate results of employment of, on battle-field. Use of smokeless powder in war: bearing on tactics of the three arms, as well as on each arm separately. 1. Infantry.

Notes and book reviews.

Revue Militaire de l'Etranger.

OCTOBER, 1891.—Velocipede service in foreign armies. Officers' schools in Holland.

NOVEMBER, 1891.—Organization in peace of Spanish Railway Military Service. Belgian rifle, model 1889. The expedition to Suakim, 1885.

DECEMBER, 1891.—Complementary officers of the Russian Army. German colonial troops. The school of application of Artillery and Engineers at Turin.

Mittheilungen ueber Gegenstaende des Artillerie-und Genie-Wesens.

NINTH NUMBER, 1891.—The fortifications on the French—German frontier, according to the latest authorities.

A description and study, with maps, of the defenses and communications of the French—German frontier.

On indirect field-artillery fire.

TENTH NUMBER.—On indirect field-artillery fire (continued).

ELEVENTH NUMBER.—The fortifications, &c., as above. On the most important international [redacted]-units.

TWELFTH NUMBER.—On the most important international [redacted]-units. The Italian siege-artillery park. The method of attack of General Von Sauer. Rock blasting under water. Incendiary compositions of antiquity and of the Middle Ages.

Notice of a paper of Berthelot, in the *Revue des deux Mondet*, August 15th, 1891.

Proceedings of the Royal Artillery Institution.

NOVEMBER, 1891.—Ranging a battery. The world's war-ships.

The first of a series of articles intended to furnish such information as regards appearance, &c. of ships, as will enable sea-coast artillerymen to recognize the type, and regulate their fire accordingly.

Extracts from the reports of the ordnance committee on experiments with siege material, carried on at Lydd in 1890. Comparative trial of steel bodied shrapnel, carried out at Shoeburyness in 1882—83.

States results of experiments made as described. Found that for 6'' and upward, the base was the best place for bursting charge; for 5'', results doubtful: for 4'', the head gave better results.

Practice at snow parapets (translation from the Russian).

DECEMBER, 1891.—The Cantor Lecture, 1890: William Sturgeon. The concentration of fire from forts. On the range indicator dial. Notes of two lectures of field fortifications, delivered at the School of Gunnery, Shoeburyness. The French manœuvres of 1891. Translations.

Aldershot Military Society.

No. XXXII.—Lecture: Saddles and saddlery, bits and bitting, by Veterinary Surgeon F. Smith.

No. XXXIII.—Lecture: Visual signalling, by Colonel Keyser, C. B., Inspector of Signalling.

No. XXXIV.—Lecture: Combined military and naval war operations, by Rear Admiral Colomb.

The United Service Magazine.

NOVEMBER, 1891.—Field Marshal Count Von Moltke on the Franco—German War of 1870—71. The dual nature of coast and harbor defense. The progress of modern tactics. Manning the navy. The conveyance of troops by sea. Forty-eight hours in a man-of-war. Russian Central Asia—a correction. On military weakness in India I. Soldiers' institutes. The recruiting question. Sandhurst and its legends.

DECEMBER, 1891.—Field Marshal Von Moltke &c. as above. The present fortifications of Constantinople and its environs, I (with map). Naval engineering in war ships. The conveyance of troops by railway. Soldiers' institutes. Our military weakness in India II. Sandhurst and its legends II. The progress of modern tactics II. The treatment of German soldiers. The French naval manœuvres of 1891 I. His day of honour.

Journal of the Royal United Service Institution.

OCTOBER, 1891.—The re-establishment of a separate navigating line in the royal navy. The military resources of the Island of Jersey. History of volunteering in India. French naval manœuvres of 1891. Heligoland—Its strategic importance to Germany. The French staff.

A short sketch of the growth of the French staff, followed by an elaborate analysis of its organization, as determined by the law of the 20th March, 1890.

NOVEMBER, 1891.—The feeding of seamen and marines on board H. M. ships, and those in the navy of the United States. On the entry and training of the naval executive. "That the re-establishment of a separate navigating line in the navy is unnecessary." Magazine rifles in war—a military prospect. Colonel Von Löbell's annual reports upon the changes and progress in military matters in 1890. The French naval manœuvres of 1891.

DECEMBER, 1891.—The question as to the military-political situation in the Mediterranean Sea. A light cavalry regiment on active service (with sketch-maps). Report made in the name of the commission of the budget charged with examining the "Projet de Loi" for fixing the "Budget Général de l'Exercice 1892." Mounted infantry patrols the necessary results of our present system of fighting. An artillery practice game. Notes on some recent experiments with the submarine sentry.

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FORT MONROE, VIRGINIA.

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SEA-COAST GUNS AND STEEL ARMOR.

By First Lieutenant ERASMUS M. WEAVER, R. Q. M., Second Artillery, U. S. A.

For more than thirty years the contest between guns and armor has been going on. At times the gun has been the acknowledged victor, and again the plate has been first. So regular indeed has been the pendulum like swing of advantage from the one to the other that an existing supremacy of either has seemed enough to initiate a corresponding advance of the other. Only a few years ago it seemed that the gun had fairly conquered the plate, and it was supposed that, in view of the improvements made in projectiles, it would, this time, retain its vantage ground for a longer period than usual. But, following the lead of Schneider and Company, of France, plate makers have, step by step, been able to give armor a position farther in advance of the gun and projectile than ever before. Were it not for the teachings of the past one might look for little material alteration in the present relations between gun and plate. It remains for the gun and projectile makers to meet the conditions established by the Annapolis trials of 1890 and the Indian Head trials of 1891. Until they do, the plates must be considered to have gained an advantage over both the gun and the projectile.

It will be the purpose of this paper to examine the relations existing between modern naval armor and the ordnance type-guns of 8-inch, 10-inch, 12-inch, and 16-inch calibre, which stand as the representatives of our future sea-coast armament.

Except where specially otherwise indicated in this paper vertical armor only is referred to, and the discussion will be limited to the guns named.

The ballistic elements of these guns are as follows:

	INITIAL VELOCITY.	WEIGHT OF PROJECTILE.
16-inch:	2000 f. s.	2300 lbs. * (proposed)
12-inch:	1930 f. s.	1000 lbs. † (one made)
10-inch:	1953 f. s.	571 lbs. † (one made)
8-inch:	1935 f. s.	300 lbs. ‡ (two made)

The effort has been made to secure the highest possible measure of projectile energy in these guns. It will be noticed that while the initial velocities are rather lower than the same calibres of the naval guns, the projectiles are considerably heavier. By thus securing energy through increased weight of projectile, there will be greater remaining energy at long ranges than would follow the use of higher initial velocities and lighter projectiles. The leading idea in the construction of the guns and in the adjustment of the relative weights of charge and projectile is, that the projectiles must be able to perforate ship armor at considerable distances, to pierce the outer steel covering that now coats the hulls of men-of-war and push on into the interior, between decks, where, by exploding the gun-cotton or other high explosive charge they carry, they will spread destruction of life, destroy the engines, dismount or render useless the armament. Such guns have in truth, no reason for their use on shore, in sea-coast defense, except the attack of armor carried by war vessels.

It will be understood that guns of such large calibre as these are not the best for use against *unarmored* ships, or the *unarmored portions* of partially armored ships. They ought, indeed, never to be used designedly to attack such targets. Smaller calibre, lighter guns, are better suited to this work. In such a case great

*From Fortification Boards' Report.
†From advertisement for bids issued by the War Department.
‡From published firing reports.

energy is not needed to drive the projectile to the interior of the ship, and by using smaller, quicker firing guns, a greater number of shots can be delivered in a given time, and, thus, the chances of reaching the vitals of the vessel proportionally increased. The introduction of unarmored cruisers and partially armored battle-ships has, indeed, given rise to the use of a special class of guns, so mounted and loaded and aimed and fired as to greatly increase the rate of fire; the calibres of these guns range from 3 inches to 5 and perhaps 6 inches and, therefore, have the penetration and shell power of field and siege pieces, which are amply sufficient for the work in hand. To these guns is entrusted the attack of unarmored parts.

While the question of horizontal armor is not to be treated in detail herein, it is proper, in this connection, to refer, in a general way, to the fact that the guns we are considering are not serviceable against deck armor.

The decks of all armored ships are now covered with horizontal armor of from 2.5 inches to 3.5 inches thickness. The direct fire of high-power guns is not effective against this when delivered from sites of ordinary height. The angle of fall of the 8 inch gun is less than 10° at 6000 yards, and at 4000 yards it is about 5°; the corresponding angles of fall for the larger calibres would, of course, be still less than these. If a projectile strike deck armor under an angle less than 30° with the face of the armor it will not bite into the armor but will ricochet off; and it has been estimated that at angles of about 10° it requires about four times the energy required for normal impact to break through the plate. These facts operate to exclude the guns in question from the attack of deck armor. Such armor must, in truth, be attacked by the high angle fire of howitzers or mortars, or, in special cases, by plunging fire from elevated sites.

It thus appears that the practical worth of high-power sea-coast guns rests solely on their capacity to perforate vertical side armor.

It must be remembered, also, as a fundamental principle, that in actual service we do not have either the short range or the normal impact of the testing grounds, but, on the contrary, normal impact will occur only as the rare exception; also the range at which the armor must be attacked by the gun will depend upon the positions battle-ships will find it to their advantage to take up, since the ship has the power of selection of position. This introduces the question of the actual range of combat between fort and ship, and it comes to the front in such a way as to require its treatment before the subject of gun power can be considered, for the point of real value is, the power of the guns measured by the energy their projectiles have on striking the armor.

RANGE OF COMBAT.

In case we should have occasion to go to war with a great naval power, and our coast should be threatened with attack by a hostile fleet, such an attack could have two and only two designs: 1. To land a large force of troops for military operations inland; 2. The destruction of property along the coast by bombardment. Landing and bombardment, these two, determine the kind of attack we should have to meet, and, reciprocally, the nature of our defense. In order to arrive at conclusions as to the fighting range of sea-coast guns it will be necessary to consider separately these two kinds of attack.

As to landings, it may be broadly stated that they are are not so much to be feared as formerly. Even in Napoleon's day it was thought to be a hazardous undertaking to transport an army to a distant hostile shore and land it there. It will not be forgotten how he looked upon the crossing of the English channel in 1804, when all of his energies were bent on invading England. How much greater would the undertaking be if the army were to be transported over an ocean! The telegraph and steam power have moreover immeasurably increased the advantages of the defense in this matter, over what they were at the beginning of the century. The all important point in case of an attempt to transport an army of invasion to a distance is, the time at which the movement becomes known to the defense, and the means the defense has of determining the point of landing and massing troops at that point.

However crafty the assailant might be, it would be impossible to prevent cable information reaching the defender of the inception and of every stage of development of the attempt. And long before the fleet could approach the shore every mile of coast would be under such observation as to make a surprise impossible. Regarding our own coast, it is easily granted that our railroad system would enable us to mass men at any point in such numbers that the odds against an invader would be simply overwhelming.

The navy, too, would find herein the opportunity of rendering important service. By means of a code of signals, the coast defense fleet could keep the shore defenders constantly informed of the movements of a hovering hostile fleet, and, unless overmatched by the convoy, it ought to be able to make the landing impracticable. Moreover, the faster boats could perhaps snatch a chance to dash in among the troop ships, or slip in among them under cover of fog or night, and work much damage, and, possibly, upset altogether the plans of the landing force.

There is so much to be risked and so little to be gained by this method of attack that no due temptation is offered to a commander to undertake it.

Attacks of the second kind, therefore, appear destined to play the most important part in future sea-coast warfare. No one doubts that our coasts offer sufficient temptation to a hostile fleet to try at the earliest possible moment an attack of this kind. Immediately on the declaration of war with any first class power our sea-coast cities would be exposed to bombardment. The problem of sea-coast defense is to meet with advantage an attack of this kind. In case the enemy's fleet defeats or breaks through the coast defense fleet, the shore forts must hold off the hostile vessels to a point such that the city behind the fort cannot be reached by high angle fire.

We thus arrive at the question: At what ranges will bombardments take place, and how far out from shore will vessels stand during bombardment?

It is at this point we come face to face with the marvelous developments of gun power and shell power during the last few years. The effect of the use of high explosives in shells is hardly yet fully appreciated by our civilian friends. Under former conditions when gunpowder made up the charge of the shell, its radius of destructive effect was so small that an immense number of shells had to be hurled into a city to work any serious damage, but with gun-cotton, melinite, emmensite, and similar explosives forming the charge of shells, the circle of destructive effect is so enlarged that a single battle-ship can in a few hours work a degree of ruin that formerly would have required a fleet. But more startling than this is the increase of range that has taken place. Within half a dozen years initial velocities of large guns have increased from 1800 feet per second to 2600 feet per second. Messrs Schneider and Company, of Creuzot, France, the makers of the plates used at Annapolis are gun makers also, and the firm has announced its readiness to furnish guns of 6-inch calibre, with a guaranteed minimum initial velocity of 2674 f. s., and 9-inch to 12-inch guns with a guaranteed minimum velocity of 2625 f. s.* The *Société des Forges et Chantiers de la Méditerranée* produces guns of the same standard. These are, of course, far in advance of the type-guns of our Ordnance Department. While they will perhaps be used against us, we can hardly hope to have such guns to reply to them. This paper therefore, accepts the standard of the present ordnance type-guns as a basis of defensive calculations.

Since the best guns will be used against us, we shall be forced to take *their* range as the initial consideration. A 12-inch Schneider gun under an angle of projection of 20° (average maximum angle used on board ship) will throw a 900-pound shell 10½ miles. There are many guns now mounted on battle-ships that have the power to throw projectiles ten miles, under maximum ship angles of projection. It has, indeed, come to be regarded as a fundamental principle in coast defense, that the shore defense must make all navigable water areas that connect with the sea and are within ten miles of the city, or the point defended, full of danger to all ships of the enemy. If an armor-clad ventures to anchor in any such water area or to manœuver in it, it ought to be exposed to a thoroughly effective fire. Assuming that the hostile ship will be exposed to a fire of this nature, and keeping in mind that its only object is bombardment of the city over the forts, *it will stand off as far from the shore batteries as it can and still reach the city*. Two considerations permit this: 1. The city is so large a target that accuracy of fire does not enter

*Naval Intelligence Annual, 1890.

as a leading factor; if the ship can only determine approximately the range of the city and its general direction, it can, almost with certainty, drop every shell into the city. 2. To the defense, accuracy is the one thing above all others that must be considered; if the ship is to be placed *hors de combat*, or compelled to retire and give up the bombardment, she must, to use Prince Hohenlohe's terse expression, be "hit and hit and hit." Now it is self evident that the nearer she stands to the fort the oftener will she be hit, and the further off she stands from the fort the fewer hits will be made by the same fire. It is, therefore, clear that this second consideration would lead the ship to stand as far as possible from the fort, and the first presents no strong reason for not doing so.

Nor will the ship be tempted to run in to close quarters with a view to silencing the fire of the fort. She cannot afford to do this; the relative advantages in such a combat are decidedly on the side of the fort. In the first place the fort can protect itself by metal-armor, earth, or concrete, *ad libitum*; it can, also, always mount more powerful guns than can be carried on board ship, and more of them than can be carried by one, or even several men-of-war; it is free to arrange its guns so as to give a concentrated fire on a ship at close range and on all accessible water areas; it will be within supporting fire of other adjacent forts; and prominently, above all, stands the crowning advantage, that shore fire, gun for gun, at all ranges, is immeasurably more accurate than ship fire, since the former takes place from an immovable platform, while the latter is always affected by the rolling and rocking of the ship. It may be safely said that no battle ship can stand up long at close quarters, against a modern fort properly armed and manned and fought, and no fleet can silence the fire of a series of such forts properly placed in supporting relations.

Everything points, therefore, to comparatively long range fire for guns mounted on the exterior line.

But how shall the limits of these ranges be established with any precision? In answer, it may be said, that each locality must be considered separately in all details of fire. In order to determine the range for any locality, we have only to take the coast-survey chart of the section, and from the particular city under consideration as a center described a circumference with a radius of ten miles; the distance of the prominent land points from the limits of this circumference, where it passes over navigable water, is the range at which the land defense for the point in question must be made. From Portland, Me., for instance, it will be found that the ten-mile circle passes out to sea fully 6000 yards beyond the nearest land point; it is evident, therefore, at Portland we must be prepared to fight at 6000 yards. At Boston the ten-mile circle passes about 4000 yards from the nearest land. The ten-mile circle from Brooklyn passes about 4000 yards south of Coney Island. These may be taken as fair examples of ranges along our coast, as they are, also the more important. The ranges of 4000 yards and 6000 yards will, therefore, be taken to represent the average ranges at which sea-coast forts on the exterior line will have to engage armored ships.

Before proceeding to the determination of the energy of sea-coast projectiles at these ranges, it will be convenient to take up, first, the subject of armor strength.

RESISTANCE OF STEEL ARMOR.

The effect obtained in normal fire against a steel or compound plate, depends essentially upon the quality of the projectile and the quality of the plate; besides, there are certain secondary phenomena, such as the formation of cracks in the plate and change of form of the projectile, which often completely modify the results. It is because of these factors that, until recently formulæ have not been found practicable. In case of very soft steel plates, in which cracks are not produced by single shots, it is thought by some that sufficiently accurate results can be obtained by using proper coefficients in the formulæ for forged iron, but, as yet, no satisfactory coefficients have been found. As the question is at present, when we wish to determine the strength of a steel plate, we can only calculate from the forged-iron formulæ, the effect that would be produced on a forged-iron plate of the same thickness by the projectile to be employed. To the values thus

determined a certain percentage of resistance is credited to the steel and compound plate. Krupp estimates that this percentage should be from 10 per cent. to 20 per cent. when the plate is attacked by projectiles that do not break up; others have placed it as high as 25 per cent. to 30 per cent. General Abbot has found by comparing a number of experiments that "a steel or compound plate rarely fails to yield to a projectile having an energy in foot-tons represented by sixty times the square of its thickness in inches;" but this rule fails to introduce the diameter of the projectile, and therefore must of necessity be inaccurate, if applied in a general way to all projectiles.

It requires a greater number of foot-tons to carry a large projectile through a given plate than it does a small projectile, but Krupp has pointed out that large calibre projectiles give relatively much better results against hard armor, for the reason that the strain upon the metal of which the projectile is made, decreases as the ratio of the diameter of the projectile to the thickness of the plate decreases, and therefore there is less tendency to change of form. From this it follows that thick plates are relatively more effective than thin plates; that is, assuming the same standard of metal, have a higher per cent. of resistance per unit of weight for a given calibre. Another point well established is, that a plate offers a greater absolute resistance to projectiles as the calibre of the projectile increases; this should be so, since penetration is, essentially, overcoming the force of cohesion existing among molecules at and about the point of impact, and as the diameter of the attacking projectile increases, for a given plate, the number of molecules distributed is increased.

The conditions now existing between armor and projectiles may be considered to have been introduced about the year 1888. Just before this time the Firminy, Holtzer and other projectiles had established their supremacy over the armor then made. To meet this Schneider made an important change in the manufacture of Creuzot plates. Also, for the first time, the manufacture of steel plates was seriously undertaken in England by Vickers, and the decline of the English compound plates became apparent.

Since 1888 the projectile has remained about the same, while there have been two decided steps in advance by armor, viz: 1. The use of nickel alloyed with steel. 2. The introduction of the Harvey face carbonization principle.

The nickel-steel armor was developed by Schneider at his works at Creuzot, and its virtues were first proclaimed to the world by the famous plate trials which took place at Annapolis in 1890.

The Harvey method of face hardening is the invention of Mr. H. A. Harvey of the Harvey Steel Company, Newark, N. J. The process consists essentially in exposing the face of an ordinary steel plate to carbonaceous gases or matter at a high temperature, whereby some of the carbon is appropriated by the metal of the face, and it becomes a steel of a higher per cent of carbon than the rest of the plate.* It thus is susceptible of taking on a high temper and becoming very hard. This type of armor has been tested at Annapolis and Indian Head, giving most satisfactory results. In the recent tests at Indian Head, it was clearly shown that Harveyized nickel-steel armor containing about 0.35 per cent. of carbon, possesses a degree of strength far greater than any armor that has heretofore been tested.

The development that has taken place in armor may readily be noted by an examination of the following tabulated statement of data, selected as typical from the important tests that have been made since 1886. The characteristic features of this period are that the plates crack only slightly, or not at all when attacked, and the projectiles either rebound entire or are only slightly deformed, while the depth of penetration has steadily decreased for the same projectile conditions:

The advance made in armor in 1890–91 is perhaps best shown by comparing the Annapolis trial of 1890 with the Indian Head trial of 1891. This appears in the following table:

*It is said that a steel plate 10.5 inches thick and containing 0.35 per cent. of carbon may be superc-arbonized by 0.[illegible]0 per cent. at a depth of three inches.

Projectile.	Number of shot.	1890.		1891.			
		Schneider.		Carnegie.	Bethlehem.		
		Penetration.		Penetration.	Penetration.		
		All steel.	Nickel steel.	N*-steel c = .44 per cent	N*steel, c = .30 per cent.	N-H †-steel, c = .27 per cent.	N-H †-steel, c = .35 per cent.
		inches.	inches.				
6 inch.	1	11.25	13.5	12.5	13.25	10.07	12″
	2	12	15.4	10.75	10.07	9.7	6.82
	3	12.5	12.5	12.0	12.75	. . .	12.25
	4	12.5	14.5	11.9	10.37	10.0	7.32
8 inch.	5	15	21.5	. . .	15.5	. . .	12.9

* N = nickel.
† N-H = Nickel Harveyized.

The average penetration of the five 6-inch shot in the Schneider all-steel plate in 1890 was 12.06 inches; in the Schneider nickel-steel 13.7 inches; in 1891 in the Carnegie high-carbon untreated plate 11.8 inches; in the Bethlehem high-carbon untreated plate 11.6 inches; in the Bethlehem low-carbon Harveyized plate 9.9 inches; in the Bethlehem high-carbon Harveyized 9.5 inches. It appears from these data that the Indian Head armor was approximately 40 per cent. stronger than the Annapolis armor.

The Harvey principle is still, of course, in the experimental stage.* Although most promising now and perhaps introducing a new phase in the contest between guns and armor, it will have to stand the test of many other trials before its precise merits can be definitely known. At the present time, the best armor upon which ballistic calculations, can be based is the Creuzot standard. The uniformity of its behavior has been established by many trials and the data are accessible and authoritative.

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*Since this was written further improvements have been made in the manufacture of Harvey armor, and the Navy Department has entered into a contract with the Harvey Company to have all armor for war vessels treated by the Harvey process. It may therefore be said to have passed beyond the experimental stage, but its merits rest on so few trials that defects may yet develop.

NORMAL IMPACT.

It has been observed in steel armor plate trials, that the surface of the plate about the point of impact shows signs of molecular disturbance throughout a superficial area of the plate, that appears to bear a definite relation to the calibre of the projectile. For armor plates of mean thickness, this area includes that portion of the surface within about two calibres from the edge of the shot hole. The molecular action is indicated by the increased temperature of this portion *immediately after impact* and by the bulge produced. It may be assumed from this, that the surface layer of the metal to this limit participated in the resistance, and it may be assumed, further, that the mass of the plate behind this surface layer was also involved ; this is strongly confirmed by the appearance of the backs of the Annapolis and Indian Head plates, which, on an examination after the trials, revealed the fact the effect of the six-inch projectiles extended to a radial distance of about nine inches and the eight-inch projectiles to about eleven inches. All other trials of steel plates show the same front and rear bulges and heat circles. These are well illustrated in the accompanying reproduction of the first Bethlehem plate, tested at Annapolis January 20th, 1891.

From an examination of the results of a number of tests, and from subsequent application of the principle, there is reason to believe that when the diameter of the projectile is equal to the thickness of the plate, the metal involved in resistance will be limited to a disk about the point of impact, the diameter of which is 6.25 times the diameter of the projectile, the thickness of the disk being the thickness of the plate. Not only does the diameter of this resisting disk vary with the diameter of the projectile, but it also varies with the *diameter of the projectile and the thickness of the plate*. As a result of numerous trials and comparisons the law of this variation may be expressed by the following formula:

$$\frac{r}{d} = n = 3.125 + 0.11\,(t - d) \qquad (1)$$

in which

$r =$ radius of resisting disk.

$n =$ the ratio of the radius of the resisting disk to the diameter of the projectile.

$t =$ thickness of the plate in inches.

$d =$ diameter of the projectile in inches.

The weight of the disk in tons will be given by the following formula:

$$w = 0.0004\, n^2\, d^2\, t \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

in which

$w =$ the weight of the resisting disk in tons.

n, d and $t =$ the same as above.

It is assumed that the metal of the resisting disk has an intrinsic power of resistance,—a property based on the resistance offered by the molecules of the metal to change of position with respect to one another. This may be expressed in the form of the energy per ton necessary to produce a given change in the relative positions of the molecules, as, for example, that resulting from the perforation of the plate by a projectile. The value of this factor will be a constant for the same kind of metal. An examination of a number of trials of Creuzot armor leads to the belief that, for metal of this standard, the inherent resisting capacity to perforation is between 1800 foot-tons and 1900 foot-tons per ton of the metal of the resisting disk. It is higher, naturally, for the more recent trials than for those made some years back. Keeping in mind the aim of this paper, the *average* armor now afloat and to be afloat in the immediate future, will be better suited to the calculations here to be made. For such armor, it is thought after many applications, the value 1828 foot-tons per ton of resisting disk is a proper one to make use of.

Multiplying the weight of the resisting disk in tons as given by the equation above, by the resisting capacity of the metal per ton (1828 foot-tons) we shall obtain the measure of the plates' resistance to perforation in tons of the projectile energy. The resulting expression takes the form:

$$E = 0.7312\, n^2\, d^2\, t \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)^*$$

*This equation was deduced in the fall of 1890, when no equation was known to the writer that would give a measure of steel armor strength by direct process. Since that time the formula of Captain Jacob de Marre has come to the notice of the writer. The two have been applied side by side to many plate trials, and it is believed the values given by this formula agree more closely with the results of actual experiments than those given by de Marre's formula. The curve of the two when plotted, as illustrated herewith, shows that this formula gives slightly smaller values for the thinner plates than de Marre's, and greater values for the thicker plates. The curve has a more rapid change as the thickness of the plate increases for a given projectile, and this is believed to be in harmony with actual results.

in which

E = the projectile energy in foot-tons required to perforate the plate.

$n = \frac{r}{d}$ = ratio of the radius of the resisting disk to the diameter of the projectile.*

d = diameter of the projectile in inches.

t = thickness of the plate in inches.

This is a general formula applicable to normal impact against plates of Creuzot standard, steel or its equivalent, of any ordinary thickness, by projectiles, of any caliber. It is assumed that projectiles are not *materially* deformed by impact, and that the plate is not *seriously* cracked.†

OBLIQUE IMPACT.

If a projectile do not strike the plate at right angles to the face of the plate, only a fractional part of the projectile's energy will be expended normally, and it is, of course, only that energy due to the *normal* component of the velocity that is efficient in overcoming the resistance offered by the plate. It is precisely in connection with this question of oblique impact that it has been the custom to overlook, and to fail to credit to armor one of the most important advantages it has over the gun and projectile. If

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* If n be made equal to the ratio of the *diameter* of the resisting disk to the diameter o the projectile, we have:

$$n = 6.25 + 0.22\,(t - d)$$

and:

$$E = 0.1828\,n^2\,d^2\,t.$$

For the metric system the formula becomes

$$E = \frac{w\,v^2}{2\,g} = 13.82\,n^2\,d^2\,t.$$

$$n = 3.125 + 0.043307\,(t - d)$$

in which,

E = energy in kilogramme-metres.

w = weight of projectile in kilogrammes.

v = velocity in metre-seconds.

d = diameter of projectile in centimetres.

t = thickness of plate in centimetres.

†The application of the formula to some actual trials will be found in "The United Service" Magazine for May, 1891.

we call to mind the actual conditions of attack, it appears at once very clear that normal impact must of necessity be an exceptional occurrence. The motion and direction of the ship, the curved shapes given to armor, the angle of fall of the projectile, all operate to make normal impact a rare event.

From this the following principle may be enunciated: that whereas the gun never realizes in full the advantages it has on the testing-ground, the plate, reciprocally, is never so much at a disadvantage as on the testing-ground; the plate will not lose a foot-pound of its resisting capacity, and the chances are it will gain greatly by the actual conditions of combat.

It is desirable to introduce into our calculations, if possible, factors that will give recognition to these features of armor resistance.

At the threshold of the question we see that it is necessary to take some angle of impact as a limit. Between normal impact and that angle which causes a projectile to glance off without biting into the armor, we must assume an intermediate angle as one up to which our guns ought to give perforations, and beyond which we should have penetration only; we can not, of course, impose the condition that projectiles shall break through armor up to the glancing angle.

Experiments bearing on this point have been conducted by almost all European Governments, but especially by England, France and Denmark, and in July last by our own Government at Indian Head. Some experiments carried on at Shoeburyness seem to place the biting angle at about 50° with the normal. At Gâvre it was determined to be about 46°. On the basis of the Gâvre trials the French have formulated a rule which may be stated as follows:—

"As long as the angle of incidence is not greater than 30° (that is, if the plate is not inclined less than 60° from the horizontal) a projectile of good material will pierce the plate, provided that the normal component of the striking velocity is equal to, or greater than the velocity necessary to pierce the plate normally. Beyond 60° to the horizontal, chilled projectiles striking the plate are broken, and if the individual pieces have not the force to pierce the plate normally they are glanced off. Beyond 44° to the normal (46° to the horizontal) the projectile will not bite the armor, and is glanced off without serious damage."

A very trustworthy trial of plates under oblique impact took place at Copenhagen in March, 1883, under the auspices of the Danish Government. Among others a 4-inch Schneider platè was attacked by 9-inch Armstrong and 5.75-inch Krupp steel projectiles. The plate made an angle of 24° with the horizontal, the line of impact was therefore 66° with the normal. All of the projectiles were deflected by the plate.

The most recent and perhaps the most useful test of plates under inclined impact, was that that took place at the naval proving ground at Indian Head in July. Two sets of plates were mounted, one made by Cramp and Sons, and the other by Carnegie, Phipps and Company. The former was all steel, 2.5 inches thick, made up of two plates each 1.25 inches thick, placed one over the other; the latter was nickel-steel 3.0 thick, made of two plates each 1.5 inches thick placed as before. The plates were inclined 22° to the line of fire, that is, the angle between the line of fire and the normal to the plates was 68°. They were attacked by the 6-inch naval gun, firing chilled iron projectiles. The striking velocity was 1515 ft. sec. The projectiles were weighted up to 100 lbs. Five shots were fired at each plate. All were glanced off, leaving elliptical dish-like depressions in the plates, varying from a maximum depth of 3 inches in the Cramp plate, to 1.9 inches in Carnegie plates.

From a consideration of these trials and some others of minor importance, it is thought that steel armor will deflect all projectiles that strike under an angle greater than 60° with the normal. Now, it is assumed that it will not be too much to ask that our sea-coast guns shall be effective against armor for which they are respectively intended, throughout *one-half* of this angle of 60°; that is, let us impose the condition that sea-coast guns must be able to perforate armor up to, and including an oblique impact of 30° with the normal, or 60° with the face of the plate.

The velocity normal to the plate under a 30° impact for 4000 and 6000 yards, will be had by multiplying the remaining velocities of the projectiles at these ranges by the cosine 30°; this will give a reduction of 14 per cent. of the total velocity. But other influences than this are involved in oblique impact. The form of the head of a projectile is a matter of controlling importance. Armor piercing projectiles have an ogive struck with longer radius than other projectiles*, and, the metal of the projectile must be so hard and tenacious that the form of the projectile will not be materially altered by impact. Whatever be the velocity with which a projectile strikes a plate, it will not penetrate to the full depth due to the velocity unless the position of the projectile at impact, with reference to the face of the plate, is such as to give full effect to the *form* of the projectile. Now this form is designed strictly for normal impact, and if the projectile does not strike squarely point on, this fact alone, apart from all others, will materially reduce penetration; the flat curve of the side of the projectile's head is more or less presented to the face of the plate, and a "racking" effect will be to this extent substituted for the "wedging" effect of normal impact. The advantage due to the special form of the projectile disappears in large measure on this account, even when the variation from the normal is small. This is well illustrated in the "Nettle" trials at Portsmouth in 1888. The steel plate, for instance, furnished by Cammel and Company, which was tested May 19th, 1888, was penetrated to 23 inches by the Holtzer projectile under normal impact, to 15.5 inches, only, under 8° with the normal, and to 11 inches under 16° impact. The three projectiles remained intact and behaved generally in the same way, and the plate did not crack. Apparently the falling off in penetration was due entirely to the varying angle of impact. Here we see that 50 per cent. of the normal penetration is lost within an angle of 16°. If this rate continued the shot would have glanced at about 32°; but it is probable that the falling off is greater in the first angles near the normal. This is evidenced in the fact that 62 per cent. of the falling off above occurred in the first 8°, and only 38 per

*Holtzer A. P. projectiles are as a rule struck with a radius of two calibres.

cent. in the latter 8°. The glancing angle would, therefore, have been probably beyond 32°, but however this may be, the facts strongly confirm the hypothesis made at first, namely, that 60° with the normal may be taken as an angle beyond which projectiles will not bite into steel armor.

If 60° with the normal may be taken as the limiting angle beyond which projectiles striking steel armor will glance, the falling off of penetration will be 100 per cent. for this angle, or 1.7 per cent. per degree. We have seen that this falling off is more rapid, probably in the smaller angles and less in the larger ones, but sufficient data are not at hand to determine the law governing this; it will be necessary, therefore, to make the rate uniform for the purposes of calculations, and this will be done with the remark that it is materially in favor of the gun and against the plate.

If t represent the depth of penetration under normal impact, and t_1 that for an angle of impact θ then we may represent the above conclusions by the following equation:

$$t_1 = t - .017\,\theta\, t \quad \ldots\ldots\ldots\ldots \quad (4)$$

Solving with reference to t and substituting in equation (3) we have the following equation for the strength of armor under oblique impact:

$$E_\theta = 0.7312\, n^2 d^2 \frac{t_1}{1 - .017\,\theta} \quad \ldots\ldots\ldots\ldots \quad (5)$$

Making t_1 in equation (5) in succession equal to the thickness of plates from 5 to 20 inches, and d in succession equal to 8, 10, 12 and 16, and making $\theta = 30°$, the following values are obtained for the strength of armor under 30° impact:

STRENGTH OF STEEL ARMOR EXPRESSED IN TERMS OF THE PROJECTILE ENERGY, REQUIRED TO PERFORATE IT UNDER 30° IMPACT.

Thickness of Plates.	Energy Required to Perforate Expressed in Foot-tons. Impact—30° with the normal.			
	8-inch projectile.	10-inch projectile.	12-inch projectile.	16-inch projectile.
5 inches.	3730	4947	5959	. . .
6 "	4726	6455	7834	. . .
7 "	6077	8162	9974	. . .
8 "	7462	10000	12395	. . .
9 "	8996	12205	15105	. . .
10 "	. .	14570	18136	. . .
11 "	. .	17180	21485	. . .
12 "	. .	. . .	25183	33047
13 "	. .	. . .	29232	38795
14 "	. .	. . .	. . .	45137
15 "	. .	. . .	. . .	52092
16 "	. .	. . .	. . .	59690
17 "	. .	. . .	. . .	67965
18 "	. .	. . .	. . .	76943
19 "	. .	. . .	. . .	86645
20 "	. .	. . .	. . .	97105

GUN EFFICIENCY.

Naval constructors generally agree that the battle-ship of the line should have three distinct thicknesses of armor. 1. A water-line belt from 18 to 20 inches thick; this same armor is used also to cover the turrets containing the large guns. 2. Mid-ship armor of from 4 to 6 inches thick, covering the midship battery of smaller calibres. 3. Horizontal armor covering the deck and protecting the boiler and other vital parts below deck,—about 3 inches thick.

Now it may be stated as a fundamental proposition, that our lightest sea-coast gun (the 8-inch gun) ought to be able to perforate the light side armor up to 4000 and 6000 yards; and that our largest sea-coast gun (the 16-inch gun) ought to be able to perforate water-line armor and turret-armor up to the same ranges. Let us proceed to examine the powers of these guns with this object in view.

It has been shown that the ranges at which the guns mounted on the exterior line of shore defense, will, as a rule, have to engage battle-ships, will be from 4000 to 6000 yards, and we have just obtained values for the strength of armor in terms of the projectile energy required to give perforation. It is now in order to give the energies of our sea-coast projectiles at combat ranges,

Entering the ballistic equation for velocity with the ballistic elements given in the first part of the paper, the following values for remaining velocities are obtained for the specified ranges:

AT 4000 YARDS.

8-inch projectile	1372	ft. sec.
10-inch "	1493	"
12-inch "	1548	"
16-inch "	1688	"

AT 6000 YARDS.

8-inch projectile	1196	ft. secs.
10-inch "	1305	"
12-inch "	1396	"
16-inch "	1550	"

The energies corresponding to these velocities are, respectively,

AT 4000 YARDS.

8-inch projectile	3914	foot-tons.
10-inch "	8823	"
12-inch "	16620	"
16-inch "	45440	"

AT 6000 YARDS.

8-inch projectile	2975	foot-tons.
10-inch "	6741	"
12-inch "	13510	"
16-inch "	38310	"

Entering now the above tables for armor strength with these energies, it is found that the 16-inch projectile under 30° impact, will perforate 14 inches of steel at 4000 yards and 12 inches at 6000 yards. As already stated, modern battle-ships carry water-line belts of from 18 to 20 inches of steel; 16-inch projectiles can not therefore be considered as possessing sufficient power for the attack of water-line armor. If water-line armor is to be attacked with a reasonable degree of certainty of perforation at 4000 and 6000 yards, either greater power must be given to 16-inch projectiles, or, if gun-power remain the same the calibre must be increased. Assuming that gun-power will not materially increase for these very large calibers, it can be easily shown that it will require a calibre of 20 inches to give perforation of 20-inch armor under 30° impact.

It is proper in this connection to point out that these large guns are not designed for, and therefore can not with advantage be used for any work except the attack of heavy armor on the water-line and turrets. It would be a mistake to provide large calibre guns for the attack of light side-armor and the unprotected parts of ships. The only reason that can be urged for the existence of these large guns is, that war vessels have parts beyond the power of smaller calibres, and these parts are so important that it is necessary to have guns of sufficient power to perforate them. Now the life of a large gun is short compared with smaller calibre guns. It is probable that it will not average many rounds more than 200 (one of the 119-ton guns furnished by Krupp for the defense of Spezia, is serviceable after 200 rounds), furthermore, the expense of firing large guns is great. All these points make it important that when a hit is made it shall have full effect; if a shot strike the water-line belt, say under 30° impact, and fails to penetrate because of deficient energy, it is a much more serious affair than with smaller calibres. It is in truth, better not to provide these large calibres, unless their projectiles have power to perforate at fighting ranges and under average conditions of oblique impact, the heaviest armor carried by ships; if their projectiles do have power enough for this, the guns become of the utmost importance, for, while they fire fewer shots than the smaller guns, a vessel struck by one shot on the water-line or over any vital part, will be thenceforth practically out of the fight.

Two courses of action are open to us in this matter: we must either abandon altogether the attempt to breach the heavy armor carried by battle-ships, and put the money set apart for large guns into 10-inch and 12-inch guns, with a view to increasing the volume of fire against the lighter armor, or, secondly, we must mount in our forts of the exterior line, a gun that will give a greater striking energy than the 16-inch gun as now proposed.

The use of high-explosives as the bursting charge of shells has made it a matter of first importance to war ships, that shells be kept from penetrating to the interior. With this object in view, all recent designs of battle-ships provide as already stated for a large area of side armor, varying in thickness from four to six inches. This is well illustrated in the latest designed English battle-ships, which are planned to have the entire midship section above the water-line belt, covered with five-inch armor protecting the auxiliary battery of six-inch guns. The introduction of this light armor has greatly changed the conditions of attack. Before it was introduced the rule was to leave these parts unprotected, therefore, projectiles of low energy could easily penetrate to the interior; but with five inches of steel covering the greater part of the ship, the resistance offered by the ships to the attack of the smaller calibres has been vastly increased. This use of armor is bound to become general, and its attack becomes the most important feature in the contest between fort and ship. Our principal armament should be made up of guns able to perforate at least six inches of steel under 30° impact at fighting ranges, and no gun ought to be mounted on our exterior line that is not easily able to perforate six-inch armor up to 6000 yards under 30° impact.

Going to the tables of armor strength again with the energies of the 10 and 12-inch projectiles, respectively, at 6000 yards, it is seen that the 10-inch projectile will perforate six inches of armor under 30° impact, and the 12-inch projectile eight inches. Both the 10-inch and 12-inch guns may, therefore, be considered as thoroughly efficient for the attack of the midship armor, and these guns ought to form the main feature of our armament.

Passing to the 8-inch gun the conditions are not so favorable. Its projectile at 6000 yards has but 2975 foot-tons of energy remaining; it will require over 4500 foot-tons to perforate 6 inch armor; the 8-inch gun is, therefore, not powerful enough for the attack of the midship armor at 6000 yards. Under normal impact it would not perforate 7-inch armor; under 30° impact its penetration would be only 3.9 inches. There is but one conclusion, namely, its use must be confined to localities where the possible range in action will be less than 6000 yards, or to points that will not be exposed to attack by regular battle-ships.

It has been urged that the 8-inch gun, if not effective against the light side-armor, might be of service in the attack of deck armor. But it must be remembered that the 8-inch gun is a high-power gun, which, as a result of great care and expense of manufacture, is able to give its projectile great initial velocity and a flat trajectory; now this flat trajectory defeats the very object sought after in the attack of deck-armor, namely, a high angle of fall. At 6000 yards the angle of fall of the 8-inch projectile is less than 10°, and the projectile would at this angle be deflected from 3-inch armor without penetration. Nor will it answer to use these high power guns with reduced charges and low initial velocities, with a view to getting a high angle of fall at 6000 yards, for this sacrifices the main object of high-power guns. Such an end could be attained more cheaply and readily by changing our present 8-inch rifles to breech-loaders, and by converting our smooth-bore 15-inch guns into low-power breech-loading rifles or howitzers, or, better still, by the new 12-inch mortars now being made by the Ordnance Department.

It appears, therefore, that the proposed 16-inch gun and the present 8-inch type-gun are deficient in power, when measured by the actual work they are expected to be able to perform. The question arises, is it possible to increase the power of these calibres so as to make them efficient?

Canet and Schneider make guns up to 50 calibres. With this length of bore and with projectiles about one per cent lighter, calibre for calibre, than those adopted by our Ordnance Department, they obtain initial velocities of something over 2600 feet per second.

It is doubtful, however, whether a 16-inch gun could be given a length of bore of 50 calibres. It is probable that the limit for the very large guns will never go beyond 40 calibres; with this length of bore we should obtain an initial velocity of about 2400 feet per second, which would fall off to 1860 feet per second at 6000 yards. This remaining velocity would give an energy of 55160 foot-tons. This would barely make the projectile superior to a 15-inch plate at 6000 yards under 30° impact. It would seem, therefore, that it is hardly possible to make the 16-inch gun thoroughly efficient for the attack of belt and turret-armor.

The bore of the 8-inch gun can, as a matter of course, easily be given a length of 50 calibres; and let us assume that the 300-pound projectile can be given an initial velocity of 2600 feet per second. At 6000 yards this would fall away to 1513 feet per second, which would give a remaining energy of 5993 foot-tons. A 6-inch plate—which we have seen is probably the maximum midship armor that will be placed on war-ships—requires 4726 foot-tons of 8-inch projectile energy for perforation. It would therefore give way under 30° impact, and, under these conditions, the 8-inch gun becomes serviceable. It would seem, therefore, that the 8-inch gun is one to which may be applied with advantage the principles of very long bores.

While refering to this subject it may be enquired, whether it would not be advantageous to apply the same principle to the 10-inch and 12-inch guns. It is true they are effective, as they are against midship armor under the moderate conditions that have been assumed, but their latitude of effectiveness would be greatly increased by giving them bores of 50 calibres length. We can do this on shore with ease, since we are not rigidly bound down to limits of weight and space such as hedge in guns afloat.

SUMMARY.

The ranges at which forts and ships will fight in time of war, will be as a rule from 4000 to 6000 yards. Battle ships will carry three thicknesses of armor: 1. Water-line armor from 18 to 20 inches thick. 2. Midship armor from 4 to 6 inches thick. 3. Horizontal deck-armor from 2.5 to 3.5 inches thick. There will be, also, certain unprotected parts. For the attack of such a target, under conditions of combat, we should have, properly, four distinct types of guns, viz:

1st. The most powerful gun that can be made, for the attack of the heaviest armor.

2nd. 8-inch, 10-inch and 12-inch long-calibre guns, for the attack of the light side-armor.

3rd. Low-power guns, howitzers and mortars, for the attack of horizontal deck-armor, for which our old M. L. ordnance is available by conversion.

4th. Rapid-fire guns of 4 to 6-inch calibres, for the attack of unprotected parts.

The 16-inch gun as planned at present is not powerful enough for the attack of water-line and turret-armor. We ought, therefore, either to abandon altogether the attempt to attack water-line armor, and put the money in 10-inch and 12-inch guns, or else substitute for the present gun one that shall give sufficient power.

The 8-inch gun, present type, is deficient in energy at ranges above 4000 yards, and its use thereby becomes so restricted that it will not be serviceable as an arm in the defense of important points. It is possible, however, to make it efficient by increasing its length of bore to, say, 50 calibres.

NOTE.—The JOURNAL is indebted to Mr. W. H. Jaques, South Bethlehem, Pa., and to the IRON AGE, of New York, for kind permission to reproduce the Plate illustrating this paper.

NOTES ON FIELD PRACTICE.

LIGHT BATTERY "F," THIRD ARTILLERY.

August 12th to September 3rd, 1891.

BY SECOND LIEUTENANT EDGAR RUSSEL, THIRD ARTILLERY, U. S. A.

The battery left Fort Sam Houston, San Antonio, Texas, on the morning of August 12th, with a full complement of officers, and fifty-six men present for duty, equipped with four B. L. 3".2 steel rifles, new pattern limbers, caissons and harness. As the afternoon heat was excessive, the marching except on the third day was done in the forenoon.

Nineteen miles were made the first day, fourteen the second, and twenty-nine the third. The average rate of marching, including halts for rest, was 3¾ miles per hour. The roads were generally fair, with exception of twelve miles of last day's march, when steep, broken hill-roads with difficult grades were passed over. The harness worked well under unfavorable conditions. On a previous march, trouble was experienced with sore necks on horses where the collar pad bears. It was suggested, that as the new pattern chests are quite low the men would sit forward, thus throwing weight on the horses necks. To obviate this, the back compartments of limber chests were loaded with projectiles, and men instructed to sit back and occasionally ride facing to the rear—result: no horses had sore necks. Metal collars were used with two pairs of wheelers; and it was found that by their use, sore shoulders were actually cured while on the march. Upon arriving in camp at Ganahl all the horses were in good condition, with exception of some slight abrasions.

The camp was situated near Ganahl, on the San Antonio and Aransas Pass R. R., in the Guadalupe valley, and about sixty-two miles north west of San Antonio. The valley here is about two miles wide, bounded by hills gradually rising from 75 to 300 feet high. There is some open ground in the flat parts of the valley, but the undulations and hills are quite thickly covered with small trees and thickets—mostly live oak. The elevation is about 1800 feet above sea-level. The Guadalupe is a clear and beautiful stream, fordable at many points.

On account of hills and trees it was found difficult to lay off ranges desired. The ranges selected for the "known distance" practice, and order of firing, were as follows: 1000, 1500, 1760 (two), 2050 and 2250 yards.

The target used was canvas, 20 feet long and 10 feet high, marked off into 2½ foot squares for convenience in signaling, and having an elliptical bulls-eye in center. This bulls-eye was, for the shorter ranges 72 by 53 inches, and for longer ranges 103 by 63 inches—corresponding to double the mean vertical and horizontal deviations at 1200 and 2000 yards, respectively.

The guns numbered 6, 8, 22 and 23, had been in possession of the battery about ten months and had not been fired with projectiles. Nos. 6, 22 and 23 were provided with Freyre gas checks, No. 8 with DeBange. Nos. 6, 8 and 23 had the ordinary bevel gear elevating devices, No. 22 the "lazy tongs" device with horizontal bronze wheel. These guns had deviation scales of rear sights graduated to "five-hundreths" of the range, and one graduated to $\frac{1}{385}$ —a serious inconvenience.

The projectiles were percussion shells of the new pattern (long ogive), fitted with Hotchkiss base fuses, and weighing, when filled with 6 oz. of rifle powder, 13½ pounds.

The cartridges weighed 3¾ pounds and were of two kinds. First, marked I. K. H. Dupont, 1890, Sp. Gr. 1,725, I. V. 1672 f. s.,—150 of this kind used first. Second, marked I. K. H., Sp. Gr. 1.725, I. V. 1700 f. s.—64 of this kind expended last. It was found difficult to force a 3¾ ℔. cartridge into the gun with DeBange gas check.

Ingalls' ballistic tables were used in computing elevations required, assuming that the I. V. of first powder was 1650 f. s. An allowance of 22′ was made for "jump," which subsequent firing showed to be practically correct.

First Day's Firing.—Clear ; temperature, 90° ; wind, 3 miles per hour, six o'clock. Observing and signaling party about 150 yards to left of target. Guns 8 and 22 fired five shots each, seven direct hits, three short ; one shell striking 15 yards short sent 18 fragments through target, and one 25 yards short, 5 fragments through upper part. Ground in front a firm turf. Noted, that there was frequently an appreciable interval between strike of shell and explosion. Started with elevations of 52′ and ¼ point left allowance ; this was increased to 1° 3′ elevation and ½ point allowance. Computation showed the powder gave I. V. of 1593 f. s., a deterioration of 79 f. s. in powder made about one year ago, in this dry, warm, climate, and stored in a fairly good magazine.

Second Day.—Clear ; temperature, 95° ; wind, three miles per hour, five o'clock. Guns 6 and 23 fired twelve shots at 1500 yards, and eight at 1760 yards range. Target visible through narrow space between clumps of trees. Right fork of clevis of left brake on gun 6, broken at first shot. Eight direct hits, one short and three over at 1500 yard range ; three hits, one short and three over at 1760 yards. The last shot, seven yards short, wrecked the target and set it on fire. The line of sight at both ranges passed near the surface of the ground, over two slight elevations. The heat "quiver" made aiming difficult, especially at 1760 yards range. At this last range great anomalies in the elevation required were noticed. Starting at 2° 25′ which the I. V. of 1593 f. s. required, the shell went over the target ; and not until 2° and 15′ was used, did the strike seem to be about right, even then many irregularities were noted.

It is suggested that refraction due to the heated air close to the ground may have caused the trouble. Indications of mirage are frequently observed here over the surface of the heated ground. In Lieutenant Dunn's paper on "Atmospheric Refraction on the Target Range" (Fort Monroe, 1888), he says in effect that increased temperature, especially when line of sight is near the surface of the ground, *generally* produces marked apparent elevation of the object, basing his statement on results obtained from observations. It is probable that our *apparent* target was frequently several feet higher than our *real* one.

Third Day.—Clear; temperature, 90°; wind, about four miles per hour, five o'clock. Target was placed on higher ground, the line of fire being across low ground. Twenty shots fired from guns 6 and 22 at range of 1760 yards. Elevation 2° 23′, about that required by computation. Allowance of 1½ points left as on previous day's fire. Fourteen direct hits, five from 1 to 15 yards short, and one 25 yards over. Every shell which struck short sent fragments through target. In two cases the target was wrecked and torn down by fragments. The ground around target was a hard turf, sloping about 4° to the front.

Fourth Day.—Clear; temperature, 75°; very light breeze, four o'clock. Eighteen shots fired by guns 6 and 22 at 2050 yards range. Noted from position of signal party near the target, that it was difficult to discover battery's position amongst the thinly scattered clumps of trees—the sunlight reflected from guidon tip giving the first indication. Of 18 shots fired, nine were direct hits, seven were from 25 to 1 yard short: and two were 40 yards over. The target was twice wrecked by fragments, being struck by fragments from five of the shells. Two shells were seen to burst high in the air after striking, giving observers at the battery the impression that they struck far over, when in reality they went through the target.

Fifth Day.—Hazy; temperature, 75°; very light breeze, four o'clock. Guns 6, 8 and 22 fired 16 shots at 2250 yards range. Four direct hits, eight over from 50 to 20 yards, and four short from 8 to 1 yard. Elevations used was from 3° 30′ to 3° 26′; average allowance from 1¾ to 2 points left. Aiming was very difficult on account of haze. Rear sight on gun 8 could not be seated accurately, necessitating an arbitrary allowance in elevation. Noted that first shot striking 8 yards short sent 40 fragments through target; the 14th shot striking 5 yaıds short wrecked the target.

Sixth Day.—Clear, slight haze; temperature, about 80°; very light breeze, 8 o'clock at first, changing later to 3 miles per hour, 4 o'clock. Twenty shots fired at 2050 yards range by guns 6 and 22. No signals were seen from target, reliance being placed upon field-glass observations, by observers on the flanks of the battery. The shooting appeared to be excellent—fourteen direct hits were counted in target after the firing, besides many holes made by fragments. The twenty shots were fired in twenty-five minutes. These guns were then limbered up and retired to the rear at a trot; after going back several hundred yards, "action rear" was executed. A space about 75 yards long and 20 yards wide, outlined by clumps of trees, on the hillside above the target was then designated by the battery commander as a supposititious earthwork; the first series of shots were to demolish interior works, the last to sweep the parapet.

The first shot appeared to hit the centre of the designated space; with elevation and allowance thus indicated, the guns were loaded and fired for ten shots as rapidly as possible. Then running down elevations three or four minutes, every shot appeared to graze the top of target as designated. The smoke interfered with aiming and impaired the rapidity of firing. Twenty shots were fired in all, the time required being about twelve minutes. Every shot but one appeared to hit. An examination of the ground afterward, showed that of the nineteen shells striking, none had varied more than twenty-five yards in range, and eight yards laterally from the centre of the space indicated. The range was approximately 2300 yards.

Seventh Day.—Hazy; thermometer, 85°; very light breeze from left at first, changing to right later. Guns 6 and 22 fired twenty shots at 2050 yards range, without signals as on previous day; the results appeared to be excellent. Guns 6, 22 and 23 then limbered up and retired to rear, to the top of a ridge several hundred yards back, and opened fire on a space indicated near the one fired at the day before. The first shot struck slightly short—with 5′ correction the next shot hit. Thirty shots were then fired as rapidly as possible, all of which appeared to hit; an opinion which the subsequent examination of the ground showed to be correct. The light breeze coming from the right instead of from the left, as at the beginning of the practice, necessitated a change of deviation scales from 1¾ points left to 1 point left. The ground designated as the target was a hard turf sloping about 5° to the front. The shells nearly all ricocheted, very few seeming to explode when they struck. The fuse, thus acting while projectile was in air gave excellent shrapnel effect, as was evidenced by surrounding shrubbery.

The aiming in this days fire was very difficult on account of haze. Time of firing the thirty shots—twenty minutes.

Eighth Day.—Clear, with slight haze; thermometer about 80°; very light breeze, about six o'clock at first. Guns 6 and 22 were placed in an opening in the woods in the low ground, at a distence from target roughly estimated at 3100 yards. The target was an old wall tent fly, tied to the uprights of the frame, and was extremely difficult to see at this range until the sun shone fairly on its face. The first shot with an elevation of 5° 35′ and allowance of 3 points left, showed a strike of about 100 over and slightly right. Correcting for this, each gun fired ten shots with apparently excellent results. These two guns then limbered up and retired to a position on higher prairie ground; the range was roughly measured, using a sextant for a range-finder, indicating it to be about 4400 yards. A deep valley in front and nearness of crest to target on the hill, introduced difficult conditions for range-finding with the gun. The first shell fired with an elevation of 10° 55′, 3½ points left was lost; it was discovered that a plus error of 22′ (the jump) had been made in elevation. The next two shots were likewise lost, but were heard to explode, apparently over the hill. The next shot with an elevation of 8° 45′, struck the top of the hill about 100 yards over. The correct elevation was about 8° 22′, allowance of 3¾ to 4½ points corresponding to range of about 4000 yards; the wind shifted from 4 to 8 o'clock. The remaining shots of the 20 appeared to be very good. The subsequent examination of the target showed several direct and many fragment hits. The new powder (1700 f. s.) was used in this day's and half of the previous day's firing. Calculations showed that it gave a velocity of 1608 f. s.

This ended the practice. There had been fired 214 shots from the guns as follows: No. 6, 92 shots; No. 8, 10 shots; No. 22, 84 shots; No. 23, 28 shots.

The behavior of the matériel under these tests is given in the following:

SUMMARY.

OBSERVATIONS UPON MATERIEL.

Harness.—Very good satisfaction throughout; metal collars superior to leather, especially where fit is not good.

Limbers.—The low chests make uncomfortable seats; cannoneers tend to sit forward throwing weight on horses necks. Helped by putting projectiles in back compartments of chests and using cushions.

Wheels, Axles, etc.—Several times the large outside nut on nave, has on the *right* side become unscrewed and locked the wheel, bending the linch pin. Boxes run dry in a few miles marching, due no doubt to easy access of dust. Cylindrical boxes on limber axle (for obturators) frequently lost lids.

The Gun.—Both DeBange and Freyre gas checks worked perfectly. Breech block of No. 22 works somewhat stiffly.

Sights.—Rear sight could not be accurately seated on No. 8. One glass in level cracked by an accidental fall.

The crossed wires of front sight were not used in the "horizontal and vertical" position in aiming. By inclining at an angle of 45°, and adjusting aim until the bulls-eye appeared to rest in the upper "crotch," much more accurate results, especially in the aiming at long ranges, were obtained.

In the first position named, even a large target would be obscured by wires at long ranges.

Cap Squares.—No perceptible springing of any of them.

Elevating Apparatus.—Worked well even when covered with dust, as no cleaning was allowed when coming into action.

The bevel gear form works more rapidly, but it has more lost motion to trouble one in finer adjustment than the "lazy tongs" form. Besides the latter is less exposed to injury and works better than the bevel gear, when covered with dust and sand.

Brakes.—Gave considerable trouble. On gun 6, one fork on clevis of left brake broken at first fire—continued to use it however. Left brake jumped off once, caught on point of shoe and bent. No accidents to No. 8 brakes. Left brake jumped off twice on No. 22 and was bent—hammered into place with an axe. No accidents to No. 23 brakes.

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AT GANAHL, TEXAS.

REMARKS.
ange 1800 feet above Sea level. Mean barom. estimated 28 in. rature about 90°. Very light breeze 4 o'clock.
off and bent, hammered into place.
frame, hits very numerous.
ure about 75°. Very light breeze, 4 o'clock. t be seated firmly in socket. 40 fragments thro' targ
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: AT GANAHL, TEXAS.

REMARKS.

Range 1800 feet above Sea level. Mean barom. estimate
during forenoon about 80°. Wind about 3 miles per ho
tion 8 o'clock at first to 4 o'clock later. Hazy.

rget. Size 9′ high by 14′ wide. About ¾ of sh
ation "Short" or "Over" never exceeded 20
tion of a few shots due to change of wind. T

ated as on previous day (over target 75 yards lo
s struck in the space. Elevation lowered 3′ a
to strike supposed crest of earthwork. Difficu
aze. Time of firing 30 shots about 25 minutes
shell about 200 yards in front of gun.

of shot (as estimated from firing point.)
about 80°. Wind 3 to 5 miles per hour, puffy
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me target as above (9 by 14 feet). Placed 50
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In every case where the brake jumped off, caught and bent, the trail had, by repeated firing, worn a depression in the ground. By slightly shifting the position of the gun each time, no further accidents of the kind occurred.

It is suggested that small guide plates with edges curved outward attached to guard rails, would shove the brake *outward* as it falls, force the shoe to engage in proper positions on the wheel, and would prevent such mishaps as those referred to.

Handspike.—Worked perfectly. Not found necessary to disengage it when firing.

Short Sponge and Rammer.—Would very frequently spring loose from its firing position on guard rails, when the gun was fired.

Jointed Sponge and Rammer.—Sliding collar will invariably jam if slid in wrong direction. A stop should be provided.

Projectiles and Fuses.—No projectile tumbled. Band stripped from one about 200 yards in front of gun. As far as noted 6 out of 214 failed to explode. Very many burst in air after the first graze; one burst on second ricochet. A fluttering sound was noticed in flight when elevation was 6° and over. The drift was found to be nearly double that given in the tables. This may be due to the new pattern projectile, with longer ogive than the preceding pattern.

NOTES ON THE ENGLISH PROVING GROUND AT SHOEBURYNESS.

By Mr. BURNIE C. BATCHELLER, C. E.

It was the fortune of the writer to spend the winter and spring of 1890 and 1891 at Shoeburyness. During this time an excellent opportunity presented itself of observing the system used at the proving ground as well as the methods of experiment then in use, and the facilities for carrying on the work. Thinking that officers on this side of the Atlantic might be interested in knowing how such work is carried on abroad, I have made note of some of the more important facts that came under my observation.

The proving ground at Shoeburyness is situated on the east coast of England and on the north side of the estuary of the Thames, about forty miles from London. The land in this region is quite level and only a little higher than the water at high tide, much of it having been reclaimed from the sea. The average rise and fall of the tide is from eight to ten feet, and when it ebbs the water recedes a distance of about two miles, leaving the beach quite dry. The sands thus uncovered by the water are so firm and hard that horses may be driven over them without sinking; and range-wagons driven rapidly across, sound to a person at some distance as if they were passing over a stone pavement. At high tide the sands are covered with water to a depth of about six feet, varying of course considerably at different times. This available beach extends for a distance of about eighteen miles, and is the most valuable and important feature of the proving ground. Nearly all firing, except at armor plates, is done either over the sands when the tide is out and the range of the shot is desired, or over the water when the tide is in and it is desired to recover the shot. No more convenient means of recovering shells can be imagined. The hard, smooth and level character of the sands is a great advantage, because ranges and deviations can be measured quickly and accurately; moving targets are easily arranged and nothing obscures a clear view of the ranges at all times, making instantaneous observations more certain and reliable. Ordinarily in firing over a land range there is considerable danger of stray shots doing injury to persons or property in the vicinity. This is hardly possible at Shoeburyness, for those conducting the experiments have a clear view of the ranges at all times. Some small vessels come in at high tide, but they are comparatively few.

Another important feature in the situation of the proving ground is the convenience of getting to and from Woolwich Arsenal where the government laboratory, gun and carriage shops are located. Boats ply daily between Woolwich and Shoeburyness for the transportation of material.

In this country the army and navy each have a proving ground under the direction of their respective departments; but in England there is only one, its work being directed by a body of officers known as the Ordnance Committee, whose members are appointed from both branches of the service. They are men who have had half a life time of experience in the service, and are supposed to be selected because of their peculiar fitness for the position. They have other duties than the direction of the experimental work at Shoeburyness. At the time of which I write, General Hay was chairman of the committee.

Towards the end of each week a programme is prepared by the experimental officers, of experiments to be made on each day of the following week. This is sent to Woolwich and submitted for approval to the Ordnance Committee. If approved, it is returned to Shoeburyness and every one concerned knows what is to be done each day during the following week. This gives a system to the work that it would not otherwise have. Very frequently the Ordnance Committee visit the proving ground and witness the experiments.

In addition to the experimental department there are several courses of instruction for young artillery officers, in the mounting and dismounting of guns; in the manipulation of new types of guns and carriages and in a variety of other work. This instruction is given by officers detailed for the purpose, and it is entirely separate from the experimental work.

There are two engineer officers at the proving ground who have charge of all engineering work, such as the erection of armor plates, the laying of foundations and emplacements, the extension of railways, the construction of buildings, earthworks, &c. Civilian laborers are employed for this work.

The sentry and other post duties are performed by several regular batteries of artillery. This relieves the officers and men carrying on the experimental work, from duties that would otherwise occupy a large portion of their time.

This experimental work is conducted by four artillery officers, including the commandant. They are appointed to this duty for a term of several years. The manual labor, such as mounting and dismounting guns, setting up targets, running wires, &c., is done by a company of enlisted men that have been carefully selected from different parts of the service, principally for their fine physique and good habits. They are strong muscular fellows averaging nearly six feet in height and weighing from 175 to 200 pounds. They remain permanently at Shoeburyness and have no regular military duties to perform. They become very expert in some of their duties, which facilitates the work and makes it much easier for the officers in charge. For example, a sergeant with several men is permanently detailed for range duty, such as measuring the ranges and deviations, recovering shells, erecting targets, &c. He very seldom makes a mistake in his measurements and accomplishes his work much more quickly than a man less familiar with it. Another sergeant is detailed to take photographs and has no other work to do.

Ample facilities have been provided at Shoeburyness for rapidly and easily handling guns, carriages, armor plates and material of all kinds. A line of railway extends from one end of the proving ground to the other. Numerous branches lead from this to storehouses, emplacements and wherever material is needed. The rails used are of extra heavy section, weighing 110 pounds per yard, and the sleepers are laid quite close, in order that heavy guns may be transported without injury to the road bed. The line was tested while I was there by drawing over it a 110-ton gun, mounted on a special carriage, the whole weighing more than 200 tons. Three light locomotives are used on the railway, and carriages are provided for the officers and men. The local railway is connected with the main line from London, making the delivery of heavy material, such as armor plates and mountings very convenient.

Most of the guns and carriages are brought from Woolwich by vessels, and special means have been provided for transporting guns weighing more than fifty tons. A barge named the "Gog," has been constructed, having one end removable and a section of railway laid down inside of it close to the keel. For example, a 110–ton gun, mounted on a special carriage that will run on a standard-gauge railway is placed in the barge, which is then towed to Shoeburyness at high tide, where special arrangements are made to receive it. At one point in the sea-wall, gates have been constructed similar to the gates of a dry dock. The barge is placed with her removable end in front of these gates. When the tide goes out she rests on the sand. The gates are then opened, the end of the barge is removed and the section of railway inside is connected to the railway on shore. Locomotives are then coupled to the gun carriage, and it is drawn out of the barge and taken to any point of the proving ground that may be desired. Similar arrangements have been provided for loading and unloading at Woolwich. By these means a gun and carriage weighing 200 tons may be brought from Woolwich in the morning, tested during the day, and returned to Woolwich in the evening.

A special platform has been constructed for testing heavy guns. It is built of concrete and has over it a large traveling crane operated by hydraulic power. It is located on the sea-wall and so arranged that a gun can be hoisted out of a vessel lying along side, and be placed on its carriage in position for firing. A branch of the local railway also extends under the crane.

All along the shore may be seen concrete emplacements of different designs for sea-coast guns. These are new designs that have been recommended for trial, before any are built for permanent use at fortified points on the coast. Guns are mounted upon them and fired many times to demonstrate whether or not they will stand the repeated shocks. Similiarly all new mountings have to undergo a severe trial here before any are put in service elsewhere. Many modern mountings are complicated, containing considerable mechanism, especially the disappearing carriages of the hydro-pneumatic type. These have to undergo an extended trial, to prove not only that they can stand the repeated shocks of recoil, and that their mechanism will work properly under all conditions of service, but that they do not disturb the accuracy of fire of the gun by a want of rigidity. Oftentimes experiments have to be made to determine the best material to be used in different parts of their construction. For example, at one time a series of experiments was made to determine the best liquid to be used in the hydro-pneumatic mountings.

Guns of all types, except small-arms, come here to be tested for accuracy, muzzle velocity, durability, &c.

An important part of the work is the trials of armor plating and projectiles. The government requires that one plate from every lot manufactured be tested. The plates are usually held in heavy wrought-iron frames, to give the support they would receive from neighboring plates on the side of a ship, and they are backed with many feet of solid oak. In rear of the oak, sand is piled up to stop the projectile in case it pierces the plate and timbers. In addition to these many plates are required for testing armor piercing projectiles. From every lot of projectiles that are made for service, three are selected at random and sent to the proving ground. If they stand the required test the whole lot is accepted, but if they fail it is rejected. The gun used for firing is usually placed two hundred yards or more from the plate, and screens are erected along the line of fire for taking the velocity of the shot.

During the past few years a great many new powders have been tested, most important of which has been the smokeless type. Gun-sights, instruments of all kinds, and hundreds of other war appliances all come to Shoeburyness to first demonstrate their peculiar qualities and fitness for service.

In all experimental work accuracy is of first importance, and here great pains are taken to secure it. Ranges and deviations are measured in the following manner: A line of fire is laid off from each gun and pegs are driven at every hundred yards, branded with the distance from the gun. The range sergeant carries a two-yard stick, and if the shot strikes upon the line of fire he simply measures this distance from the nearest peg and enters it in his book. If the shot strikes upon one side of the line, then he projects its position on to the line, and to make sure that the line of projection is at right angles to the line of fire, he uses a large wooden square, ten feet on each side, which he lays down on the sands and sights across. Having done this he then measures the distance from the line of fire to the point where the shot struck for the deviation and from the projected point to the nearest peg for the range. All measurements are made to one-fifth of a yard.

The velocities of projectiles are measured with the improved form of Boulangé chronograph. This instrument and its method of operation are so generally understood that I need not describe it in detail here. As a check upon the results, two instruments having separate circuits are always used. The screens are made double by stretching separate wires on each side of the frames. If both instruments do not give essentially the same velocity the records are considered of no value. Storage batteries have been found to give the most satisfactory results for operating the instruments, and where they are permanently set up, as they are here, there is no reason why they should not be used. The instruments are placed upon solid brick pedestals in a convenient building. Main wires run to local boxes in different parts of the proving ground. Connections are quickly made at any time between these boxes and the screens by cables strung along the ground. A portable telephone can be connected at the local boxes, and communication established between the officer at the gun and the officer manipulating the instruments.

Pressure in the bore of guns is measured by means of the copper "crusher-gauge"; no doubt similar to those used in this country. A small cylindrical piece of copper is placed in a cylinder having a closely fitting plunger which is sealed with tallow against leakage of powder gases. The whole is placed in the powder chamber of the gun. The copper is accurately calipered before and after being subjected to pressure, and the difference of these measurements is a measure of the pressure in the bore. The instrument has to be calibrated by subjecting similar copper cylinders to a known pressure and noting the compression. The officers expressed themselves as having very little confidence in measurements made with an instrument of this kind, but it continues to be used for want of a better one.

For measuring the times of flight of projectiles the stop-clock is used, and there seems to be no other practical method. Some of the clocks read to hundredths of a second, and two skilled observers get practically the same readings with them when two are used simultaneously. The clocks are regulated by allowing them to run half an hour and comparing them with an ordinary clock.

The velocity of the wind is taken with the well known form of cup-anemometer. They can be held in the hand and have a minute-glass attached for giving the time. The readings have to be referred to a calibration curve.

One very interesting experiment was made at Shoeburyness while I was there, showing the effect upon armor plating of a shot from one of the largest guns in the English Navy. It was a 110-ton gun, taken from one of the iron-clads, having a calibre of a little more than sixteen inches. The projectile used was of the armor piercing type having a very hard point. The target consisted of two compound armor plates of iron and steel, having a combined thickness of twenty-eight inches. They were supported in heavy wrought-iron frames, and were backed with twelve-inch oak timbers twenty feet deep. Back of the oak stood a brick wall faced with granite, probably six or eight feet thick. The projectile passed through the twenty-eight inches of iron and steel, breaking the plates and bending out of shape the massive frames that held them ; then it passed through the twenty feet of oak, crushing and displacing the timbers in all directions, and turned up sideways against the brick wall in almost as good condition as before being fired. While it failed to pierce the wall it cracked it in all directicns, and displaced some of the granite blocks on the face farthest from the gun. It was hard to realize that so much work could be done by a single shot from any gun. At the Naval Exhibition held in London during the past summer, this experiment was illustrated by a full size drawing.

One of the most noted experiments made at Shoeburyness was the firing of the "Jubilee Shot," for the purpose of checking mathematical computations of range at high angles of elevation. The gun used had a calibre of 9.2 inches, The elevation was about forty-three degrees and the range obtained was about twelve miles.

[TRANSLATION.]

THE DETERMINATION OF THE VELOCITIES OF PROJECTILES BY MEANS OF SOUND PHENOMENA.

[CONCLUDED.]

BY CAPTAIN FERNAND GOSSOT, OF THE FRENCH MARINE ARTILLERY.*

EXPERIMENTS.

The experiments to be described are divided into two groups:

1st. Those having for principal object the comparison of results obtained by the old and new methods, respectively.

2nd. Those in which has been investigated the application of the new method under various conditions of practice.

In what follows there have been left out certain experiments not made under clearly defined conditions, and whose results, in consequence, admitted of no check. We must not lose sight of the fact that a very small number of special experiments has been made, and that as far as possible the daily practice has been utilized to study the working of the apparatus.

* Translated with the permission of the author by 1st Lieutenant Cornélis De W. Willcox, 2nd Artillery.

1ST—EXPERIMENTS FOR THE PURPOSE OF COMPARING THE TWO METHODS.

	22nd August.	4th August.	17th September.	2nd October.	8th January, 1891.*
Calibre	65 mm. R. F.	34 cent. Model 1870—1884.	24 cent. Model. 1870.	10 cent. Model 1880. Conv. R. F.	65 mm. R. F.
Projectile { Kind	Common shell.	Ogival shot, shell.	Ogival shot, shell.	Cylindric shot.	Loaded shell.
Projectile { Weight (kil.)	4	345	144	14	4
Position of frames	100 190	125—179—1269—1319	80.130—740.780	100—160	70—140
Position of membranes	100 190	1299—1319	740.780	100—160	600—650
Angle of fire	1°	1° 8′	1° 10′	0° 30′	8°
Number of shots	10 10	7 7	7 7	20	43
Initial velocity measured by { Frames	730.8 708.0	602.2 601.0	441.1 449.7	543.0	746.0
Initial velocity measured by { Membranes	733.8 711.3	602.3 601.8	441.3 449.2	541.7	745.6
Mean deviation { Frames	1.5 1.6	1.0 0.9	1.0 1.5	1.2	2.5
Mean deviation { Membranes	1.2 1.7	1.3 2.2	1.0 1.3	1.2	2.7

*This series was carried out with the Cousin interrupter not equipped with the auxiliary re-establishment of current. The latter remade itself at each shot by the mere elasticity of the spring *R*. The apparatus was left to its own devices and worked without incident. The current was perfectly steady.

It may be seen from the preceding table that the differences between the results of the two methods may be neglected. It is very important to note that if velocities are measured far from the muzzle, the coefficient of reduction must be known; now on the 4th of August and 17th of September this coefficient was measured during the practice itself. Two other series are not reported, one with a 65 mm. R. F. G,, the other with a 19 cent. piece, model 1887, firing cylindric shot; the results of these two trials were in effect not well established, because the coefficient of reduction was not determined during the practice itself. The differences between the measurements arising from the two methods, bear opposite signs in the two cases.

It may be remarked that the series of October 2nd was fired with the interrupters arranged in such a fashion, that their indications were identical with those of the target frames. Under these conditions the employment of the apparatus was attended by every convenience. The current re-established itself after each shot without the intervention of the operators. Furthermore, the installation of the apparatus on the field is far simpler than that of the frames. The firing is equally simplified and accelerated. It is no longer necessary to aim with the extreme care exacted by the necessity of hitting frames of small dimensions.* The determination of the initial velocity is made by usual methods, without requiring in this case, the computer to bestow attention on the nature of the interrupter.

2ND—EXPERIMENTS INTENDED TO BRING OUT THE IDENTITY OF RESULTS WITH FIRE UNDER DIFFERENT ANGLES.

Four series of five rounds each were fired in a medium calibre (16 cent.) at a velocity of 625 mm., under four different angles, with the object of determining whether the application of the method set forth above, would under these different conditions give the same initial velocity. These series were carried out at the same meeting, in order that the constancy of the lot of powder used might be legitimately granted. This kind of experimentation is crucial for the proposed method. For it is clear that if the variation in the angle of fire could bring about systematic variations in the measure of initial velocities, we could no

* In the series of January 8th, the two Cousin interrupters were left completely to themselves; they registered the velocity at each shot (52 in all), the rate of firing being greater than one round per minute. The fouling of the contacts were hardly perceptible at the end of this series.

longer feel sure of obtaining in ballistic firing, results as worthy of confidence as those of former special firings for velocity determinations, and the object I set before myself, to-wit: to do without the latter, would be no longer attained.

In view of the capital importance of this result, and equally, in order to bring out clearly by an example the theories given above, I append a table of the results obtained by interrupting membranes, as well as the method of computation applied to these results. This method involves a slight modification of that expounded above, bearing in reality more upon an abridgment of the notation used, than upon the method itself.

For the first fifteen shots three, and for the last five, two, couples of interrupters were set in the plane of fire. These three couples worked three Le Boulengé chronographs.

Meeting of November 18th, 1890.—Sixteen cent. gun of irregular model, ordinary cast-iron shell, ballasted to 45 kil. Powder A S $\frac{28}{34}$, $\tilde{\omega} = 20$ kil.

Given conditions used in computation:

Temperature, 12°; component of wind parallel to plane of fire, 5 m.

a for temperature of 12°	339.7
Mean variation in a due to wind	—3.7
$a =$	336.0

$\log b = 4.1548$; $x = 130$; $d = 60$.

$m = o$ for first fifteen rounds.

$m = -o^m.38$ for last five.

$$\alpha = \quad 7^\circ \quad 15^\circ \quad 20^\circ \quad 0^\circ\ 38'.$$

$$v_1 = \frac{d}{\theta} = 524.2 \quad 453.2 \quad 421.5 \quad 600.6.$$

For the computation of initial velocities, the method hitherto employed was modified as follows:

The equation

$$a\theta = d \cos \psi \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

may be written

$$a \sec \psi = v_1,$$

designating by v_1 the velocity registered by the chronograph for the interval d.

If we compare this equation with

$$a \sec \varphi = v \quad \dots\dots\dots\dots\dots\dots \quad (2)$$

v being the velocity corresponding to the distance,

$$s = x \sin \psi \operatorname{cosec} \varphi,$$

taken along the trajectory, it is seen that they are of the same form.

The registered velocity v_1 corresponds therefore to a certain point of the trajectory at a distance S_1 from the muzzle; at this point the angle φ_1 characteristic of the velocity, is precisely the angle ψ.

The initial velocity is deduced then by the usual formula

$$V_0 = v_1 e^{bs_1} = a \sec \psi\, e^{bs_1} \quad \dots\dots\dots\dots \quad (3)$$

The unknown S_1 is obtained by comparing this formula with that used at former meetings,

$$V_0 = v \cos \tau \sec a\, e^{bs} \quad \dots\dots\dots\dots\dots \quad (4)$$

whence

$$e^{bs_1} = \frac{\cos \psi}{\cos \varphi} \cdot \frac{\cos \tau}{\cos a} e^{bs} \quad \dots\dots\dots\dots\dots \quad (5)$$

The angle ψ comes from (1). τ and $\varphi = \psi + \tau$ are computed by methods already given [(22) et seqq].

This calculation is made only for mean velocities. The initial velocity of each shot may be obtained by the formula

$$\log V_0 = \log v_1 + (b s_1 \log e),$$

the quantity $b s_1 \log e$ being constant for the whole series. It will be more expeditious to apply the following method:

We have

$$\frac{d V_0}{V_0} = \frac{d v_1}{v_1} \text{ or } d V_0 = \left(\frac{V_0}{v_1}\right) d v_1.$$

The ratio $\frac{V_0}{v_1}$ being constant for a given series, it will be found sufficient to prepare a table of the multiples of this ratio, and to evaluate at each round the difference $d v_1$ between the measured velocity and the mean velocity v_1, in order to obtain by a mere reading the corresponding variation $d V_0$.

For the mean velocities V_0 there have been obtained the values,

a	0° 38′	7°	150°	20°
Mean of measured velocities v_1	600.6	523.7	453.2	421.2
Corresponding distance S_1	280	1254	2264	2766
V_0	625.6	626.4	626.2	625.5
$\frac{V_0}{v_1}$	1.04	1.20	1.38	1.48

It is seen that the deviations of the velocities corresponding to each round will have to be multiplied by $\frac{V_0}{v_1} > 1$ in order to obtain the deviations in the initial velocities. It may be conceived therefore, that for equal precision in the measurement of the velocities v_1, there will correspond in the measurement of initial velocities a precision as much less as the angle of fire is greater. If the observed deviations in velocity could come only from variations of initial velocity, and were independent of the variations proper to the means of measurement, it is evident that the smaller the velocity measured the smaller these deviations. This is not the case with membranes, their employment involving special errors.

Results of the Firing.

Apparatus.	Chronograph No. 1. 5—6		Chronograph No. 2. 1—2		Chronograph No. 3. 3—4		Mean value of v_1	$d\ v_1$	$d\ V_0$	V_0
	H	v_1	H	v_1	H	v_1				
FIRE UNDER ANGLE OF 7°.										
1	342.2	525.8	341.4	527.2	In this first series, chronograph No. 3 was not adjusted.		526.5	+2.8	+3.4	629.8*
2	5.5	0.0	4.2	2.2			1.1	—2.6	—3.0	623.4
3	2.5	5.2	3.0	4.4			4.8	+1.1	+1.3	625.1
4	3.6	3.4	3.8	3.0			3.2	—0.5	—0.6	625.8
5	1.7	6.6	2.8	4.6			5.6	+1.9	+2.3	628.7
FIRE UNDER ANGLE OF 15°.										
6	389.8	455.0	392.2	452.2	389.8	455.0	454.1	+0.9	+1.2	627.4
7	91.9	2.4	1.8	2.4	90.7	3.8	2.9	—0.3	—0.4	625.8
8	2.1	2.0	1.7	2.6	89.9	4.8	3.1	—0.1	—0.1	626.1
9	2.1	2.0	1.4	3.0	90.7	3.8	3.0	—0.2	—0.3	625.9
10	2.1	2.0	1.6	2.6	90.3	4.2	29.	—0.3	—0.4	625.8
FIRE UNDER ANGLE OF 20°.										
11	420.3	420.4	419.1	421.6	417.5	423.4	421.8	+0.6	+0.9	626.4
12	0.3	20.4	19.1	1.0	7.5	3.4	1.8	+0.6	+0.9	626.4
13	1.6	19.2	20.6	0.2	9.0	1.8	0.4	—0.8	—1.2	624.3
14	0.5	20.2	19.4	1.4	9.2	1.6	1.1	—0.1	—0.1	625.4
15	0.1	20.6	19.6	1.2	9.9	6.8	0.9	—0.3	—0.4	625.1

* Warming charge: thrown out.

FIRE UNDER ANGLE OF 0° 40′.

Apparatus.	Chronograph No. 1. 5—6 Target frames.		Chronograph No. 2. 1—2		Chronograph No. 3. 3—4		Mean value of v_1 Mean for membranes.	$d\ v_1$	dV_0	V_0	Initial velocities. Target frames
	H	v_1	H	v_1	H	v_1					
16	302.7	609.6	306.6	600.0	306.0	601.4	600.7	+0.1	+0.1	625.7	621.0
17	2.6	10.0	7.0	599.0	5.9	1.6	.3	—0.3	—0.3	625.3	621.4
18	2.6	10.0	6.8	599.4	5.7	2.2	.8	+0.2	+0.2	625.8	621.4
19	2.1	11.2	7.2	599.0	5.4	3.0	.5	—9.1	—0.1	625.5	622.6
20	6.4	600.4	10.4	Abnormal.	9.5	Abnormal.	Abnormal.	. .	. .	. .	611.6
. .	. . .	. . .	. . .		. . .			. .	. .	. .	. . .

MEAN AND EXTREME RESULTS.

		0° 40′	7°	15°	20°
Measured velocities, v_1	a	0° 40′	7°	15°	20°
	Apparatus 1–2	599.3	523.7	452.6	421 2
	Apparatus 3–4	602.0	——	454.3	422.2
	Apparatus 5–6	——	523.7	454.7	420.2
	v_1 (mean)	600.6	523.7	453.2	421.2
	$e\ m$	0.2	1.5	0.36	0.48
	V_0	625.6	625.7	626.2	625,5

Extreme deviation of initial velocities obtained under the four angles 0.7

V_0 for the 19 rounds . . . . 625.7 mean error 0.63

V_0 obtained by frames (four rounds) 621.6 mean error 0.50

Difference 4.1

In the preceding practice, the three pairs of membranes gave agreeing results.

The velocities measured at all the shots of each series are very uniform, as is shown by the mean errors obtained, The initial velocities computed for each of the four angles

0° 40′ 7° 15° 20°

by means of the velocities measured under these angles agree very closely; the greatest difference indeed being but $0^m.7$. Now if we recollect that the influence of an error in the velocity a of sound increases as the angle of fire increases, we may conclude that the atmospheric conditions were accurately estimated.

From the identity of the results obtained for initial velocities with fire under the four angles given above, it follows that the formulas used take into account with sufficient accuracy, the influence exerted by the variations of the angle of fire on the velocities measured by chronograph. Now these variations for constant positions of the apparatus are marked, as may be seen from the following table:

a	0° 40′	7°	15°	20°
v_1 (measured)	600.6	523.7	452.7	420.2

Hence, the hypotheses at the foundation of the formulas used, may be considered to be legitimate. We must remark here that the mean initial velocity deduced from measurements made with the membranes, is greater by four metres than that obtained with the frames. Without seeking the cause of this difference, we may note that on other dates (August 4th, September 17th and October 2nd, 1890) identical results were got from membranes at the foot of the frames. The results obtained at Sevran-Livry under the same conditions lead to the same conclusion. The anomaly in question is therefore accidental, and in any case of slight importance.

3RD—EXPERIMENTS TO DETERMINE VELOCITY IN BALLISTIC PRACTICE.

The object of the experiments tabulated below was to determine velocities in ballistic firing. I have recorded only those firings in which the initial velocity is accurately known from velocity determinations made very shortly before. A great many other experiments were made with the object of studying the working of the various devices tried. In the majority of them, practice was not carried on with the service charge, so that no results were attainable from the measured velocities except through calculation. These series have all been thrown out, their results not being sufficiently trustworthy.

BALLISTIC FIRING.

	Sept. 8th, 1890.	July 15th, 1890.	Aug. 25th, 1890.	Aug. 11th, 1890.	Sept. 18th, 1890.
Calibre	10 cent., model 1881. Conv. R. F.	32 cent., model 1890.	32 cent.. model 1870—1884.	32. cent., model 1870—1884.	24 cent., model 1870.
Proj'tle { Kind, Weight, (kilog.)	Cylindric shot, 14	Battering shell, 345	Shot, 345 Shell, 345	Shell, 345	Ogival Shot, 144 Shell. 144
Position of membranes	200—260	593—643	596—674	596—674	592—646
Number of rounds	2	3	5	7	7 7
Angle of fire	15°	15°	8° 45′	13°	14° 30′
I. V.	$529^{m}.7$	$447^{m}.6$	604^{m} 604^{m}	$601^{m}.3$	440.1 441.1
Mean error	0.2	1.3	1.1 1.6	2.8	2.1 2.2
	Automatic adjustment, one couple.		Automatic adjustment, two couples of membranes.		Automatic adjustment, two couples of membranes.
Initial velocity measured by target frames	528.2	$447^{m}.1$	$602^{m}.2$ $601^{m}.8$	$601^{m}.8$	441.1 442.7
	Sept. 8th. 1890.	July 2nd, 1890.	Aug. 4th, 1890.	Aug. 4th, 1890.	Sept. 17th, 1860.

BALLISTIC FIRING.

	October 1st.	Nov. 26th.	October 30th.	October 23rd.
Calibre	24 cent., model 1870.	16 cent., model irreg. No. 2.	16 cent., model irreg. No. 1.	16 cent., model irreg. No. 1.
Projectile { Kind, Weight, (Kilog.)	Shell, 144	Common shell, 45	Common shell, 45	Common shell, 45
Positions of membranes	594—649	100—160	67—117	560—600
Number of rounds	8	5	8	2
Angle of fire	27°	13°	27°	14°
I. V.	439.5	617.5	616.7	616.4
Mean error	5.0	1.8	2.7	"
	Two couples of membranes, automatic adjustment.	Two couples.	Two couples, difference of level $+4^{m}$.	Two couples.
Initial velocity measured by target frames	442.7	616.6 621.6	618.8	616.5
....	Sept. 17th, 1890.	Nov. 11th and 18th, 1890.	October 21st, 1890.	Oct. 21st, 1890.

SUMMARY AND FINAL CONSIDERATIONS.

The wave of condensation accompanying a projectile endowed with a velocity greater than 340 m. about, can indicate its passage over any point situated in the plane of fire. Current-breakers working a chronograph allow the measurement of the interval of time between the passage of the projectile through two points, that may be mathematically connected with the impressed apparatus.

I have in the preceding investigation brought out the methods of deducing the remaining velocity and the corresponding point of the trajectory, from the time interval registered by the chronograph, and from the positions of the interrupters. The problem is divided into two.

In the first, a single remaining velocity is measured at a point very near the muzzle, and in practice with any angle of projection up to about 30°. The method of calculation giving the desired solution is based on the hypothesis of the rigidity of the trajectory in the neighborhood of the muzzle.

The interrupters will in general be three in number, and will work three Le Boulengé chronographs. The agreement of the readings will be a guarantee of the confidence to be accorded to the results. The use of three chronographs requires twelve wires for the establishment of the circuits. This complication of electric communication offers but little inconvenience if the interrupters are near the gun. Further, the comparative simplicity of the hypothesis on which rests the mode of investigation followed, permits an almost instantaneous deduction of the initial velocity for each shot from the readings of the instruments, thanks to a few preliminary computations that may always be made at leisure. This rapidity in the determination of the velocity is in the majority of cases a necessity.

In the second problem, it is proposed to measure the remaining velocity of the projectile at several points of its path. and over its whole extent. The number of these points is in general at the minimum three. It is proposed, also, to measure the time interval of the projectile between the points in question.

As the remaining velocities whose measure is sought must not be sensibly less than 400 m., it will be advantageous, and furthermore always possible, to determine the angle of fire corresponding to a final velocity at the point of fall, at least equal to this inferior limit.

Under these conditions, trajectories will always be very flat, either because the projectile, of small calibre, has a very high initial velocity; or because, if of large calibre, it holds its velocity; or because these two conditions are both satisfied. The object of practice of this sort is the complete study of a trajectory under a given angle. If the three points chosen are very near, the first, to the gun; the second, to the vertex; and the third, to the point of fall, three velocities will be got, giving for each round two values of the coefficient of reduction. From these two values, may be deduced with great accuracy the initial and the arriving velocities.

The time-interval measured between the muzzle and the vertex, when compared with the computation of this interval, which may be made with precision from a consideration of the extreme velocities as made known by observation, will furnish either a verification of the coefficient of reduction; or, if it be supposed known from preceding experiments, an evaluation of the abscissa of the vertex. As a matter of fact, it is known that chronograph-indications depend on the difference of level of the instruments.

Considering the entire trajectory, the chronograph furnishes the time of flight between the first and last points; and therefore, the total time of flight if we add to the measured interval, on the one hand the time between the muzzle and the first point; on the other, that elapsed from the passage of the third point and the point of fall. We see then how complete are the indications in the preceding case.

The method of calculation is based on Didion's hypothesis, which is perfectly legitimate for angles of fire less than 10°, high initial velocities, and the constancy of the coefficient of resistance as regards an entire power of the velocity (here the square). The deductions are more laborious than in the case preceding, but can all be made at leisure.

The interrupters will require neither greater nicety of construction nor greater sensitiveness than in the first case, seeing that they are operated by the *sound of the projectile;* and this will always pass near by. The chronograph employed must indispensably give continuous indications, like the Schultz as modified by MM. Marcel Deprez and Sebert. This apparatus requires only one circuit, a very great advantage at considerable distances from the gun. It takes longer to get results from this instrument than from that of Le Boulengé. The inconvenience lies chiefly in the length of time required to make readings, and it is to be desired that great improvement be made in order to allow a greater rapidity of fire.

This improvement can be easily made by registering on the cylinder of the chronograph the oscillations, or half oscillations of an electric pendulum attached to the instrument. It will be sufficient before firing to standardise this pendulum with reference to the tuning-fork. This installation will shortly be made at Gâvre.

It is also worth while to produce on the cylinder a signal at the moment when the projectile reaches the muzzle. It has been found necessary for many reasons to abandon the wires at the muzzle. It has seemed preferable to me to get a signal showing the closing of the current by arranging at the muzzle and on the chronograph a circuit and special register. This circuit, broken in a normal interval of time is closed by the passage of the projectile, which touches two metallic brushes put in the circuit at the muzzle. We may thus rest assured that the signal produced is not due to the gases of the powder.

The employment of the Schultz chronoscope exacts the addition to the interrupter of a device that will very rapidly re-establish the current, in order that the circuit broken at one instrument may be certainly restored before the next one works.

Whatever the problem, the principal advantage of the proposed over the old method lies in the fact *that no special practice is necessary to its solution.* This method will make it possible to get the initial velocity in all ballistic firing, and to study thoroughly the trajectories of fire at great ranges. This study is necessary to the determination of the coefficient of reduction for the projectile considered, and of the laws of atmospheric resistance at high velocities.

These studies are all as yet in their infancy; the apparatus used will doubtless receive many material improvements. It is to be desired that these investigations be carried on without interruption; a thing that is possible, as it appears to us, from the happy circumstance that the greater part of the firing of proving boards may be used for this purpose without entailing additional expense.

Note.—We are indebted to Captain Ingalls, 1st Artillery, for permission to print the following extracts from letters received by him from Captain Gossot:

"By the method submitted, it is possible to determine . . . in a single trajectory of great range as many velocities as desired, thus permitting, under atmospheric conditions as nearly identical as possible, the comparison of resistances for greatly varied velocities."

[August 16th, 1891.]

"The measure of initial velocities proper [by Captain Gossot's method] has become a matter of common practice [at Gâvre]. The apparatus needed to make this simple measurement is very simple and cheap. It offers no difficulty of either construction or adjustment. . . . At the moment when the compressed wave moving with the velocity of the projectile strikes . . . the metallic membrane, it yields to the latter its quantity of motion, which in turn is transmitted entirely to the sphere in rear.

"This, in virtue of its slight mass, immediately moves with a relatively high velocity and thus breaks the electric circuit, of which with the membrane and receiver it forms a part. The resulting rupture is like that of a target-frame. The LeBoulengé chronograph is well suited to make this measurement. It needs hardly be pointed out, that two instruments of this sort are necessary in order to take a velocity. It was my custom to always use two couples, sometimes three. . . . The current re-establishes itself in about $0^{s}.2 - 0^{s}.3$ after the rupture. Before firing disjunctions may be taken, in order to satisfy one's self of the agreement of the instrumeuts.

"It is extremely important to break the circuit very abruptly, in order to avoid the delay of magnetisation due to the variable prolongation of the current following the spark of rupture. . . . With this simple apparatus I was enabled to take fifty velocities in an hour and a half. The instruments worked of their own accord without observers, and furnished the same results as the target-frames operated at the same time. . . .

"Contacts must be of platinum and *plane*, not pointed or shaped like a drop."

[Dakar, Senegal, November 24th, 1891.]

TABLE OF FUNCTIONS.

$$\text{Log. } \Phi = \text{log. } e^{z}, \text{ log} \left\{ \frac{1 - e^{-2z}}{2} \right\} = \text{log. } Shz\, e^{-z}.$$

z	Log. e^{z}	Log. $Shz\,e^{-z}$	z	Log. e^{z}	Log. $Shz\,e^{-z}$
o	o				
0.000	0.000	$-\infty$	582	253	7395
16	17	$\bar{3}$.1954	597	259	7505
31	18	4959	613	266	7611
47	20	6712	0.629	0.273	$\bar{2}$.7715
63	27	7955	644	280	7815
0.079	0.034	$\bar{3}$.8917	660	287	7913
94	41	9702	676	293	8009
110	48	$\bar{2}$.0364	692	300	8103
126	55	0937	0.707	0.307	$\bar{2}$.8194
141	61	1443	723	314	8282
0.157	0.068	$\bar{2}$.1894	739	321	8369
173	75	2301	755	328	8454
189	82	2672	770	334	8538
204	89	3012	0.786	0.341	$\bar{2}$.8619
220	96	3327	802	348	8698
0.236	0.102	$\bar{2}$.3621	818	355	8775
251	109	3894	833	362	8852
267	116	4151	849	369	8927
283	123	4392	0.865	0.376	$\bar{2}$.9000
298	130	4620	881	383	9072
9.314	0.136	$\bar{2}$.4837	897	390	9142
330	143	5042	912	396	9212
346	150	5237	928	403	9272
361	157	5423	0.944	0.410	$\bar{2}$.9346
377	164	5601	960	417	9411
0.393	0.171	$\bar{2}$.5772	975	423	9476
409	178	5935	991	431	9538
424	184	6093	1.007	438	9601
440	191	6245	1.023	0.445	$\bar{2}$.9660
456	198	6390	039	451	9721
0.471	0.205	$\bar{2}$.6531	054	458	9780
487	211	6667	070	465	9838
503	218	6798	086	472	9895
519	225	6925	1.102	0.478	$\bar{2}$.9952
534	232	7048	118	485	$\bar{1}$.0007
0.550	0.239	$\bar{2}$.7167	133	490	0061
566	246	7283	149	499	0115

z	Log. e^z	Log. $S h z e^{-z}$	z	Log. e^z	Log. $S h z e^{-z}$
165	506	0167	768	768	1731
1.181	0.513	$\bar{1}$.0219	784	775	1763
197	520	0270	800	782	1795
212	526	0321	1.816	0.789	$\bar{1}$.1827
228	533	0371	832	796	1858
244	540	0420	848	803	1889
1.260	0.547	$\bar{1}$.0468	864	810	1920
276	554	0516	880	817	1951
292	561	0562	1.896	0.824	$\bar{1}$.1981
307	568	0609	912	831	2011
323	574	0665	928	838	2040
1.339	0.581	$\bar{1}$.0700	944	844	2071
355	588	0745	960	851	2100
371	595	0789	1.976	0.858	$\bar{1}$.2129
387	602	0832	1.992	865	2157
403	609	0875	2.008	872	2185
1.418	0.616	$\bar{1}$.0917	024	879	2213
434	623	0958	040	886	2241
450	630	0999	2.056	0.893	$\bar{1}$.2269
466	636	1041	072	900	2296
482	643	1081	088	907	2323
1.498	0.650	$\bar{1}$.1121	105	914	2350
514	657	1160	121	921	2376
530	665	1198	2.137	0.928	$\bar{1}$.2402
545	671	1237	153	934	2429
561	678	1275	169	941	2455
1.577	0.685	$\bar{1}$.1312	185	948	2481
593	692	1349	201	956	2505
609	699	1386	2.217	0.963	$\bar{1}$.2530
625	706	1422	233	970	2555
641	712	1458	249	977	2580
1.657	0.719	$\bar{1}$.1494	265	984	2604
673	726	1528	281	991	2629
689	733	1563	2.298	0.998	$\bar{1}$.2653
705	740	1597	314	1.005	2677
721	747	1631	330	012	2701
1.737	0.754	$\bar{1}$.1665	346	019	2724
752	761	1698	362	026	2747
			2.378	033	$\bar{1}$.2771

Log. (1 + f)

2z	log. (1 + f)	2z	log. (1 + f)	2z	log. (1 + f)	2z	log. (1 + f)	2z	log. (1 + f)
0.02	0.00436	1.02	0.24016	2.02	0.51012	3.02	0.80983	4.02	1.13377
0.04	00872	1.04	24523	2.04	51584	3.04	81609	4.04	14046
0.06	01309	1.06	25032	2.06	52157	3.06	82236	4.06	14715
0.08	01749	1.08	25542	2.08	52731	3.08	82864	4.08	15386
0.10	02190	1.10	26054	2.10	53307	3.10	83493	4.10	16057
0.12	0.02632	1.12	0.26567	2.12	0.53884	3.12	0.84123	4.12	1.16728
0.14	03076	1.14	27082	2.14	54462	3.14	84754	4.14	17401
0.16	03521	1.16	27597	2.16	55041	3.16	85386	4.16	18074
0.18	03967	1.18	28114	2.18	55621	3.18	86018	4.18	18748
0.20	04415	1.20	28633	2.20	56202	3.20	86652	4.20	19423
0.22	0.04865	1.22	0.29153	2.22	0.56785	3.22	0.87286	4.22	1.20098
0.24	05316	1.24	29674	2.24	57369	3.24	87922	4.24	20974
0.26	05768	1.26	30196	2.26	57954	3.26	88558	4.26	21451
0.28	06222	1.28	30720	2.28	58540	3.28	89196	4.28	22128
0.30	06677	1.30	31245	2.30	59127	3.30	89834	4.30	22807
0.32	0.07134	1.32	0.31772	2.32	0.59715	3.32	0.90473	4.32	1.23485
0.34	07592	1.34	32300	2.34	60304	3.34	91113	4.34	24165
0.36	08052	1.36	32829	2.36	60895	3.36	91754	4.36	24845
0.38	08513	1.38	33359	2.38	61487	3.38	92396	4.38	25526
0.40	08975	1.40	33891	2.40	62080	3.40	93038	4.40	26208
0.42	0.09439	1.42	0 34424	2.42	0.62673	3.42	0.93682	4.42	1.26890
0.44	09904	1.44	34959	2.44	63268	3.44	94326	4.44	27573
0.46	10371	1.46	35495	2.46	63864	3.46	94971	4.46	28257
0.48	10839	1.48	36032	2.48	64462	3.48	95618	4.48	28941
0.50	11309	1.50	36570	2.50	65060	3.50	96265	4 50	29626
0.52	0.11780	1.52	0.37110	2.52	0.65659	3.52	0.96913	4.52	1.30312
0.54	12252	1.54	37651	2.54	66260	3.54	97561	4.54	30998
0.56	12726	1.56	38193	2.56	66861	3.56	98211	4.56	31685
0.58	13202	1.58	38736	2.58	67464	3.58	98861	4.58	32373
0.60	13678	1.60	39281	2.60	68068	3.60	99513	4.60	33061
0.62	0 14157	1.62	0.39827	2.62	0.68672	3.62	1.00165	4.62	1.33750
0.64	.14636	1.64	40375	2.64	69278	3.64	00818	4.64	34439
0.66	15117	1.66	40923	2.66	69885	3.66	01472	4.66	35130
0.68	15600	1.68	41473	2.68	70493	3.68	02126	4.68	35820
0.70	16083	1.70	42024	2.70	71102	3.70	02782	4.70	36512
0.72	0.16569	1.72	0.42577	2.72	0.71712	3.72	1.03438	4.72	1.37204
0.74	17055	1.74	43130	2.74	72323	3.74	04095	4.74	37897
0.76	17543	1.76	43685	2.76	72935	3.76	04753	4.76	38590
0.78	18033	1.78	44241	2.78	73548	3.78	05411	4.78	39284
0.80	18524	1.80	44799	2.80	74162	3.80	06071	4.80	39979
0.82	0.19016	1.82	0.45358	2.82	0.74777	3.82	1.06731	4.82	1.40574
0.84	19510	1.84	45917	2.84	75393	3.84	07392	4.84	41369
0.86	20005	1.86	46479	2.86	76010	3.86	08054	4.86	42066
0.88	20501	1.88	47041	2.88	76628	3.88	08717	4.88	42763
0.90	20999	1.90	47605	2.90	77248	3,90	09380	4.90	43460
0.92	0.21499	1.92	0.48169	2.92	0.77868	3.92	1.10045	4.92	1.44158
0.94	21999	1.94	48735	2.94	78489	3.94	10710	4.94	44857
0.96	22501	1.96	49303	2.96	79111	3.96	11375	4.96	45556
0.98	23005	1.98	49871	2.98	79734	3.98	12042	4.98	46256
1.00	23510	2.00	50441	3.00	80358	4.00	12709	5.00	46957

Log. $(1+F)$

$2z$	log. $(1+F)$	$2z$	log. $(1+F)$	$2z$	log. $(1+F)$	$2z$	log. $(1+F)$	$2z$	log. $(1+F)$
0.02	0.0029[illegible]	1.02	0.16074	2.02	0.34531	3.02	0.55774	4.02	0.79742
0.04	0058[illegible]	1.04	16416	2.04	34928	3.04	56228	4.04	80248
0.06	00873	1.06	16759	2.06	35327	3.06	56682	4.06	80755
0.08	01166	1.08	17104	2 08	35726	3.08	57137	4.08	81263
0.10	01460	1.10	17449	2.10	36127	3.10	57594	4.10	81772
0.12	0.01755	1.12	0.17796	2.12	0.36529	3.12	0.58051	4.12	0.82282
0.14	02051	1.14	18144	2.14	36932	3.14	58510	4.14	82793
0.16	02347	1.16	18492	2.16	37336	3.16	58970	4.16	83304
0.18	02645	1.18	18842	2.18	37742	3.18	59430	4.18	83817
0.20	02944	1.20	19193	2.20	38148	3.20	59892	4.20	84331
0.22	0.03244	1.22	0.19545	2.22	0.38556	3.22	0.60355	4.22	0.84846
0.24	03545	1.24	19898	2.24	38964	3.24	60819	4.24	85362
0.26	03846	1.26	20252	2.26	39374	3 26	61284	4.26	85878
0.28	04149	1.28	20608	2.28	39785	3.28	61751	4.28	86396
0.30	04453	1.30	20964	2.30	40197	3.30	62218	4.30	86915
0 32	0.04758	1.32	0.21322	2.32	0.40610	3.32	0,62686	4.32	0.87435
0.34	05064	1.34	21680	2.34	41025	3.34	63156	4.34	87955
0.36	05370	1.36	22040	2.36	41440	3.36	63626	4.36	88477
0.38	05678	1.38	22401	2.38	41857	3.38	64098	4.38	88999
0.40	05987	1.40	22763	2.40	42274	3 40	64570	4.40	89523
0.42	0.06297	1·42	0.23125	2.42	0.42693	3.42	0.65044	4.42	0.90047
0.44	06608	1.44	23490	2.44	43113	3.44	65519	4.44	90573
0.46	06920	1.46	23855	2.46	43534	3.46	65995	4.46	91099
0.48	07232	1.48	24221	2.48	43936	3.48	66472	4.48	91627
0.50	07546	1.50	24588	2.50	44380	3.50	66950	4.50	92155
0.52	0.07861	1.52	0.24957	2.52	0.44804	3.52	0.67429	4.52	0.92684
0.54	08177	1.54	25326	2.54	45229	3.54	67909	4.54	93214
0.56	08494	2.56	25697	2.56	45656	3.56	68390	4.56	93746
0.58	08812	1.58	26069	2.58	46084	3.58	68872	4.58	94278
0.60	09131	1.60	26442	2.60	46513	3.60	69355	4.60	94[illegible]11
0.62	0.09451	1.62	0.26816	2.62	0.46943	3.62	0.69839	4.62	0.95345
0.64	09772	1.64	27191	2.64	47374	3.64	70325	4.64	95[illegible]0
0.66	10095	1.66	27567	2.66	47806	3.66	70811	4.66	96416
0.68	10418	1.68	27945	2.68	48239	3.68	71299	4.68	96952
0.70	10742	1.70	28323	2.70	48673	3.70	71787	4.70	97490
0.72	0.11067	1.72	0.28703	2.72	0.49109	3.72	0.72277	4.72	0.98028
0.74	11394	1.74	29083	2.74	49546	3.74	72767	4.74	98568
0.76	11721	1.76	29465	2.76	49983	3.76	73259	4.76	99108
0.78	12050	1.78	29848	2.78	50422	3.78	73751	4.78	99650
0.80	12379	1.80	30232	2.80	50862	3.80	74245	4.80	1.00192
0.82	0.12710	1 82	0.30617	2.82	0.51303	3.82	0.74740	4.82	1.00735
0.84	13041	1.84	31004	2.84	51745	3.84	75235	4.84	01279
0.86	13374	1.86	31391	2.86	52189	3.86	75732	4.86	01824
0.88	13708	1.88	31780	2.88	52633	3.88	76230	4.88	02370
0.90	14043	1.90	32169	2.90	53078	3.90	76729	4.90	02917
0.92	0.14378	1.92	0.32560	2.92	0.53525	3.92	0.77228	4.92	1.03465
0.94	14715	1.94	32952	2.94	53973	3.94	77729	4.94	04013
0.96	15053	1.96	33345	2.96	54422	3.96	78231	4.96	04563
0.98	15392	1.98	23739	2.98	54871	3.98	78734	4.98	05113
1.00	15733	2.00	34134	3.00	55322	4.00	79238	5.00	05664

Table expressing the velocity *a* of sound as a function of the temperature.

Temperature	0	1	2	3	4	5	6	7	8	9
0	332.4	333.0	333.6	334.3	334.9	335.5	336.1	336.7	337.3	337.9
1	338.5	339.1	339.7	340.3	340.9	341.5	342.0	342.6	343.2	343.8
2	344.4	345.0	345.6	346.1	346.7	347.3	347.9	348.5	349.0	349.6

BOOK NOTICES.

The Principles of Strategy, by John Bigelow, Jr., 1st Lieutenant 10th Cavalry, U. S. A., with illustrations and maps. New York, G. P. Putnam's Sons; London, T. Fisher Unwin, 1891, 200 pages, 32 maps.

We are pleased to notice that an American officer, 1st Lieutenant John Bigelow, 10th Cavalry, has placed before the military student a work on strategy, "illustrated mainly from American campaigns." Naturally, we not being a military people, the fund from which to draw examples is limited; but certain important principles of strategy have been exemplified in our history, which have been the subject of criticism by European writers, and have found a place in foreign standard works on this subject.

Chapter I begins with definitions of war, tactics, strategy, the offensive, defensive, &c. Examples of the mixed defensive cited are Ulm, Marengo, Metz and Sedan; of the pure defensive, Fredericksburg and Gravelotte.

We next come to "An army on the march." After reference to the general requirements, there follow examples of Bonaparte's army in Egypt, the British in the Soudan, a division of fifteen thousand men marching on the same road; and due attention given to the necessity of dividing up into parallel columns when the army is too large to march on one road.

The "Strategic Chess-Board" next demands our attention. This is made to include about every feature, natural or artificial, which is to be found within the theatre of war. The author starts out by saying that "it differs essentially from the ordinary chess-board, in that it is not the squares that are played on, but the lines of demarcation between them." The chess-board comparison may well be left out, as war bears no resemblance whatever to chess or any other game.

With regard to strategic points and their subdivisions, the author brings to memory the pedantry of the older writers.

We are surprised in traversing the "Ocean Barrier," to find adrift the section and elevation of a corduroy road, Page 42, Fig. 10. Remarks as to the advisability of poisoning springs, wells, &c., seem quite as much out of place under the "Ocean Barrier" heading.

The passage of obstacles, communications and transportation is well but briefly handled, examples being taken from our own civil war.

The elements of strategy can be presented to the logical mind only with great difficulty. War is not a precise art. All the elements that contribute to make differences in the personal equations of commanding officers, are complicated by differences of national traits, race impulses, different civilizations or want of civilization. Probably the best method is by studying military history, drawing deductions, comparing the deductions of eminent authoriti s, reflecting on the successes and mistakes of eminent commanders. This takes time, involves voluminous reading. Napoleon said, "I have studied history a great deal, and often for want of a guide have been forced to lose considerable time in useless reading."

In war psychological elements play an important part. It is with great difficulty that principles are formulated. Rules are frequently made conspicuous by their exceptions. What rule of Kriegsspiel would have countenanced Jackson's détour in presence of a superior force and flank attack at Chancellorsville? Again, do we see that bold officer taking such great risks at the second Bull Run. How often was Bonaparte hampered by the pedantic traditions of his day? And still there are principles unchangeable. To attempt to place these principles before the young student is difficult. Probably one of the worst ways is to attempt it by graphical or geometrical figures. The earth presents no plane on which to combat. Natural obstacles upset all geometrical calculations. The shortest distance between two points geometrically, is frequently the longest in the time necessary to traverse it. We believe that the author in resorting to graphical strategy or the geometric system, has retrograded many years.

In illustrating "The Manoeuvre," the army on the defensive having but one point to protect, the simple circle suffices to represent the author's ideas. This developes into three intersecting circles with three points to be covered. Perplexing definitions are involved. We already at this stage have "general areas of command" and "areas of general command." With an army covering a single line we have for the line of "direct command" the two branches of an equilateral hyperbola; and worse and more of it when an army has to cover two lines, the "general area of command" is bounded by the arcs of four circles, and the "general area of direct command" by the arcs of four circles and four hyperbolas; and the author says he proves it, and resorts to auxiliary lines sufficient to elucidate a complicated problem in descriptive geometry. Such a system is misleading to the young student, and of positively no use to the mature mind. Fortunately after the completion of this chapter, graphical strategy figures but little throughout the rest of the book.

The author divides the subject of strategy into regular strategy, tactical strategy, and political strategy.

The examples of regular strategy are well selected. For tactical strategy the brilliant campaign of Jackson in the Shenandoah Valley serves as illustration; and for political strategy the capture of Philadelphia in the revolutionary war, and the blockade of southern ports during the civil war afford examples.

The British operations in the south, 1776–1781, are well described; but it does surprise us that the author gives "Among the more important teachings of this (Cornwallis') campaign" the following:

1. "The value of undisciplined militia as a home guard."

* * * * *

An appreciable part of the work is devoted to General Grant's most brilliant campaign, that of Vicksburg.

The author's strength lies in collecting and arranging the data of campaigns as previously shown in his "Mars La Tour" and "Gravelotte."

This book should find a place in every military library as a book of reference for the military student, with regard to American campaigns.

C. D.

The Artillery of the Future and the New Powders, by James Atkinson Longridge, Member Institute Civil Engineers, Honorary Member North of England Institute of Mining and Mechanical Engineers; Author of 'A Treatise on the Application of Wire to the Construction of Ordnance,' 'Smokeless Powders', etc., etc., etc. E. & F. M. Spon, 125 Strand, London; New York, 12, Cortlandt Street, 1891.

In the history of artillery the periods of transition have been far apart but brief. We are now about to enter upon such a period if Mr. Longridge reads the signs aright. The new guns, wire wound, are now being made by one power and must soon be made by all. The broad general principle for which he contends is that, other things being equal, a high-power gun which can withstand thirty tons pressure per square inch, is a better gun than one which can withstand only seventeen and one-half tons per square inch.

"I am not sanguine that these conclusions will be speedily adopted, or even favorably considered by the ordnance authorities in this country.

"It has taken me about thirty years to convince them that my views about gun construction were correct, and that the use of coiled wire, and the separation of the material for resisting the bursting and the longitudinal strains were important features in gun construction. It will probably be the same again."

Mr. Longridge proceeds to the investigation of the effect of the Nobel powder, cordite and BN powder.

"The method of investigation adopted is no doubt open to criticism. It rests to a certain extent upon hypothesis and assumptions, and does not possess the analytical value of M. Sarrau's method, but it will be found to give approximately correct results as regards the new powders, and moreover is applicable to estimating the pressures along the chase of a gun more directly, and perhaps with greater accuracy than has been done heretofore.".

In Chapter II the action of pressure gauges is considered. In this he follows the method of Messrs Sarrau and Vieille.

In Chapters III and IV the subject of pressure curves is considered. He divides the pressure curve into two parts, the point of division being at the point of maximum pressure.

The part of the curve behind the maximum ordinate he assumes to be the quadrant of an ellipse. The remainder is an adiabatic curve having for its exponent 1.2.

"The advantages of a high maximum pressure will, however, become more evident if we compare a gun, working with the pressures now in general use in this country, or about 17 tons per square inch, with the same gun working at a pressure of 30 tons per square inch.

"To illustrate this I will take the 8.24-inch gun of 35 calibres. * *

"Thus by increasing the working pressure in this way, we have with the same gun obtained the following advantages: increase in muzzle velocity from 2002 to 2876 feet per second.

* * * * *

"This gun would weigh only 15 tons, and yet its power of penetration is within 10 per cent. of that of the 13.5-inch Woolwich gun weighing 67 tons, and is 12 per cent. greater than the 12-inch gun of 47 tons.

"This naturally leads to the conclusion that by adopting the high pressure system, ballistic results equal to those obtained from the existing guns may be got from much shorter guns constructed for the new powders.

"How is such a change as I have spoken of above likely to be looked on by our officials in the Ordnance Department? It is not difficult to imagine the horror with which they will regard such a proposal as another reconstruction of armament. 'What,' they will exclaim, 'sacrifice the magnificent forged steel guns which have cost us such enormous labour and expenditure of money to bring to perfection?'

"It is no doubt a grievous prospect, but facts are facts, however unpleasant in their aspects, and the statements I have above made represent what I believe will be in a very short time established facts.

"If so, that nation that first recognizes the truth will most profit by it, and will be in a position relative to other nations similar to that of the Prussians armed with the needle gun in the campaign of 1866."

It is to be noted that Mr. Longridge is still a heretic on the subject of longitudinal strains. He states "The very heavy longitudinal strain, arising mainly from the friction of the products of combustion." While this friction may cause longitudinal strain, its effect is not in any way comparable with that of the backward acceleration of the gun; but the rest of the book is surely sound doctrine.

It is written from the Island of Jersey, and very appropriately combines the French and English ballistic methods; it is a thoughtful presentation of this important subject, and challenges the earnest consideration of those whose duty it is to design, make or use the armaments of our national defenses.

L. G. B.

Repertoire Alphabetique de Termes Militaires Allemands, par. R. Roy Capitaine au 41e Regiment d'Infanterie. Berger-Levrault et Cie, Paris, 1891, Pp. vi, 178.

To those of our officers who may be compelled for lack of a good German-English military dictionary, to get at the meaning of German military terms through the French language, this little work may be heartily recommended.

The author has sought not merely to translate but to define. It follows that he gives not only the French equivalent, but information in regard to the terms defined, that it would be hard to find elsewhere in so compact and convenient a form. Take as an example—'kompagnie.' The French equivalent is followed by a statement as to the constitution of a company, its subdivisions for purposes of drill and interior economy, the number and grade of officers, both commissioned and non-commissioned, and the effective in peace and war Many words not to be found in ordinary German-English dictionaries, or else, if found, inadequately defined, are here fully explained; for example, Professor Whitney's dictionary translates 'controle' by 'control', that is, does not in a military sense translate it at all; but Captain Roy gives full information in regard to it and its various compounds. One need only consult the words 'offizier', 'inspektion', 'intendant' and 'adjutantur', to mention no others, in order to be satisfied of the range and accuracy of the information furnished under them. In short, the little book under consideration is an encyclopædia as well as a dictionary. The last forty pages form a separate alphabetical supplement, devoted to a description of the German Army as it exists to-day, in all its details, from the organization of the staff down to the facings of the uniform.

Captain Roy's book will be more than welcomed by all whose studies lead them to German authorities.

C. DeW. W.

Information from Abroad. General Information Series No. X. The Year's Naval Progress, 1891.

It is with considerable pleasure that we have read this book, and we doubt if there is another amongst the military works published this year, which contains so much technical information and which can be read with so much profit by artillery officers. It is a genuine treat to pick it up and find such a vast amount of new information in regard to subjects, of which heretofore we have scarcely caught a glimpse.

It might be inferred from the title that it contains matter of interest only to the naval profession, but the reader will not be long in undeceiving himself, for before turning over many pages his eye will fall upon subjects which are of the utmost importance to the army. It fairly abounds in facts, which are not only needed but must be possessed by the artillery officer if he wishes to keep abreast of his profession.

The volume is divided into eleven parts or chapters, and as these can best be considered in regular order we pass to the matter of these parts more in detail.

I. Notes on Ships.—Gives an extended description of the new ships which have been added to the different navies of the world, the ships that have been dropped from them and all important naval changes that have been made. This part being strictly naval in character, possesses but general interest for the army officer.

II. Notes on Machinery.—This chapter, like the preceding, is limited to discussion and trials of marine boilers and other marine machinery and need not be further mentioned.

III. Notes on Ordnance.—In attempting to sum up this chapter it would be impossible to improve on the author's words.

"In the record of progress in ordnance during the past year will be found references to the following notable events:

The failure of another English 110-ton gun.

The successful results of an unusually severe proof trial of a Canet 12.6-inch, 65-ton, breech-loading rifle constructed for the Japanese navy.

Grüson's Tangerhüette experiments, in which the tests of rapid-fire guns were the most complete ever undertaken, and the results obtained most valuable. The trials of a rapid-fire gun against a target representing the forward part of a torpedo boat, and of a rapid-fire howitzer against earthworks, were especially noticeable.

Krupp's protective deck experiments with armor-piercing projectiles discharged from breech-loading rifled howitzers at long range.

Important trials of rapid-fire guns.

The development of a new model of the English magazine rifle.

Practical tests of cellulose.

Late practical developments in torpedo warefare.

The notes on armor and high explosives will be found in the articles on those subjects in succeeding chapters.

Up to the present time a 9.2-inch breech-loading rifle has attained an actual range of 12⅓ miles, which was within a few hundred yards of the calculated range. The calculated maximum ranges of modern high power guns of larger calibres are even greater.

The maximum ranges of the armor-piercing calibres of rapid-fire guns are not less than 9 miles.

With the pneumatic gun a range of 2.4 miles has been attained with dummy projectiles."

(*a*) HIGH POWER GUNS.—The principal events of the year touching high power guns, are the disappearance of the largest calibre guns from ships, and the substitution of guns not over 13.5 inch calibre; the bursting of several English guns and the failure of the *Sanspareil* 110-ton gun. This gun was fired in all 16 times, only a portion of which were with full charges. The gun is now practically useless.

In France a 16.54-inch B. L. R. yielded at the muzzle and the design has been discarded. Navy guns above 12.6-inch calibre are not considered satisfactory.

In Germany 12.01-inch calibre guns are the largest afloat and none larger have been designed.

The test of the 12.6 inch Canet guns made for the Japanese Navy is probably the most important event of the year, as regards ordnance and gunnery. The conditions to which the gun was subjected were severe. Smokeless powder was used; with a maximum chamber pressure of 15.49 tons a velocity of 2308 feet was obtained. The gun and carriage came out of the trial in perfect order.

(*b*) ARMOR PIERCING PROJECTILES.—The important point in this connection is the trial of the Holtzer and Firminy projectiles against the Harvey plate. The projectiles were smashed to pieces without appreciable injury to the plate.

(*c*) RAPID-FIRE GUNS.—Several breech mechanisms were tried by the Navy Department during the year. Some of these devices are extremely simple and ingenious.

In Europe important tests were made with the 4.72-inch and 6-inch Armstrong rapid-fire guns. With chamber pressures of 14 and 14.7 tons in these guns respectively, velocites of 2196 and 2413 feet were obtained.

Canet rapid-fire guns were tried extensively. Amongst numerous results of these guns, those with the 5''.91 are remarkable. With the B N smokeless powder, sample A, and chamber pressures varying from 18.2 to 20.8 tons, velocities from 1811 to 2880 feet were obtained. An ingenuous mechanism for elevating and directing the gun, and an electric sight for night firing deserve especial notice.

In addition to the guns just noticed, those of Hotchkiss, Nordenfelt, Maxim, Gruson, Krupp and others were in the field, but those of Armstrong and Canet are in the lead. The latter is evidently ahead of all competitors. The beautiful shape of this gun, approximating closely that of a long cylinder, shows the realization of almost uniform pressure, which taken with the unprecedented initial velocities, all but make the gun an ideal weapon. All the trials were with smokeless powders, but the absence of smoke is but one of their many advantages over the old powders.

(*d*) HIGH ANGLE FIRE.—

1. Krupp's experiment, two series.
2. The Japanese experiments.
3. Gruson's Tangerhüette experiments.

The details of these experiments can not here be given but must be read to be appreciated. They were made under high angles of elevation to test the accuracy of this kind of fire.

(*e*) GUN MOUNTS.—Several new and important carriages are described. Canet's carriages seem to possess nearly the same excellence as his guns.

(*f*) SMALL ARMS.—

(*g*) SMOKELESS POWDERS.—Considerable space is given to the new powders and numerous experiments recorded. Lower chamber pressures and higher initial velocities seem to be the general result of their use. The effect of the pressures, lower in the beginning, but more sustained along the bore, is shown in the thickness of the walls and shape of the gun which is becoming nearly cylindrical. It is unnecessary to comment on the value of these changes.

(*h*) TORPEDOES.—The uncertainty of the Whitehead torpedo is pointed out and made apparent by mention of several instances where it has failed. The subject of torpedoes is made especially interesting by a description of their use during the late Chilean war. New torpedoes, nets and other related apparatus are mentioned.

IV. Electricity on Shipboard.—While the use of electricity on shipboard does not in itself interest us materially, the application of this agent to military problems must always be a matter for our consideration. As many of our coast defense problems will be similar to those on board ship, we may find it convenient and economical to solve them in the same general way. Again as navies adopt electric light and other electric apparatus, we will find ourselves in self defense, compelled to make use of the same auxiliaries. Warfare whether on land or sea has reached that point where the applications of electricity can no longer be disregarded. Our navy is especially fortunate in having recognized this several years ago, and in consequence our new ships are either fitted up or are being fitted up with the latest electrical appliances. Guns on one ship at least are controlled by electric motors; electric light, search lights and fans are being put in, and all parts arranged to obtain the full value of electricity. This policy we believe is wise, not only on account of immediate, but future results.

Electric power must in future defense play a prominent part, and we believe the sooner this is recognized the better. It would be useless here to attempt to enumerate its applications in a modern fortified place, and its applications in future are unbounded in promise. For many reasons the electric motor is to-day the machine best adapted for training and elevating guns. The ease with which the power can be controlled, carried and distributed, and the ease with which the motor can be connected to the carriage and protected are considerations worthy of notice.

The guns of the *Capitan Prat* are handled by electric motors. France is experimenting with motors for rapid-fire guns. From their evident suitability for such work, they seem predestined to replace all other means. We are not cognizant of any steps being taken in our army even to investigate the subject. In view of the numerous guns now being constructed and the sea-coast guns which we hope to have, can we do so too soon?

V. The Naval Maneuvers of 1890.—Maneuvers were carried out during the summer of 1890 in England, France, Germany, Italy and Russia. The English were not very successful in their efforts. As a whole they were principally marked by the defending fleet sailing about for ten days without even catching sight of the enemy. At the close they were 1700 miles apart. Points of interest consist in remarkable runs and attacks made by torpedo boats. The results of the maneuvers, we think, show that torpedo boats will be in future a most important factor in marine warfare.

The number of accidents to ships is almost beyond belief, and rather forces upon us the conclusion that an excellent time to attack a nation would be immediately after one of these grand maneuvers.

The exercises of the French fleet were little more definite in purpose and conclusion, and the general results in the two cases similar.

Germany had a combination of naval and land maneuvers, in which one or two points were definitely settled.

The Italian exercises were mainly to test their semaphore system and were considered successful.

The plan of the Russian maneuvers were somewhat complicated; several important conclusions were obtained and some of the incidents exceedingly interesting.

VI. The Armor Question in 1890.—The year of 1890 marks an epoch in the development of armor; several historic trials of armor took place.

The following classification given by the author of the chapter clearly outlines the experiments during the year:

"From the varying conditions of the trials which will be detailed and discussed, we consider that a good idea of the armor question at the present time will be best imparted by treating the subject under the following heads:

(I) The development of compound armor plates as shown by details of the most noted trials of late years.

(II) The trials of English steel armor plates in 1888.

(III) The development of Schneider steel armor plates as shown by details of the most noted trials of late years.

(IV) The trials of a Cammel compound armor plate representing the armor of the Argentine coast defense vessel *Independencia.*

(V) A comparison of English compound, Vicker's steel, Schneider's steel, and Schneider's nickel-steel armor plates from the results obtained in the recent competitive tests at Ochta and Annapolis.

(VI) The first trial of a nickel-steel armor plate.

(VII) The armor best adapted to naval use.

The firing trials herein detailed and discussed are only those of which we believe the data given to be authentic. A number of other trials have been referred to in the public prints, which will not be reproduced here because we have been unable to obtain reliable authority for the details given."

We need only add that these different trials are thoroughly discussed and illustrated by one hundred and six cuts and photographs. Taken as a whole the chapter is probably the most *valuable in the history of armor.*

VII. The Coast Defense Systems of Europe.—This chapter has probably caused more thought and discussion amongst our military men than all the rest of the book. Every page in the chapter bristles with would be arguments in favor of transferring our sea-coast to the navy. The article in itself is chiefly devoted to the consideration of the different coast artillery systems of Europe. Having learned what are the conditions in the most important countries of Europe and the respective means chosen to satisfy them, the writer of the chapter implicitly assumes that the several conditions exist here, and that we should follow the lead of these countries and transfer our sea-coast defense to his branch of the service

Before taking up his reasons for this change, we will devote a few remarks to our own sea-coast defense, and point out a few defects which should be remedied before plunging headlong into changes and complications, such as have been adopted in Europe, none of which have ever been tried in war. There are many defects in our own system, if it may be called a system, which can easily and effectually be removed, without entering the realm of experiment and speculation.

As it now stands it matters little by what name we call it, we are utterly without a system of sea-coast defense. As we are now constituted, the weaknesses in our so called system are neither military or naval, *they are organic.* We have five regiments of artillery—artillery only in name. Large bodies of these five regiments constantly serve at inland places and never see a sea-coast gun, and know absolutely nothing of coast defense duties. On account of the numerous moves and transfers from one place to another, artillery officers scarcely ever attempt any legitimate artillery work, and when they do a move surely prevents them from completing it.

The artillery as now controlled, is debarred from having any voice in the construction of the works it will occupy, the guns it will use, and is practically excluded from having a voice in regard to its own organization. All artillerymen are willing to admit these defects in our organization and administration, but they are not essential to the service to which we belong. The naval organization is superior to our own, and in case of transfer to their control, the coast defense would certainly profit by the exchange, provided we inherited their organization as part of the contract.

But to make such an exchange would, as we shall endeavor to show later, require numerous sacrifices in economy and defensive efficiency, which in the best interests of the country need not be made. To transfer the coast defense to the navy would involve the solution of many complicated problems, and still leave us with a system unsuited to our conditions and above all untried. To give the coast artillery as a land force, the best organization for efficiency, requires the straightforward solution of a definite problem.

In the discussion of the question sentimental considerations should be laid aside, and arguments pro and con should rest upon well established premises. The determination of the best system of coast defense is to-day the important military problem before the country, and promises to retain its importance until definitely and satisfactorily solved. In a general sense it includes all that relates to the protection of our coast, either directly or indirectly. Therefore, we believe it can best be considered by treating it as a general problem for solution. The main conditions to be satisfied we believe, can be ascertained with reasonable accuracy. Having them the problem admits of an approximately definite solution.

As the military and naval man differ widely as to the best scheme for solving it, and as each is apt to view it from his own standpoint only, each will have to set forth a scheme, that the country may choose the one best suited to its wants.

We will now notice some of the considerations involved, and the arguments advanced by the author, favoring the transfer.

Germany is supposed to furnish the crowning argument in favor of naval control of the sea-coast defense. A few years ago this nation turned over the sea-coast to the navy. The reasons for this are perfectly plain. To Germany her sea-coast is nothing, her frontier is everything, her national existence depends on its protection; where there is any conflict in her defensive system all considerations must be subordinated and interests sacrificed to this one end. Surrounded by natural enemies and her own territory bristling with forts and fortified places, we need not wonder that her Engineers were needed in other places, and were glad to shift the coast defense to other shoulders less burdened than their own. Do any of these conditions exist in our own country and do the same arguments apply?

The reasons urged for the transfer in Germany are as follows:

(1) "The guns and carriages are similar to those used in the navy.

(2) "As this defense is chiefly against attack by ships and naval landing parties, seamen will appreciate more readily the points of weakness and the objects of manœuvres by ships, and will recognize the probable designs of the enemy from his preparations.

(3) "As the defenses consist largely of turrets moved by steam or hydraulic power, a class of men which does not exist in the army is necessary for the manipulation of the machinery.

(4) "Seamen are better fitted to take care of works situated at the mouths of rivers and will coöperate more advantageously with the submarine defense.

"Similar reasons were advanced for the transfer of all submarine defenses from the Engineer Corps of the Army to the hands of the Navy."

While the above reasons are those assigned for the change in Germany, they are so connected as to appear good for all countries, and so far as we can make out the author considers them especially applicable to the United States.

(1) Carries with it the assumption that gun-carriages suited to the narrow conditions of a ship will best suit the more liberal conditions of a land fort, and that all sea-coast forts should be equipped with naval gun-carriages. Without going into this question we will hazard the opinion that this is not only not true, but that if the navy were to equip a land fort to-day, they would not do so with their own carriages. If then, it turns out that land carriages should be different from sea-carriages, it follows from the author's own reasoning that the *navy should not control the sea coast.*

(2) The substance of this reason is probably true so far as it goes, but the statement of the case is not complete. Land works are always liable to flank and rear attack from land, especially if important and their capture contemplated. Such attacks would include siege operations and the maneuvering of infantry and artillery. In such cases we think our naval defenders would be puzzled fully as much by these movements, as the land forces would be in the attack by sea.

(3) Turrets, we believe, are not to play an important part in the defense of our coast; but were our coast to be lined with them the proposition has no

application whatever. We have in the army as well as in the navy a few representatives of the class of men needed, but the great fact remains that the *men* do not exist in either service, and would have to be *enlisted and drilled with equal care and expense by the service in control.*

(4) If it is a fact that *seamen* will coöperate more advantageously with the submarine defense, they will for like reason coöperate less advantageously with the land defense. Il they incline towards one duty they will incline from an entirely different one. As to *seamen* being better fitted to take care of works at mouths of rivers, it would seem that the correctness of this statement depends somewhat on the kind of works, and on the exact meaning of the term *seamen*. If land works are meant are not *seamen* less suited to them?

The substance of the above reasons amounts to saying that for some purposes it would be better and for some worse to have *seamen* in charge of the coast, with a balance in favor of leaving it as it is.

In the discussion as in most others of similar character, a great deal of decisiveness is lost by the author's use of indefinite terms. The reader's mind is thus befogged by them, and conclusions made to appear where with use of accurate and well defined terms the contrary would appear. Reason (4) illustrates this perfectly. *Seamen* is used in a general sense, and the conclusion at once reached that they are better suited than landsmen to man works at mouths of rivers. There is no necessary connection between fortifications and mouths of rivers, and while the fort or work may be on and calculated to defend a river, the care of the work and nature of its administration is not changed thereby.

Many rivers in Europe are protected by forts, but it does not follow that they are, or should be garrisoned by *sailors*. The exact kind of works and class of *seamen* must be clearly defined before readers can come to an intelligent conclusion as to whether or not there is truth in the proposition It may be well for the reader to bear in mind that the description of a thing in loose words does not change its nature; we may characterize our coast defense as marine, military or civilian, but the conditions and great problems involved remain unchanged. If those who have studied these problems and learned coast defense duties are to be replaced, their successors must learn their duties by experience and they will doubtless come to conclusions similar to our own. It is somewhat unreasonable, we think, to expect *seamen* to come in and learn new duties, and do them as well as the men who have learned them at first hand.

Even according to the German system the land defense is permanent in its character and it does not appear to lose efficiency on that account.

The defense of the coast divides itself naturally into three parts, (*a*) the land defense, (*b*) the naval defense, and (*c*) a defense intermediate between the two which partakes of the nature of both. No matter who controls the coast defense, these divisions remain and they must coöperate. In this country, unlike Germany, whatever may be the size of the navy, the first and third divisions of defense must ultimately receive and repel the attack. All these must combine to obtain the best results: but when the fleet is beaten, whether driven outward or inward, the other defenses must then bear the brunt of the battle and check the enemy. Whatever may be the size of our navy, our ships can not hope to outnumber a possible enemy at all our important ports. Again, from a defensive point of view, our coast is hopelessly extended and divided, so that an attack made at any point would be over before a general concentration at that point could take place. Hence we see the necessity for something more substantial than a few ships at different points, which can be easily overwhelmed and beaten in detail.

The first and third divisions of the defense are essential to the nation's safety. To depend upon ships alone would be to withdraw the line of battle and reserves, and trust all to a line of skirmishers. These remarks find special application in the scheme outlined by the *Naval Policy Board.* This board estimates for a navy which is intended to prevent our ports from being blockaded. That the proposed navy in case of attack would be wholly unable to accomplish this object, we believe needs no demonstration.

The estimated cost of the proposed navy is $281,550,000 in addition to $67,965,000 already spent, making a total of $349,515,000. The estimate for sea-coast defenses made by the Endicott Board was about $126,000,000. This amount was to provide for an efficient land and submarine defense of all important points liable to attack. Our present navy costs annually about $20,000,000. With the proposed navy the annual cost would be greatly increased. If the amounts already invested and proposed are any indications of present and future cost, we should have a navy costing annually about $100,000,000 and yet have very inadequate protection. The scheme laid down by the Endicott Board contemplates no material change in annual expenses for coast defense.

Unity of command should above all things exist if possible, but with the conflicting considerations which must be satisfied in the problem it seems impossible. In no country except Germany has the navy complete control of the land defenses. In France "the army assists in the protection of the naval ports by manning all forts not on the sea front, and, in general, in defense against an attack from the land side. Should the attack be solely from the sea, the army may be sent if necessary, by order of the maritime prefect to reenforce the marine artillery in the sea forts; and as has frequently happened in war, when the army forces were required elsewhere *all* of the forts are manned by sailors, by the marine infantry and the marine artillery."

During the Italian maneuvers in 1890 at Spezia, the artillery officers were unable to distinguish the friendly from the hostile ships, and naval officers had to be stationed at the batteries to give the officers the necessary information. On the same page of the discussion we find:

"For the design and construction of fortifications belonging to the navy a general officer of Army Engineers is detailed as Chief of the Office of Military Engineering in the Ministry of the Marine, and is regarded as temporarily detached from the army. He is intrusted with the design of all the forts, dry docks, improvements in dockyards, buildings, etc., and in the execution of such designs is aided by other engineer officers, who are placed temporarily under the orders of the Ministry of Marine. At the Maddalena the works were of such importance that a board of six officers and four employés were so detailed from the Corps of Engineers."

Thus we see that the systems of Europe are pretty well divided between the two services.

If it be understood that at a certain stage of the defense the command shall pass from the naval to the artillery commander of the harbor, no confusion should arise. This stage of the defense and time for transfer of superior command would naturally be when the fleet is defeated and no longer able to check the enemy. From this time forward the fire of the forts becomes the important element in determining the result, and the control of the harbor should be in keeping with it. To turn the whole affair over to the navy and attempt to defend it entirely with ships, would certainly be poor economy even were there reasonable promise of success. One gun on land used to be worth two afloat; with modern aiming improvements this disproportion will increase. Since the rolling effect of the sea can not be removed, similar improvements on board ship will not increase accuracy in the same ratio, and the gun on land will constantly gain in value over that on shipboard. This greater accuracy and economy should be a powerful factor in settling the question.

The preceding remarks are given as they strike the artillery officer; much if not all here given has been said before, but as these lines may reach a class of readers who should be interested in the subject we give them for what they are worth.

The transfer of the coast defense to the navy has been proposed; the question is now before us for discussion and the arguments should be brought out. Many do not think about it at all; some ridicule the idea; a few treat it seriously. The question is of first importance and merits serious treatment. It is a live problem, which, with an energetic support, will find its way to the front. Ridicule, however pointed, can not hurt an active principle evolving itself from surrounding conditions. The conditions may change or be changed and the principle die, otherwise it will run its course. In this particular case history may repeat itself once more and indifference and discord on our part justify the change. We may have the logic of words on our side, but all the fine-spun arguments in the world will do no good unless we have the logic of facts. We must do something more than talk—*we must act.* The great and convincing arguments will consist in our ability to show better work and higher efficiency. If we show ourselves progressive, alive to the work before us and aggressive, the coast defense will belong to us by right. The time is at hand when we can no longer show indifference to the problems before us. *To succeed we must be masters of our art.*

VIII. Service High Explosives.—This chapter contains a history and enumeration of the different high explosives. With few exceptions the matter of this chapter has appeared in other places.

IX. The Torpedo Vessel, a History of its Development.—This is of interest to the navy only.

X. The Systems of Promotion in several European Navies.

XI. Some Standard Books on Professional Subjects.—Contains a list of books of scientific and professional value.

In closing we have to add that the praise given the book in the beginning is not too high, and we heartily recommend it to every artillery officer. This however carries with it the provision that he can get it. It is greatly to be regretted that so many difficulties are in the way of obtaining it. A few copies are obtained through the Adjutant General and Chief of Ordnance, and some are found and bought in junk shops, but the total number is small. Most of us therefore never see it. This is most unfortunate, since from its value to artillery officers it should be in the possession of all, and we feel compelled to ask if there is any valid reason why it should not be issued to artillery officers generally.

J. W. R.

The Naval Annual 1891. Fifth Year of Publication, Guffin & Co., Portsmouth.

This volume is replete with information of interest, especially to the navy. Part I by Lord Brassey, gives additions to the various navies of the world for the year 1890, and shows that the activity in the construction of war ships was about normal.

When all the ships for which Congress has appropriated money have been built, the United States will "possess a modern navy of fifteen armored vessels, five of which will be of the battle-ship type and thirty-one unarmored steel vessels. These forty-six ships will be of latest type as to construction and armament."

The English Navy was increased by sixteen cruisers and three torpedo boats; the French Navy by three battle-ships, five cruisers and fourteen torpedo boats.

The breaking down of the hydraulic mechanism of two of the guns of the *Inflexible* "can not fail to strengthen the hands of those who claim that the guns should be capable of being man-worked also." However the First Lord of the Admiralty in his report, claims that the mechanism for hand-working the guns is not so simple as that where hydraulic power is used, owing to the necessity of multiplying parts in order to obtain the necessary mechanical advantage.

Chapter XII is devoted to a review of that excellent book "The Influence of Sea-Power on History," by Captain Mahan of the U. S. Navy.

The remainder of Part I treats of mobilization, naval manœuvres, administration, coaling stations and their protection.

Part II, entitled British and Foreign Armored and Unarmored Ships, by F. K. Barnes, Esq., M. I. N. A., contains 124 pages of tabulated information under this heading, accompanied by 95 full page colored plates illustrating same.

Part III by Captain Orde Browne, R.A., treats of armor and ordnance, giving the Gruson experiments with shielded mountings and quick firing guns, concluding that "thus in the defense of a fortress fresh ground might be taken and a gun placed in a spot which might greatly annoy the besiegers."

The Annapolis and Ochta armor tests are given. It will be noted that in both cases the compound plate was worsted. At Annapolis the five per cent. nickel plate (Schneider) best withstood both piercing and fracture, while at Ochta the all steel Vickers plate stood best. A sharp frost on the day of the Ochta trials, is by some claimed to have reversed the order of merit as found at Annapolis.

The author admits the inadvisibility of using the compound armor for new vessels, but seems to incline to a change in, rather than from, the present system of compound armor, that is to the using a compound armor of soft and hard steel. He also considers that the ships at present having the compound armor are not at any disadvantage as compared with their contemporary steel clad vessels, for the reason that this steel is not equal in quality to that submitted for trial. The author evidently confines his considerations to naval combats, for his reasoning is not applicable to the case of land forts *versus* ships.

In view of the fact that we have adopted (or are about to adopt) high angle fire for distant defense, the following experiments noted in the Annual are of interest:

"The target was a horizontal deck 52'x13', composed of four steel plates riveted together, the three upper ones making up a thickness 76 mm. and the lower one 13 mm., total thickness was therefore 3½". This was backed with iron ribs and wood and firmly supported at a height of five inches from the ground. Ten shots were fired at a range 3870 yards from the 28.55 cm. howitzer of 11.6 calibres, carrying an armor piercing shell of 611 lbs. The charge was 25 lbs of pebble powder, elevation 45°, striking velocity 610 f. s. and angle of incidence 46½°.

"One hit was obtained with longitudinal deviation of 6¼ feet and lateral deviation of 19 inches. The target was pierced and the supports considerably bent. The shot was buried ten feet in the earth.

"A second series of 16 shots fired at an elevation of 65° with 33.8 lbs. powder gave but one hit which also pierced the armor. All the 26 shots would have struck a deck 360 ft. by 50 ft., such as that of the *Centaur*.

"Inclined targets (45°) were struck and easily penetrated by this howitzer at a range of 165 feet. One plate was 114 mm. and the other 89 mm. and both well backed with pine.

"Trials of steel breast-plates and shield-plates are shown to require a thickness of 6 mm. to resist the hardened lead bullet of the small calibre, having a striking velocity of 600 m. Undoubtedly these plates will be largely used on shipboard and in trenches."

Plates VI to IX show at a glance what thicknesses of plates certain guns may be expected to penetrate.

Captain Browne favors the proving to destruction of one of each type of heavy ordnance, and seems rather doubtful of the endurance of the heavy (110½ tons) Elswick gun. He thinks the lack of unfavorable report on the Krupp heavy ordnance, may be due either to faultless guns or uncomplaining officers. "Silence proves little in Germany; we are forced to judge from what comes out."

Description and plates of Elswick and Canet guns are given. Plate XIV shows a battery of five high angle howitzers, screened in front by a natural hillock, and having a masonary wall of three or four feet immediately in its front, with no other protection.

"Mr. Longridge considers that if full advantage is to be obtained from the high ballistic properties of the new (smokeless) powders, it can only be obtained by use of comparatively high pressures," requiring strong guns such as are found "in the wire system of construction," and that while present ordnance may withstand this increase near the seat of the charge, the chase will require strengthening.

H. C. D.

Handbook of the Hotchkiss 12 pounder (3 inch) Mountain Gun. London, Harrison & Sons, St. Martin's Lane, Printers in Ordinary to Her Majesty, 1892. Pamphlet 27 pp., Photo-Lith. Illustrated, 6 plates.

To all artillerymen interested in mountain artillery, this work will be interesting. Clear and concise, it briefly describes the latest of the models of the mountain guns of the Hotchkiss Company, showing up a gun that is a decided advance upon the small model familiar to our service, also made by the Hotchkiss Company.

The gun appears to be simplicity itself in its construction. Made from the best oil tempered steel, its parts are few, easily dismounted for cleaning or repairs, and as easily assembled; it is therefore but little liable to derangement even in the rough service of the mountain.

Its weight (218 lbs.) and the weight of all the parts are such as to be readily packed without excessive weight upon any one mule; while it may be transported, by hand, for short distances, in regions inaccessible to mules. With all this, it is far from being a toy or plaything, as is most conclusively shown by its calibre, the weight and character of its ammunition, and its range.

Pack-mule service is notoriously the hardest and most expensive kind of service. Yet with the number of mules for the battery transportation appears to have been reduced to a minimum for efficient work: one mule for gun, one for carriage, one for wheels, shafts and accessories, with six for ammunition, or nine mules per gun detachment complete, compares favorably with the detail of the service of other guns we see abroad; yet with this number, ninety-six rounds per gun are carried.

The complete organization of the battery is not given. It appears however, that in addition to the fifty-four mules necessary for six guns complete, eight mules are necessary to carry pioneer outfit, forge, artificer, wheel-wright and saddler's tools and supplies, spare carriage complete and small arms ammunition. How many riding mules there may be, or what provision is made for the transportation of rations, cooking and camp utensils, &c., &c., for the sixty odd men comprising the battery is not mentioned, so that one is at a loss for complete information. But perhaps such information hardly belongs to a handbook of the gun alone, and the details of organization have either been left to the experience and exigencies of the service, or have been worked out in some other book.

An interesting feature of the book is the detail of the prairie limber for use upon roads, or in comparatively level country before the actual mountain country is encountered. The construction and adaptability appear to have been carefully worked out, and the limber to be admirably suited for its purpose, relieving the number of back loads for many a weary mile, substituting draft by relief therefor. This prairie limber is not for the mountain at all, but is to be abandoned, temporarily if not absolutely, when no longer of use from the rough character of the country. When the limbers are not available, and yet smooth country is being passed over, shafts are provided for wheel transportation and draft of the guns, so that as much relief from actual packing as may be is provided for.

The ballistic features of the gun are not to be despised. With a projectile of 12 lbs., a charge of 14.1 oz., and an initial velocity of 852 f. s., the gun appears well adapted to the special work of mountain guns, where the ability to search out reverse slopes and shelters by curved fire, is of more importance than a flat trajectory and high power direct fire. With a range up to 3500 yards, and a remaining velocity of 560 f. s., at that range, it would appear to have about all the range that will be needed for mountain work, while it might also give a good account of itself in the open.

It is to be regretted that the detailed description and illustration of the mode of packing the complete outfit is not embraced in the book, so that complete information of all the details might be at hand. True enough, details of pack outfits almost without number are to be found in other works; but they are adapted to some special guns, differing in size and weight from that under consideration. These may be doubtless modified to suit this gun; but it would have been more complete to have had the special outfit as adapted to this gun fully described and illustrated. But a brief mention is made of the order of dismounting and packing, prescribing the duties of each number. This is all sufficient for a drill book, for those already familiar with the special pack outfit. But it conveys no information to those not so familiar, leaving each one to imagine or to devise for himself the detail of construction, of packing, adjusting and securing; in short, all the details of the complete outfit necessary to a complete organization.

Happily our days of constant Indian troubles appear to have ended. Our great Indian campaigns were all conducted with but little aid from mountain guns, mainly however for want of a proper weapon or any organized mountain service. Comparatively recent events within the history of Indian trouble have shown the necessity for a thoroughly reliable and efficient gun and service for this work, and here appears to be a gun much better than anything we now possess, one that might well be adopted and tested, and used as a basis from which to build up a complete and efficient organization, to be available at any moment in case of need, and thereby do away with our present makeshift. Such a gun and such a service may be an imperative necessity in any extended campaign against any foe, and should be prepared while there is time to perfect all the details at leisure.

Taken all in all the book under consideration contains much information of importance. It is admirably arranged and annottated upon the margin. In connection with other works upon the subject, it cannot but help to give a more complete knowledge of what is now available for mountain service, and thereby lend its aid to a complete and efficient organization.

C. D. P.

Barracks, Bivouacs and Battles, by Archibald Forbes, LL. D. London, MacMillan & Co., and New York, 1891, Pp. 328.

This volume is made up of papers contributed from time to time by Mr. Forbes to the magazines. Of these papers, some are efforts of the imagination, while others are based on personal experience in various quarters of the globe. Whether Mr. Forbes's stories are good or not is a question of taste, with which we are not here concerned. But it is otherwise with the professional and semi-professional papers. The most important of these—the essay on Fire Discipline—will give the reader a good deal to think about. The author's opportunities for observation of actual war have been unequalled, and lend a weight to his opinion of matters military, that is not diminished by his lack of a commission. When, therefore, he asserts that assiduous drill in cover-seeking has in the British Army resulted in a loss of *moral*, the statement becomes significant. It is surely most unusual in an English book to read of British troops going to pieces "in uncontrollable scare." "My campaign in Pall Mall" will never find a place in treatises on the art and science of war, but it is nevertheless an interesting and amusing example of British red-tape. "The Divine Figure from the North," "A Forgotten Rebellion," as well as other pieces deserve more than passing notice, while "A Yarn of the 'President' Frigate" is the account of an extraordinary occurrence.

C. DeW. W.

SERVICE PERIODICALS.

Revue d'Artillerie.

JANUARY, 1892.—Investigation of the effects of time-shell fire, and of the formations to be adopted when under artillery fire.

The gun and projectile being known, certain elements follow, viz.: the angle of fall, the probable error of the time of burning of the fuse, the probable errors of practice both vertical and lateral, the angle of the cone of dispersion, and the number of bullets or fragments furnished by the shell. A *mean shrapnel* is selected as a type. If we take into account the dispersion of hits, we may by these elements determine the number and distribution of hits on a plane normal to the mean trajectory, and passing through the point of fall. Assuming now certain formations of infantry, exposed to artillery fire, the number of rounds necessary to get a given number of hits may be computed.

"The conclusions from investigation thus bear, not only on the relative vulnerability of various infantry formations, but also on the method of conducting artillery fire so as to develop its maximum efficiency."

Employment and destruction of foreign artillery material—Italian mountain-artillery.

Notes on the field-piece of the future.

Notes and reviews.

FEBRUARY, 1892.—Austrian 8 mm. repeating carbine, model 1890, (concluded). Field-artillery material, Canet system, furnished to the Brazilian Government. Apparatus for transporting mobilization-maps. Notes on the field-piece of the future, (continued). Importance of smokeless powder in war, (translation from Russian).

Effect of adoption of smokeless powder on artillery. 1. Artillery reconnaissance. 2. Choice of artillery position. 3. Advance of batteries on combat-line. 4. Opening of artillery fire. 5. Shelter of rear of battery. 6. Discipline; technical and tactical fire control.

Effect of, on general command and direction of troops; attack and defense.

Notes and reviews.

Revue du Cercle Militaire.

JANUARY 3, 1892.—The French-Italian frontier. Military applications of electric search lights.

JANUARY 10, 1892.—Russian field-mortars. The French–Italian frontier, (continued).

JANUARY 17, 1892.—Russian field-mortars, (concluded). The French–Italian frontier, (concluded).

JANUARY 24, 1892.—Reorganization of the Spanish Army. An English opinion of the German Cavalry.

JANUARY 31, 1892.—The question of Touat. Instruction in musketry.

FEBRUARY 7, 1892.—An intrenched camp in Sicily. Notes on the Austro-Hungarian Army.

FEBRUARY 14, 1892.—Antiseptic surgery in the service. Notes on the Austro-Hungarian Army, (continued). Trains and the passage of rivers.

FEBRUARY 21, 1892.—Second letter of Dragomiroff on the question of *armes blanches*. Antiseptic surgery in the service, (concluded). Notes on the Austro-Hungarian Army, (continued).

FEBRUARY 28, 1892.—How the lance is handled in Germany. Antiseptic treatment in the service.

Revue Militaire de l'Etranger.

JANUARY, 1892.—The field-piece of the future according to the theories of General Wille. Military ballooning in Russia. Dutch Colonial Forces. Military news.

FEBRUARY, 1892. Promotion in the German Army, and the age of officers in the different grades. Military organization of the Russian railway service during peace. The field-piece of the future, according to the theories of General Wille. Military news.

Mittheilungen ueber Gegenstaende des Artillerie-und Genie-Wesens.

FIRST NUMBER, 1892.—The fortifications on the French-German frontier. Photogrammetry; topographical surveying by photographic means. Notices: Aubrat's artillery-practice game. Photochronographic investigations.

SECOND NUMBER, 1892.—The 9-cent. pointing arc, M. 1890. On the most important international units of measure.

Rivista di Artigliera e Genio.

JANUARY, 1892.—On the exact solution of the ballistic problem under the law of the square.

FEBRUARY, 1892.—The fortifications of Switzerland. Target-practice in field-batteries.

Proceedings of the Royal Artillery Institution.

JANUARY, 1892.—Notes of two lectures on Field Fortification. Naval attack of Fortifications. Experiences at Okehampton, 1891. Retrospect of equipment, services, etc. of the 1st and 2d Russian Mountain Batteries in the last war. [Translations]—Apparatus for checking recoil. Angular velocity of rotation of projectile. Graydon dynamite projectile.

FEBRUARY, 1892.—Field artillery fire. I. Fire discipline. II. Bringing batteries into action. Historical note. World's war-ships, French, Russian. Naval attack of fortifications. [Translation]—Fiske's telemetric and pointing instruments.

Journal of the Royal United Service Institution.

JANUARY, 1892.—Notes on organization and training, by a regimental officer. Notes on the attempted invasions of Ireland by the French in 1796–98. Description of the reconnaissance work undertaken by the Home District Tactical and War Game Society in the summer of 1891.

Foreign Section.—Naval schools of chief Continental Powers. Short account of recruitment, conditions and duration of service in German Navy. The training of the seamen personnel in German Navy. History of 33rd East Prussian Fusiliers 1870–71. Letter after Waterloo.

FEBRUARY, 1892.—The Miranzai expeditions, 1891. Distant signalling in the Royal Navy. Notes on the attempted invasions of Ireland by the French 1796–98. Russian language and literature. Foreign Section—Naval schools of chief Continental Powers, Part II. Spanish Army in Caroline Islands. History of 33rd East Prussian Fusiliers 1870–71, (continued.)

Army and Navy Gazette.

MARCH 5, 1892.—The Indian Cavalry camp. "Short service for the Navy." Civilian *versus* military officials. Our Naval literature—III. The equipment of the soldier—III. Clothing and its advisibility. The Devonshire Regiment.

United Service Gazette.

MARCH 5, 1892.—Photography and reconnaissance. The Austro-Hungarian artillery. The army estimates. The Hamilton programme.

MARCH 12, 1892.—The militia. Naval gunnery. The Russian Navy. What the Americans think of the Canadian Militia. The terrain in its relations to military operations—VI (a reprint of Lieutenant Reed's paper in the January number of the Journal of the N. S. I.). The navy estimates. The Royal United Service Institution. The army estimates debate. Russia and the invasion of India. Army recruiting.

Aldershot Military Society.

No. XXXV.—The physical training of the recruit and drilled soldier.

Engineering.

JANUARY 1, 1892.—Canet *versus* Krupp guns (by a French artillerist).

Table VII.—Comparison of data of Canet and Krupp quick-firing guns.

Tables VIII and X.—Ballistic data of Canet and Krupp quick-firing guns.

Tables IX and XI.—Particulars of Canet and Krupp guns, field and mountain guns respectively.

Tables X and XII.—Ballistics of Canet and Krupp guns, field and mountain 2''.95 guns respectively.

JANUARY 15, 1892.—Canet *versus* Krupp guns.

JANUARY 22, 1892.—Canet *versus* Krupp guns.

Table I.—Tests and performances of Canet 27 cent. (10.63-inch) guns. Krupp gun of 30.5 cent. and 35 calibers. Canet gun of 32 cent. and 40 calibers. Canet gun of 27 cent. and 36 calibers.

Table II.—Tests and performances of Canet 15 cent. (5.9-inch) gun. Krupp quick-firing gun of 15 cent. and 40 calibers, Canet quick-firing gun of 15 cent and 48 calibers, Canet quick-firing gun of 15 cent. and 45 calibers, Canet quick firing gun of 12 cent. and 45 calibers.

The want of torpedo-boats. A new French torpedo-boat.

JANUARY 29, 1892.—Canet *versus* Krupp guns.

Table III.—Performances of Krupp quick-firing 10.5 cent. guns of 35 calibers and Canet quick-firing 10 cent. of 48 calibers.

Table IV.—Performances of Krupp and Canet 12 cent. siege and garrison guns.

Table V.—Performances of Krupp and Canet 75 mm. field guns.

Table VI.—Performances of Krupp and Canet 75 mm. mountain guns.

FEBRUARY 5, 1892.—Krupp *versus* Canet guns.

Table VII.—Efficiencies of Canet 12 cent. guns, 36 and 43 calibers long.

Quick-firing guns in the navy.

FEBRUARY 19, 1892.—Military ballooning The Engineering. branch of the U. S. Navy.

MARCH 4, 1892.—H. M. battle-ship *Ramillies*. Railways in war time.

MARCH 11, 1892.—30.5 cent. (12.01-inch) cast-iron howitzer.

MARCH 18, 1892.—Modern United States Artillery—No. I.

Considered under the following heads:

(*a*) Rodman guns still in service. (*b*) Carriage for 15-inch Rodman gun with plan and elevation. (*c*) Efficiency of the 15-inch Rodman gun.

Table I.—Particulars of the Rodman 10-inch coast defense gun.

Table II.—Particulars of the 15-inch Rodman coast defense gun.

Table III.—Firing trials of the 15-inch S. B. Rodman sea-coast gun.

(*d*) Mortars.

Table IV.—Particulars of the Coehorn mortar.

Table V.—Particulars of the 8-inch siege mortar.

Table VI.—Particulars of the 10-inch siege mortar.

Table VII.—Particulars of the 13-inch siege mortar.

(*e*) Fuzes and primers.

Journal of the Military Service Institution.

JANUARY, 1892, First Part.—The Terrain in military operations. A United States Army. Rapid fire guns. Discipline and tactics. Reminiscences of Tonquin. Comment and criticism. I. Magazine and ammunition service in a sea-coast fort. II. Mounted Infantry. III. Battle tactics.

Second Part, [Reprints and translations].—Smokeless powder. Letters on Infantry. Service range-finding. Infantry attack. Artillery questions of 1890. Military notes. The Berthier rifle. Inspection report on British Cavalry. The artillery of the future and the new powder. [Reviews and exchanges.] The Franco—German war. The year's naval progress. On the border with Crook. The history of a regiment.

MARCH, 1892, First Part.—Position finding service. Army transportation. Was Gettysburg decisive. Artillery service in the Rebellion. Infantry fire. Shrapnel fire. Power of military courts to punish for contempt. [Comment and criticism.] A United States Army.

Second Part, [Reprints and translations].—The progress of tactics. Smokeless powder. Coast and Harbor defense. Canet *versus* Krupp guns. Changes in military matters. Letters on Infantry. Military notes. The German torpedo shell. Mannlicher bullets. Coast batteries. [Reviews and exchanges.] Drill regulations for street riot duty. The National Guard in service. The principles of strategy. The electric motor and its applications. Instructions for courts-martial. The naphtha launch. Recent articles of special interest.

Hamersly's United Service.

JANUARY, 1892.—A word on the artillery question. History of the U. S. Frigate "Constitution". Colonel Burnaby's parents. The experience of a staff officer in time of war. Should our harbor defenses be controlled by the navy?

FEBRUARY, 1892.—The education of officers for the armies of to-day. Romance and rebellion. For the best interests of the service. Blockade-running. "La Haute Ecole".

Scientific American.

JANUARY 23, 1892.—Improvements needed in the new navy.

FEBRUARY 6, 1892.—The new American war steamer *Miantonomoh*. The "Adamson" gun. The Washington gun factory.

MARCH 5, 1892.—Practical work on big guns and armor. Probable influence of quick-fire guns on naval tactics.

MARCH 12, 1892.—Military ballooning.

MARCH 19, 1892.—The gatling gun for police patrol service.

Scientific American Supplement.

JANUARY 16, 1892.—Canet quick-fire guns. Armor tests and development. The armor trials.

JANUARY 23, 1892.—New high speed gun-boat. Recent progress in industrial chemistry.

JANUARY 30, 1892.—Japanese coast-guard ships.

FEBRUARY 13, 1892.—The military engineer and his work.

This is a reprint of a lecture delivered by Colonel W. R. King, U. S. Engineers, before the students of Sibley College, Cornell University, December 4th, 1891.

"According to the text books the first thing to be done, if possible, in the case of a regular siege, is to 'invest' the fortress. This is done by surrounding it as quickly as possible with a continuous line of troops, who speedily intrench themselves and mount guns bearing outward on all lines of approach to the fortress, to prevent the enemy sending in supplies or reenforcements. As this line must be at considerable distance from the fort it is usually quite long, and so is its name, for it is called the line of 'circumvallation." Inside of this line is then established a similar line facing toward the fort, to prevent sorties by the garrison. This line is called the line of 'countervallation,' and should be as close to the fort as the range of its guns and the nature of the ground will permit, etc."

MARCH 5, 1892.—The Sims-Edison Torpedo.

MARCH 12, 1892.—The dynamos at Frankfort exhibition.

The Iron Age.

MARCH 3, 1892.—Smokeless Powders.

A summary of the present state of the question of smokeless powders. The relative power of smokeless and ordinary powder is illustrated by the following comparison, the gun used being a 33-pounder Hotchkiss :

POWDER.	WEIGHT OF CHARGE (pounds.)	I. V. (feet.)	CHAMBER PRESSURE PER SQUARE INCH (tons.)
Smokeless	6.8	2215	15.25
Ordinary	13.2	1903	15.50

Very interesting data are given in regard to Professor Munroe's smokeless powder.

"The qualities in addition to smokelessness which it has been sought to combine in this powder have been: *a*, progressive rate of burning to insure high initial velocity without undue strains; *b*, complete physical and chemical homogenity; . . . . *c*, permanency."

In regard to this last property, we read that heating for prolonged periods, submergence and even boiling in water, have apparently left it unchanged. A sample subjected for five weeks to the action of a mixture of ether and alcohol, was unaffected thereby.

From a ballistic point of view, Professor Munroe's powder seems equally to satisfy all requirements, as may be seen from the table following:

POWDER.	GUN.	CHARGE (gram'es.)	I. V. (f. s.)	CHAMBER PRESSURE PER SQUARE INCH (tons.)
Munroe	3-pdr.	310	2250	14.8
Ordinary	"	700	2000	15.0
Munroe	6-pdr	400	1960	16.0
Ordinary	"	820	1800	15.5

"The extreme regularity, uniformity amd correspondence of velocities pressures . . . throughout the various tests to which this powder has been submitted are considered as very favorable."

The Brown wire-wound gun.

Report of a trial of test-cylinder. With a charge of 3.25 pounds, a pressure was registered of 53850 pounds per square inch. No change whatever is reported in the diameter of the bore, in spite of this enormous pressure.

March 17, 1892.—American Armor.

Gives the decision of the board as to the relative merit of the plates tested, and a summary of the opinion of the Secretary of the Navy. An excellent double full page illustration accompanies this paper.

The Railroad and Engineering Journal.

JANUARY, 1892.—The United States Navy. The trial of American-made armor-plate. Foreign Naval notes.

Armor-plates hardened by a new process invented by Captain Tresidder are said to give better results than those heretofore attained. The result is to increase the liability of projectiles to break up on impact, without removing the inherent defects of the compound system. As usual, the Palliser shot gave the poorest results.

The Adamson Gun.

"The principal feature of this type of guns consists in abolishing the trunnions and substituting therefor a ball joint, or spherical enlargement, which works in a suitable socket on the gun carriage."

FEBRUARY, 1892.—Army ordnance notes. The United States Navy. The recent armor trials. Foreign naval notes.

MARCH, 1892.—The United States Navy. The Gunboat *Petrel.* Foreign naval notes.

The Forum.

FEBRUARY, 1892.—Is our military training adequate?

The Electrical World.

JANUARY 23, 1892.—The electrician in war.

In a short editorial appears a discussion on the importance of the electrician in war. The suitability of the electric motor for controlling guns is pointed out The remarks are well taken.

The electric lighting of the French battle-ship *Marceau.*

This article gives the wiring of the ship under the following heads: (*a*) The dynamos, (*b*) projectors, (*c*) signals, (*d*) running lights, (*e*) reflectors, (*f*) interior lighting, (*g*) branch circuits.

FEBRUARY 6, 1892.—The Sims-Edison Torpedo.

Editorial mentions this torpedo's success in trials abroad.

The Engineer.

JANUARY 1, 1892.—What constitutes a coaling station. General editorial review of engineering progress during the previous year: (*a*) Civil Engineering. (*b*) Electrical engineering. (*c*) War material.

Notices failure of 110-ton gun and bursting of other guns in English service, and one Krupp gun at Hurten, Germany. France, 'generally speaking, behind in actual issues.' On account of great length, serviceability of Canet guns questioned. Smokeless powders still in experimental stage. Conditions of frontier defense between France and Germany modified by late experiments with high explosive shells. Compound armor plates still undergoing trial in England. The Brown compound plates, specially treated, succeeded in breaking Holtzer and Hadfield projectiles. Value of nickel in plates not considered settled. Manganese steel plates are said to have given good results in trials by Grüson.

(*d*) Sanitary Engineering. (*e*) Water supply. (*f*) Gas supply.

JANUARY 8, 1892.—France and quick fire guns.

Editorial review of the question of rapid-fire guns in France. Summary of discussion in Chamber of Deputies relating to value of these guns.

JANUARY 15, 1892.—The Navy of the United States. No. II.

Description of new navy with elevations and plans of the *Baltimore* and *Newark*, and elevation of the *Charleston.*

JANUARY 22, 1892.—The Navy of the United States. No. III.

Table giving data of new ships building, with cuts of armored cruiser *Maine*, armored steel *Cruiser No.* 2, protected steel *Cruiser No.* 6, and section of armored coast defense vessel *Monterey*.

Coal consumption in men of war. A French torpedo-boat.

The boat is No. 147; trial of boat took place at Cherbourg. Speed 23.684 knots. Under given conditions result considered remarkable.

JANUARY 29, 1892.—New quick-fire guns for the French Navy.

Table gives kind and number of quick-fire guns, which will soon be delivered to the French Navy. Following the table is a discussion relative to the comparative merits of English and French guns, especially quick-fire guns.

Editorial on torpedo-boats.

Comprises considerations affecting value and use of torpedo-boats.

FEBRUARY 5, 1892.—Probable effect of quick-fire guns on naval tactics.

Summary of paper read by Admiral Long before United Service Institution.

FEBRUARY 12, 1892.—The Sims-Edison Electrical Torpedo.

Trial of this torpedo took place February 3rd at Spithead, in presence of several distinguished military officers; map given showing path of torpedo. The trial was made to illustrate two operations: 1. The controllability of the torpedo. 2. The picking up of the torpedo and cable. The experiment was very successful.

Royal ordnance factories and the manufacturers. Military ballooning.

Summary of paper read before United Service Institution on methods of filling and using balloons in war.

FEBRUARY 19, 1892.—The Sims-Edison Electrical Torpedo.

Further trials of this torpedo in Stokes Bay. On February 12th trial was a failure owing to cable being cut some distance from ship. Another experiment on February 15th was perfectly successful.

Woolwich Arsenal and private manufacturers. French trials of Elswick rapid-fire guns.

Editorial discussion defending the Elswick guns.

MARCH 11, 1892.—The Navy of the United States—No. IV.

Table of comparison between the most recent battle-ships and cruisers of the United States and Great Britain. Plans and elevations of coast line battle-ships Nos. 1, 2 and 3—*Massachusetts*, *Indiana* and *Oregon*.

New disappearing Elswick gun-mounting.

Two large illustrations showing gun-mount and armored turret with gun in loading and firing positions.

MARCH 18, 1892.—The Navy of the United States—No. IV. (concluded.)

Elevation of the triple screw *Cruiser No.* 12, with plans of main deck and upper deck showing bridges and storage of boats.

ERRATA.

Page 104, line 16: For 'refering' read 'referring.'
Page 105, Note: For 'plate' read 'plates.' [the reference is to the reproductions of armor-plates.]
Page 111, line 3: For 'days' read 'day's.'
Page 147, line 17: For 'ingenous' read 'ingenious.'
Page 152, line 7: For 'Il' read 'If.'
Page 159, line 13: For 'annottated' read 'annotated.'
Page 163, line 14: For 'N. S. I.' read 'M. S. I.'

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CONTENTS.

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JOURNAL

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VOL. I. JULY 1892. No. 3.

THE THEORETICAL INSTRUCTION OF GUNNERS.*

BY CAPTAIN JAMES CHESTER, THIRD ARTILLERY, U. S A.

Artillery troops may be divided into three classes, namely, cannoneers, gunners and artillerists.

Cannoneers should be able to execute the manual of any piece of artillery in the system, and to perform all the duties devolving upon them in any of the mechanical manœuvres prescribed in the drill-book.

Gunners should be expert cannoneers and able to teach them all their duties. They should also know the nomenclature, manipulation and practical use of all the instruments used in gunnery; the use of ballistic formulas in the determination of range, penetrative energy, angle of fall, remaining velocity, and in the solution of plane triangles.

Artillerists should be expert gunners and able to teach them all their duties; they should be able to test the accuracy of instruments and to adjust them, and they should have a general knowledge of the history and science of artillery, and be able to organize artillery defense and plan artillery defenses.

* Read before the Lyceum, Washington Barracks, D. C.

Cannoneers should receive their instruction in the shape of drill. Gunners and artillerists should receive practical and theoretical instruction.

The course of instruction for cannoneers is prescribed in the drill-book; the course for gunners has not been specially prescribed elsewhere; the course for artillerists embraces all the literature of the profession.

The theoretical course for gunners is the subject to be specially considered in this paper. As already said it has never been authoritatively defined, and differences of opinion exist among artillery captains in regard to it. Some are inclined to look upon a gunner as only an expert cannoneer who can lay a gun, while others expect him to be almost an artillerist. In the schedule of requirements already given we have tried to strike a mean between the two. We believe that gunners should know all that we have prescribed, and we believe that men can be found in every battery sufficiently intelligent to master the course. If there be no such men in any battery, the first step towards efficiency should be, a determined effort on the part of the captain to procure them. He should be permitted to visit recruiting depots and personally make selections of men, or, even to advertise for them if other means of obtaining them fail. Material for gunners must be found, and there should be no great difficulty about it. If necessary, the pay and position of a non-commissioned officer of artillery must be raised, until men with the essential qualifications are attracted to the service. The qualifications are not excessive. A sound constitution and good physique, intelligence, mental capacity and a fair common school education. Surely such men can be found in this land of learning and athletics if due diligence is used. But due diligence is not used. The necessity for special qualifications in artillery recruits is but dimly recognized, or, if it is recognized, it is generally disregarded. Captains of field batteries are permitted to select their horses. It has been found necessary for them to do so; but men seem to be of less importance. We do not claim that all artillerymen should be of superior mental capacity, but that a battery cannot be efficient unless a certain number of the men in its ranks are so.

It is ruinous to efficiency for a captain to struggle on with incapable material; and to cover up the inefficiency of his gunners by utilizing his lieutenants as such, is dishonest. It is hiding the sore which he ought to heal, and the time may come when it cannot be hidden. If incapable men are assigned to a battery the fact should be made known to the proper authority, and an inspection asked for. The artillery will never be able to extricate itself from the slough of inefficiency in which it has been wallowing for the last quarter of a century, until some such remedy is applied. Captains must be furnished with capable men and held responsible for their conversion into capable gunners. The men must be taught and trained into efficiency. No matter how much of a bungler the embryonic gunner may be at first, he must bungle along to proficiency or be relegated to the grade of a cannoneer. The captain is not responsible for his incapacity, but if he conceals it and retains the man in the grade of gunner he is to be blamed.

Before proceeding to the consideration of the subject proper of this paper, a word may be said on that part of the gunner's curriculum which requires that he should be able to do and to teach all the duties of the cannoneer. This knowledge and ability should be practically acquired. Recitations in drill regulations are a waste of time. The gunner must learn to drill a detachment in all its multifarious duties, in the same way as he would learn to do anything else—to make shoes for instance—namely, by doing it, not once or twice but scores of times, under the supervision of a master, until he becomes a master himself. Recitations will never make him a master; but necessity and pride will drive him to the drill-book if he be called upon regularly to do what the drill-book teaches. If he knows to-day what he will have to drill his detachment at to-morrow, he will come to the work fully prepared. The best recitations in drill are those delivered to the detachment. And this is true for officers as well as non-commissioned officers The custom which has grown up since the war of making officers do non-commissioned officers duty, while it may be necessary and beneficial for very young officers who are themselves learning the drill, is absolutely ruinous to non-commissioned officers. Unless an officer is himself learning the drill he should never drill a detachment.

Again, responsibility is the only effective spur to professional ambition, and it should be felt in proper degree throughout the grades of the artillery hierarchy. Platoons and detachments are permanent units in the organization of a battery, and their chiefs should be held responsible for their appearance, instruction, drill and efficiency, just as the captain is for those of the battery. Young officers who are permitted to drone along as subalterns in a perfunctory way for at least one-half of their active lives, without feeling the weight of responsibility, will have acquired habits of indifference difficult to get rid of when they reach command rank. It is an injustice to these officers to permit them to fall into such habits. Every subaltern should be assigned to a platoon and his efficiency at the end of the season should be measured, not by the professional ability which he may display on an examination, but by the condition of his platoon. So also with chiefs of detachments; the condition of their detachments should be taken as the exponent of their personal efficiency.

Such a policy if persisted in, would certainly produce efficient sergeants and subalterns without which no battery of artillery can be efficient. Our present system has the opposite effect. Subalterns of artillery are required to do sergeants' work while sergeants listlessly look on. Beyond a certain limit the effect upon the officer is bad, and upon the sergeant it is ruinous. The latter class acquire false ideas of the functions of their office. They feel that they are not artillerymen. They are called upon to do nothing involving responsibility, except guard and police. There they are sometimes entrusted with command and saddled with responsibility; but as non-commissioned officers of artillery they are simply ciphers. Is it any wonder that they get to feel that they are fifth wheels to the professional wagon and act accordingly? It would be very extraordinary if they did not.

But we have said enough to clear away the cobwebs from our subject. Drill is a practical and not a theoretical study. Officers and non-commissioned officers of artillery should be afforded proper opportunity to learn, and required to know all the duties prescribed by the drill-book; but the knowledge can never be properly acquired by recitations. Having cleared the ground of this great incumbrance we now turn to our legitimate subject.

Assuming that gunners have fair mental capacity and a plain common-school education, and that their training in the manuals and mechanical manœuvres prescribed by the drill-book has been relegated to the drill-ground where it belongs, what methods should be pursued in imparting theoretical instruction in the subjects which we have included in the gunner's curriculum? And first, how should the necessary knowledge of instruments be taught?

Here we are confronted with the question, what are the instruments used in gunnery? The question cannot be definitely answered. The list will vary at different posts. A well equipped artillery station will be provided with cannon-sights, gunner's quadrants, gunner's levels, a stop watch, an anemometer, a thermometer and hygrometer, a barometer, an artillery wind vane, measuring instruments, weighing instruments, azimuth instruments, signal and telegraph apparatus, a plotting-board, drawing instruments, and perhaps instruments for determining pressures. If any of the instruments mentioned are absent from the outfit they should be omitted from the course. There is nothing more disheartening to the average gunner, than elaborate descriptions of complicated instruments which he does not see and has no opportunity to handle.

As many of these instruments are provided with verniers, the practical study of that contrivance should be preliminary to the study of instruments so provided.

In order that the class as well as the instructor may have a comprehensive view of the subjects to be studied and the time allowed for the work, a complete list should be made out in advance, showing the lesson for each instruction day throughout the season, and the members of the class should be required to take a copy of it. This is important, because it not only shows them the work to be done, but keeps them in remembrance of the ground already traversed. It should be distinctly understood that examination on any back subject is always in order.

Platoon commanders should instruct the gunners of their own platoons. There are several good reasons for this arrangement. It is unwise to have large classes for instruction. Then the arrangement is in line with responsibility, and fosters a wholesome rivalry between lieuténants as well as platoons. Five hours a week should be devoted to class instruction in every battery during the season, that is, one hour a day for five days in the week. That would give twenty minutes to each platoon commander, and leave twenty minutes for another purpose, which we shall explain later on. Examinations by battery commanders should be made on muster days and oftener if deemed necessary, and the efficiency of the instructors should be measured by the proficiency of the class.

The lieutenant's class, which for the sake of distinction may be called gunners of the first class, should include all the qualified men in the platoon, whether they are non-commissioned officers or not. Every well-drilled cannoneer, with the requisite education and mental capacity should be required to join the class. The capable men of every detachment who have not yet mastered their drill sufficiently well to entitle them to admission to the lieutenant's class, should be instructed by the chiefs of their detachments. These classes would utilize the third twenty minutes of the instruction hour. They should be instructed in the same subjects as the lieutenant's class, and be examined by their platoon commanders every muster day. The advantages of this arrangement are numerous. The bulk of the battery will be brought under instruction; capable cannoneers will have the benefit of a valuable preliminary course, and the operation of teaching will fasten the details of every subject taught in the minds of the instructors.

The number of men in a lieutenant's class would rarely exceed eight, and perhaps would seldom reach that number. A sergeant's class should be limited to four. Small classes and short hours are much more favorable to progress than large classes and long hours. Of the twenty minutes at the instructor's disposal, ten might be profitably devoted to a quiz on some back subject, and ten to the lesson of the day. The instruction should be oral, and in language suited to the capacity of the class. Descriptions should be simple, concise, clear and exact. The black-board should be liberally used by the instructor, so that the men may receive instruction by the eye as well as the ear. There is no better way of imparting instruction than by the living voice, if it be properly done. But the instructor must not try to exhibit his own learning or to deliver a set speech. He must come down to the level of his class and take them by the hand as it were, and lead them over the ground which he wants them to know; never deviating to the right or the left to explain collateral subjects; and when he has traversed the ground, stop talking. For instance, and by way of illustration, the instructor takes up the instrument which is the lesson for the day, and holding it up before the class tells them its proper name, being careful to pronounce it distinctly, and then writes the name on the black-board so that the men can see as well as hear the correct name of the instrument. He then goes over the nomenclature of the instrument, writing the name of each part on the black-board, and pronouncing it distinctly as he points to it on the instrument itself.

Next instruction day the class is quizzed on the same instrument. It is handed to one of them and he is required to go over the nomenclature just as the instructor did, writing the names on the black-board in the same way. His errors, if any, will be detected and pointed out by members of the class; or the subject may be divided and several members required to participate in the quiz. The last ten minutes are devoted to oral instruction on the lesson of the day.

Instruction in the correct nomenclature of the tools of your trade, is a very important and a very much neglected part of a professional education. No one can talk subjectively about any instrument, if he has been permitted to designate its parts by pointing to them and saying "this screw" or "that thingumbob." Correct nomenclature should be insisted on, in the section room, on the drill ground and everywhere.

When the nomenclature of the instrument has been acquired in the way just described, its scales and graduations should be explained. If it be a simple instrument, such as an ordinary cannon sight for instance, its nomenclature, scales, verniers, manipulation and practical use may all be included in one lesson. More complex instruments, such as the azimuth circle, would occupy several days perhaps. But to continue our illustration.

Assuming that the lesson for the day is the cannon sight, and that the quiz on its nomenclature has been completed, the instructor goes on to explain its elevation and deviation scales, stating distinctly and writing on the black-board the value of the small cut divisions on each, and showing the proper way of holding and setting the instrument to any elevation or deviation allowance prescribed. At the quiz on the next succeeding instruction day, the class should be drilled in reading the scales when set by the instructor, or setting them as prescribed by him, and this drill should be continued on the drill ground, whenever and wherever the instrument makes its appearance.

As already said the subject of verniers should be a preliminary study. Some instrument provided with a vernier easy to read should be selected, or, a couple of rulers may be prepared for the purpose, one of them graduated as the scale and the other as the vernier, sufficiently large to be read several yards away. With such an instrument or such an apparatus, the instructor can drill the class at reading verniers until proficiency is attained. The reading of verniers after the principle is known is only a question of eyesight.

Gunners should be taught how to distinguish between direct and retrograde verniers, although the latter are rarely met with. Among the instruments used in gunnery only one—the barometer—is so provided. The subject is therefor of minor importance; but ability to determine the least count must be insisted on.

The same methods should be pursued with any other instrument when it becomes the lesson for the day. The nomenclature, including scales and verniers, should first be mastered; then the manipulation, and finally the practical use of the instrument. Much care should be given to manipulation. An instrument is a delicate machine, and easily thrown out of adjustment by rough treatment. The manipulation of the azimuth circle, for instance, includes a variety of operations, all of which must be executed with care and delicacy. They should be studied and practiced separately. They are 1st, mounting the instrument; 2nd, setting up; 3rd, levelling; 4th, focusing the eye piece; 5th, focusing the object glass; 6th, adjusting the zeroes; 7th, adjusting the zero line to the base; 8th, clamping the limb; and 9th, unclamping the vernier plate. These operations should be executed in the order named, and practiced until they become as firmly fixed in the mind as the motions of the manual.

When we consider the ground to be covered in any reasonably complete course for gunners, we begin to realize that the element of time demands consideration. Certainly two recitations a week are not enough for the work. The acquisition of knowledge by half educated men is a slow operation. Instruction must be administered in small doses if it is to find a permanent lodgement in such minds. Protracted recitations are a mistake. Instructors can impart orally, all the information which the average gunner can assimilate in the ten minutes daily. In ten minutes more he can ascertain by means of a quiz on his last lecture, how much of it has taken hold. Twenty minutes daily, therefore, would be ample time for a class, and as there should be three classes in every battery, one hour per day per battery should be set aside for class room work.

Class room work is too important a part of the trainiug of artillery troops to be crowded into some spare hour, when the men have nothing else to do. It should be a recognized part of the daily routine, and one or more rooms should be fitted up at every artillery post for the accommodation of the class. At a large artillery post, such as Washington Barracks for instance, that room should be occupied six hours a day for five days in the week, each battery having its alloted hour in the lecture room, and nothing but absolute necessity should excuse any gunner from attendance.

The artillery has been cursed with a conservatism which is bred in the bone of the majority of its officers. An artillery garrison is looked upon as an infantry battalion and treated accordingly. Artillery instruction is like a side show at a circus, permitted rather than prescribed. It is never allowed to interfere with infantry work. The effect is deplorable. Artillery instruction should be the chief occupation of artillery troops. Infantry work should be the side show. The two months artillery instruction at Fort Monroe is a perfect god-send to the Third Artillery. During that short period artillery work is the order of every day, and the result is artillery progress.

A knowledge of the instruments used in gunnery and ability to use them, are absolutely essential to a gunner's efficiency, and nothing should be allowed to interfere with their acquisition. It will take at least forty hours properly distributed to traverse this portion of the course, if the instrumental outfit of the post be anything like complete. Verniers will require at least five hours; cannon sights of different kinds, four hours; gunner's quadrants, two hours; gunner's levels, one hour; wind instruments, three hours; measuring instruments, one hour; azimuth instruments, six hours; signaling and telegraph instruments, four hours; the plotting-board and its equipment, four hours; drawing instruments and protractors, four hours; pressure instruments, two hours; time instruments, one hour; and meteorological instruments, three hours. At the rate of five hours per week, this would occupy eight weeks of the instruction season.

When the course in instruments has been completed, the class proceeds to the next subject in the gunner's curriculum, namely, the use of ballistic formulas.

There are, we admit, some differences of opinion as to the usefulness of this part of the course. Some artillery captains hold that ballistics in any form are not essential to the gunner, and if the meaning of the word *gunner* be restricted to the man that lays the gun, we are ready to admit the contention. But we have adopted a broader definition for the word. The man that lays the gun is known as *number one* in some armies, and in the navy he is called *captain of the gun*. The conventional meaning imposed upon the word by our drill-books is neither wise nor convenient. We use it to designate the class of artillerymen who are proficient in their trade in all its branches, in contradistinction to that other class called cannoneers, who are proficient in certain branches only. The non-commissioned officers of a battery should certainly be gunners; but a battery may contain many more gunners than non-commissioned officers.

It is the duty of every battery commander to train and educate his men to the limit of their capacity. If he can make them all gunners so much the better. Certainly his battery cannot be efficient unless a certain number of them have qualified for that grade. The non-commissioned officers of a battery have duties to perform during a bombardment, which call for every qualification prescribed for gunners. They will be required to operate the azimuth instruments; to manage the plotting-board; to manipulate the search lights; to operate the telegraph; to determine distances; to observe and report shots, and to solve problems in plane trigonometry and ballistics. Of course every qualified gunner in a battery would not be called upon to do all these duties, but they are duties that belong to his grade, and he ought to know how to do them. It will not do to say that lieutenants should attend to such things. Lieutenants have their own duties to attend to. Two of them will be in command of platoons, and if there be a third he will probably be on duty at the magazine. The functions of a lieutenant are of a higher order than those named. Occasions may arise when a non-commissioned officer may be called upon to perform a commissioned officer's duty in battle, but the battery must have very poor material in its ranks or a very inefficient captain in command, if it ever becomes necessary for a lieutenant to do the duty of a sergeant.

But waiving the possibility that a non-commissioned officer may be called upon at a critical moment to do the duties of a lieutenant, and should be trained with that contingency in view, we maintain that the duties of his own grade demand ability to use ballistic formulas. The 1st sergeant for instance, is the captain's immediate assistant during a bombardment. He is the captain's *vade mecum* and ready reckoner, for no man can calculate and command at the same time. Imagine an action about to open, and, for the sake of simplicity let it be between some hostile ships and a four gun battery. The lieutenants are at their posts of duty; the 1st sergeant is with the captain; two sergeants are operating the azimuth instruments, the other two are at the plotting-board; the four corporals are at the guns; three trained men are at the telegraph and two at the search lights.

Get me the distance of such and such a ship says the captain, and the sergeant gets it—that is, if he and the other non-commissioned officers have been properly trained. What is the normal elevation for that range? The sergeant calculates or consults a table previously calculated, and gives the desired information. How many inches of iron can we penetrate at that distance? And the well instructed sergeant is able to answer in a very short time. And so on.

We maintain therefore, that efficiency demands, that the non-commissioned officers of a battery should know how to use ballistic formulas, for any one of them may be called upon to do the duties of 1st sergeant before the battle is over. And not only should they know how to use them, but they should be expert in their use. The question now before us is, how can this qualification be attained?

We have assumed at the outset that only capable men be permitted to enter the gunner's class. They should know arithmetic and the use of logarithms sufficiently well for a gunner's purposes, and be able to solve simple equations in algebra. Candidates for admission to the gunner's class who are deficient in these branches, must make up the deficiency by attendance at the post school, before they are admitted.

We start then with capable men, and, thanks to Captain Ingalls, the practical use of ballistic formulas has been brought well within the capacity of any man qualified to enter the gunner's class. It would be unwise however to put the hand-book in the hands of the men as a text-kook. There is much in it calculated to dishearten the average gunner, although much that is simple and valuable may be culled from its pages, and its tables are indispensable. The instructor should endeavor to make the formulas *look* as simple as possible, and avoid elaborate explanations. Gunners need not know anything more about the formulas than the average calculator knows about logarithms.

The instruction should be oral as in the course on instruments, and should begin with the conventional symbols which constitute the language in which ballistic science is written. The symbols may be taken from Captain Ingalls' hand-book, but they should be introduced to the class in such order and in such manner as the instructor may deem most effective. Every instructor will have his own particular way. We may however be permitted to introduce one method which we have found to be effective, not however as a model to be followed, but as an illustration to make our meaning clear.

The instructor taking up some small object—a pencil for instance—calls the attention of the class to the fact, that when he lets go his hold on it, it falls to the ground. He tells them, that up to a certain limit it falls faster and faster the farther it goes. That everything has a tendency to fall in the same way, and that every unsupported thing does so. Something is continually pulling everything towards the centre of the earth, and the something is called "gravity". He then goes on to say that in ballistic formulas gravity is represented by small g, and he writes gravity $= g$ on the black-board.

The numerical value g has been determined to be 32.16 feet, and he adds $= 32.16$ to the equation already on the black-board, and says, whenever you see small g in a formula, you can substitute 32.16 for it. And that is all the gunner needs to know about small g.

In a similar manner he explains the meaning and gives the numerical value—or shows how it can be found—of all the symbols which have been selected as the lesson for the day, being careful not to overtax the memory of the class. Then in order to fix the instruction given in their memories, and test their comprehension of it he gives out a number of exercises involving the symbols explained in the lesson, the solutions of which are to be handed in next day.

Assuming that g, w, and d constituted the lesson, the problems for practice should take this form:—Required the numerical values of the following expressions; the shot referred to being a 10" spherical shot, the exact diameter of which is 9.9 inches, and weight 128 pounds.

Six or eight exercises should be given to each gunner, no two of them alike, such as, $2gw =$, $\frac{w}{2g} =$, $\frac{w}{2g}d =$, $\frac{w}{d^2} =$, etc., and they should be required to perform the operations indicated both by the rules of arithmetic and by logarithms.

There ought to be no difficulty experienced in acquiring a knowledge of the simple symbols used in ballistics, or the ability to substitute for them their known values in any formula, and to reduce it to a plain numerical expression. There are some compound symbols however, introduced by Captain Ingalls in his hand-book, which it will be more difficult to deal with. Still as the gunner need know nothing more about them than how to find their numerical value from the tables, the difficulty is not insurmountable.

Considerable time should be devoted at this stage to the use of the tables, and the class should be drilled at it until they can use them as readily as they can the table of logarithms. Perhaps a day should be devoted to each table, and numerous exercises should be given out to be solved and handed in next recitation day. The exercises should take this form :—

Ex.—What is the numerical value of $S(u)$ for a rifle projectile when its velocity is 1800 f. s., and so on, at least half a dozen exercises being given out.

The symbols $A(u)$, $I(u)$, and $T(u)$, should be dealt with in a similar manner, and then the whole field should be retraversed for smooth-bore projectiles. At the end of these exercises the gunners ought to be perfectly familiar with the tables, and these compound symbols ought to have ceased to be formidable.

There is another formidable-looking compound symbol, $\frac{\delta_{\prime}}{\delta}$, which should be dealt with in the same way. Having learned the meaning of δ and $\delta_{\prime}$, and having their values given, no difficulty would be experienced in making the substitutions and reducing the fraction to a simple numerical expression. But Captain Ingalls has already done all that work, and we find the results in Table IV of his hand-book. Exercises in the use of Table IV, would therefore be in order, and should take the following form:

What is the numerical value of $\frac{\delta_{\prime}}{\delta}$ when the thermometer stands at 63° F, and the barometer at 29''?

One exercise should should always be worked out slowly and carefully on the black-board by the instructor, as a sample to be closely followed in the solution of the exercises given out. This should be left on the black-board, and the gunners should be required to copy it.

The instructor should then proceed to explain how the numerical value of large *C* is computed. Large *C* enters into almost every ballistic formula, and finding a numerical value for it is among the first steps towards their reduction. He should therefore, write the formula for large *C* on the black-board, and require each gunner to copy it. He then reads it distinctly to the class—large *C* equal to $\frac{\delta_{\prime}}{\delta}$ multiplied by $\frac{w}{cd^2}$—and calls attention to the fact that every factor in it is already familar to the class. Then to show them the shape that the solution of exercises should take, he writes a problem on the black-board and solves it for the class, leaving the solution on the board as before. He then gives out half a dozen exercises in the following form :—

What is the value of large *C* for a 10″ spherical projectile, the exact diameter of which is 9.9 inches, when the thermometer is 68° F, and the barometer 30″?

Every projectile used in our system should be the subject of at at least one exercise, and the class should be reminded that small *c* is = 1 for all muzzle loading guns now in service, and = .9 for all new pattern breech loading guns.

It would be well now to proceed to the consideration of some problems, the usefulness of which will be apparent on the face of it to the average gunner. The interest of the class in the subject should not be permitted to flag, and the alphabet of any science is always a dry subject. Turning therefore to the computations in ballistics which every gunner ought to be able to make we find them, as already stated, to be *range*, *penetration*, *energy*, *angle of fall*, and *remaining velocity*. The number of formulas to be committed to memory, therefore, is five. The instructor may take them up in any order, preferably taking up the simplest first. But for the purpose of illustrating teaching methods we shall take the list in regular order.

The computation of ranges, requires some complicated mathematical work, which, if it were not for Captain Ingalls' Tables, would be beyond the power of the average gunner. With those tables however it becomes a very simple operation.

The formula for range is, $x = C z$, certainly not a complicated formula, nor one hard to remember. The instructor should write it on the black-board, and read it in the hearing of the class, x—the range—equal to large C multiplied by z. He then should remind them that they already know how to find a numerical value for large C. There remains therefore only the factor z to deal with.

The instructor should then explain that the symbol z represents a value which is the result of a series of abstruse mathematical calculations, which fortunately it is unnecessary to go into. Captain Ingalls has already made these calculations for rifle projectiles, and has determined the value of z for all velocities between 1200 f. s. and 2150 f. s. These are to be found in *Table I, Auxiliary A* of the hand-book. But we cannot reach the value of z in that Table without a stepping stone, which Captain Ingalls calls "*auxiliary A*". But this stepping stone is not very difficult to find. The formula for it is $A = \frac{\sin 2\varphi}{C}$. This the instructor writes upon the blak-board and the gunners copy. He then reminds the class that φ is the angle of departure of the shot, which is known. Suppose it to have been 5° twice φ would be 10° and the formula would become by substitution $A = \frac{\sin 10°}{C}$.

There will be no difficulty experienced in reducing this formula to a numerical expression. The *sine* of 10° or the logarithm *sine*, for these calculations should be made by means of logarithms, can be taken directly from the Table of Logarithms, and large C is a familar factor which we already know how to deal with. As a model to be followed, the instructor should solve a problem on the black-board, including the calculation for large C and showing how the numerical value of A—the stepping stone—is obtained.

Having found the numerical value of the stepping stone and knowing the muzzle velocity of the projectile from the problem, we now go to Captain Ingalls's *Table I Auxiliary A* and look down the column headed with the given velocity until we find the nearest number to the stepping stone A, and opposite to that number in the column headed z we find the numerical value of that factor.

The original formula for range $x = Cz$ can now be reduced to a numerical expression without difficulty. The instructor completes his work on the black-board, and the class knows all that it needs to know about the computation of ranges. Exercises would then be in order, and should be continued for several days. Problems should take the following form :—

Required the range of a rifle projectile weighing 180 pounds, fired from an 8″ M. L. rifle with a muzzle velocity of 1250 f. s. The angle of departure of the shot being 3°. The thermometer standing at 80° F, and the barometer at 29″.

As already said a number of such problems should be given out, the instructor being careful at first to select only such muzzle velocities as are found directly in the Table. After the class has become familiar with the computation, the method of applying corrections when the exact velocity is not found in the Table should be explained and illustrated and new problems given out involving that variation. So also, when the exact value of *A* is not found in the Table. The class should be exercised on this formula, until they become expert in the computation of ranges.

And here it would be necessary to explain the nature and amount of jump, so far as it is known, for all the guns in our system. It should be made perfectly clear that φ—the angle of departure of the shot—is the elevation given to the gun by the gunner, plus the jump of the gun.

The computation of ranges for smooth-bore guns is of less importance than for rifles. For this reason perhaps Captain Ingalls has not computed *Auxiliary A* for smooth-bore guns. The subject will therefore, have to be omitted.

The next subject in the list is penetration. The instructor should explain that the penetrating power of a projectile is measured by the number of inches of wrought iron which it will penetrate, and that is determined by the formula $t = \frac{v}{608.3}\sqrt{\frac{w}{d}}$.

There will be no difficulty with this formula. Its reduction involves substitutions, and the performance of the operations indicated only. No stepping stones and no tables are needed. The exercises in the use of this formula should take the following form:

An 8″ rifle shot, weighing 185 pounds, strikes a wrought iron target with a velocity of 1000 f. s. Required the penetration in inches.

The formula for energy is $E = \frac{wv^2}{4480g}$ and it will need no explanation. It should be written on the black-board, and gunners should take a copy of it. Then exercises in its use would be in order, such as:—

An 8″ rifle shot weighing 180 pounds, strikes the target with a velocity of 1200 f. s. What was its striking energy?

An 8″ rifle shot weighing 180 pounds, is fired with a muzzle velocity of 1300 f. s. What is its muzzle energy?

The formula for angle of fall of a rifle projectile is $\tan \omega = \frac{B}{A} \tan \varphi$. Here, it will be observed, are two stepping stones, B and A the numerical values of which are taken from *Table I Auxiliary B* and *Table I Auxiliary A*. To enable us to get these values from the tables we need to know the numerical value of z.

The formula for z is $z = \frac{x}{C}$ which can be readily reduced to a numerical expression.

Having the values of z and the muzzle velocity we enter *Table I Auxiliary B* and opposite the value of z in the column headed with the given muzzle velocity will be found the numerical value of B In a similar manner the numerical value of A is taken from *Table I Auxiliary A*. When these values are substituted for their representatives in the formula, its reduction becomes an easy matter. Exercises should take the following form:—

An 8″ rifle shot weighing 180 pounds, was fired from the 8″ M. L. rifle with a muzzle velocity of 1250 f. s. The angle of elevation of the gun was 3° and the jump 30′. The target aimed at was 6000 feet away and the shot struck 90 feet beyond the target. Meteorological conditions normal. Required the angle of fall of the shot.

In such a problem, there are several preliminary operations all of which will be familiar to the gunners. They are

First to find the value of large C from the formula $C = \frac{\delta_1}{\delta} \frac{w}{c d^2}$.

Second to find the value of z from the formula $z = \frac{x}{C}$.

One exercise should be worked out on the black-board as a model.

For smooth-bore projectiles the following rules may be followed without sensible error :—

For ranges over 1500 yards and not exceeding 2000 yards $\omega = \varphi + 1^\circ$
For ranges over 2000, and not exceeding 3000 yards $\omega = \varphi + 2^\circ$
For ranges over 3000 yards $\omega = \varphi + 3^\circ$.

We now reach the most complicated, and perhaps the most useful formula in the list, namely the formula for velocity, which the instructor should write upon the black-board—$S(v) = z + S(V)$— and read distinctly to the class. He should remind the class that small v means remaining velocity and large V muzzle velocity. He should also explain that in the table u means either.

To explain and illustrate the use of this formula, perhaps the best and simplest method for the instructor to pursue, is, to assume a problem, and work it out on the black-board by means of this formula in presence of the class. Take this problem for instance :

A rifle projectile weighing 290 pounds, was fired from an 8″ B. L. rifle with a muzzle velocity of 1800 f. s. The thermometer stood at 80° and the barometer at 30″. What was the velocity of the projectile 2000 yards from the muzzle of the gun?

Assuming the formula $S(v) = z + S(V)$ we see that we must find the value of z and before we can do that we must know the value of large C which therefore becomes the first preliminary. Large C is computed from the formula $C = \frac{\delta_1}{\delta} \frac{w}{cd^2}$ with which the class is familiar.

The second preliminary is to find the value of z which is done by the formula $z = \frac{x}{C}$, which the class knows how to handle. When this value is found it is substituted for z in the formula.

Now for $S(V)$, we go to Table I of the hand-book, because the shot was a rifle shot,—if it were spherical we should go to Table II—and opposite the velocity in the column headed u, in the column headed $S(u)$ will be found the numerical value of $S(V)$ which is at once substituted for that symbol in the formula. By adding the two terms together the second member of the formula becomes a plain numerical expression.

Returning now to the table with the number thus found and finding the number nearest to it in the column headed $S(u)$, we find opposite to it in the column headed u the velocity required.

The class should be exercised in the use of this very important formula, until they become reasonably expert. And this will complete the gunner's course in ballistics.

It is difficult to determine, even approximately, the time that would be required to traverse that part of the gunner's course, because it must depend, in a degree, on the intelligence and zeal of the gunners themselves, but we believe that the following will be found a fair allowance.

For the symbols	2	hours
For the Tables	6	"
For $\frac{\delta_1}{\delta}$	2	"
For large C	3	"
For Range	6	"
For Jump	1	"
For Penetration	2	"
For Energy	2	"
For Angle of Fall	6	"
For Velocities	10	"
Total	40	hours, which

at the rate of five recitations per week would occupy eight weeks more of the instruction season. The course in instruments also occupied eight weeks, so we have thus far appropriated sixteen weeks of the instruction season, leaving ten weeks still at our disposal.

Of this we should devote eight weeks to the solution of plane triangles, Of the ten remaining hours, six would be devoted to examinations by the battery commander and four to reviews.

It is unnecessary that we should enter into the details of the course in Plane Trigonometry. There are no differences of opinion, as for as I know, as to the usefulness of the course, and perhaps no two men would agree as to the best method of teaching it. Only one thing should be insisted on. The course should be mapped out in advance, and every hour of time should have a specific subject assigned to it. The haphazard method of assigning lessons is not good. The course should be laid alongside of the time, and both should be laid before the class. To be a gunner that course must be mastered in that time. No lesson can be skipped. If sickness or any other casualty prevents any member of the class from taking the whole course, every lesson and exercise in it, then he cannot be graded as a gunner, unless he has made up his deficiency, and passed an examination satisfactory to his instructor and battery commander. The grade of gunner would then mean something definite, and the meaning would be the same in New York and California.

[DISCUSSION.]

Captain *Samuel M. Mills*, 5th Artillery.—The above article by Captain James Chester, 3rd Artillery, is deserving of the most careful reading.

Captain Chester contributes many valuable suggestions from his store of knowledge and extended experience of artillery instruction, covering every possible field of application, and the above paper is no exception to the general class of articles that he prepares.

I agree with him in many of the views expressed, and of the necessity of obtaining uniformity of instruction, and generally in the substance of this instruction, but not entirely in other particulars, nor in the necessity for the higher scope of instruction contemplated.

I notice at first that no reference is made to the course of instruction as now prescribed, and which has been in general use for the past two years throughout the service.

I believe the curriculum as therein ordered contains the germs out of which we will get the course of instruction best adapted to our present needs, and the capacity of the average artilleryman will admit of in the near future: we are becoming accustomed to this course, and have already made considerable progress and improvement in it. What is required now is a revision of the course with such improvements as the experience gained in the past two years suggests, and particularly describing definite, uniform and limiting powers for the guidance of boards of examiners, then "the grade of gunner will mean something definite, and the meaning would be the same in New York and California."

As now established, one board may fix a maximum standard under the heads "Judging velocity of the wind," "Speed of vessels," "Distance of stationary and moving objects," such that the judgment of each man when measured by this standard would give him a very low mark or zero, whereas another board might fix another standard, whereby equally good judgment or guesses would deserve and receive qualifying marks; again, one board is so thorough in the practical examination as to require five full days for the examination of *one* battery of thirty-five men, another board is so superficial in the examination on these same subjects as to require but *one* day for the examination of several batteries; and further, one board requires quite difficult mental conditions to be solved with the Zalinski Sight, under the head of "Reading Instruments" and "Laying Guns." At another post or battery there will be no examination on this sight or other instruments (none being on hand), and yet they are marked and graded as though all enjoyed the same privilege, and had received instruction.

The *grading* of the "soldierly character" requisite of the order is entirely ignored by most battery commanders. These are a few of the defects that should be corrected if there is to be a uniform comparison.

But I am getting off of the subject of the article. I find no suggestion in this paper on this point of examination of gunners, other than the examination by the captain of his own battery on muster days. There apparently is no test to be applied as to the proficiency of the battery as cannoneers, gunners and artillerists. No record for regimental or other commander as to the efficiency of the battery on these subjects. I am a firm believer in the benefits of the competitive idea in instruction of this kind; it is always popular with the men, and will stimulate and encourage them to make efforts which no other influence can reach, and besides it is necessary to have some means of ascertaining if the captains are performing the duties prescribed and in the proper manner, and unless there is some inspection or examination where this matter is gone into, it would never be known until too late to correct.

I prefer the present sub-divisions, viz: 1st and 2nd class gunners, to that proposed. The grade of 1st class gunner can be made to cover all the qualifications that it is necessary to have, or that we can hope to find men in the ranks qualified for, or of men that can be induced to enlist with the present, or even anticipated pay.

Under the heading "laying guns, &c.," the instruction and examination can be made to cover all the practical knowledge known in the entire range of practical artillery firing; the grade of "artillerists" would be only theoretical, as we would have no means of testing the qualifications apart from that covered by 1st class gunners.

The tendency shown in the article is a too rapid advance I think, in the direction of mental requirements for the enlisted men of artillery; we are growing into it and have made most commendable progress in the past two years. It should be born in mind though, that it is only in the last few years that all artillery *officers* have become entirely familiar with the use of direct and retrograde verniers, azimuth circles and other instruments used in artillery. We must have a little patience in bringing the men to this standard. I have seen evolved from men within the past two years with one month's instruction and little practice, who could simply *read*, had never seen or heard of anything in their lives that would aid them in acquiring this knowledge, that now can read, explain and use any instrument employed in artillery firing. The requirements as they exist to-day, have forced men (non-commissioned officers) of good standing but of limited mental capacity, to re-enlist in other branches of the service; and within my experience it is difficult to find men who will accept appointments of non-commissioned officer on account of the schools, and other instruction and responsibilities that they have to assume. I would say let us improve the course as it is now prescribed and not attempt at present to require a detailed knowledge and application of the ballistic formulas referred to. It will be sufficient, in addition to what we already require, if the men are taught the use of the tables *deduced from the formulas*, and as applied and shown in "Whistler's Graphic Method," or other means of using them.

Give us a little time and we will be ready to do the firing long betore the guns are supplied us or the batteries located.

The detailed method of daily *instruction* recommended is excellent in every way.

First Lieutenant *G. N. Whistler*, 5th Artillery.—I have read Captain Chester's article with much interest, and heartily agree with his views and particularly with his methods, with possibly one exception.

While in command of Battery "B," 5th Artillery, I began a system which I was unable to carry out, in consequence of the transfer of the regiment to California and giving up the command of the battery.

I placed the drill of the detachments entirely in the hands of the non-commissioned officers, reserving to the officers the theoretical instruction, and of course general supervision. I announced in battery orders that a prize drill would be held each month to ascertain which was the best instructed platoon. The amount of interest taken in the subject was astonishing: it was common on entering the quarters, to find the men studying Tidball and quizzing each other on nomenclature.

My idea would be to excuse any enlisted man from drill (except as instructors) as soon as he becomes proficient in his duties. There is nothing more demoralizing to men, than to be required to drill day after day at the details of gun drill after they have mastered the subject. Take the case of a detachment of eight men drilling at a muzzle loading gun, four of them proficient, and four of them not proficient. The instructor naturally places the uninstructed men at Nos. 1, 2, 3 and 4, and the proficient men are required to spend an hour heaving and hauling as Nos. 5, 6, 7 and 8, simply because the other four men are too stupid to learn how to handle the sponge staff; certainly this will not develop an enormous amount of enthusiasm for their profession.

I would also relieve any battery from drill as soon as the men are pronounced proficient. When a captain deems his battery proficient, he reports the fact to the commanding officer who examines the battery at all the guns, if found proficient they are relieved from further drill for that season. The time required for each battery, platoon and detachment to become proficient in the various drills during each year's drill season, should be published in orders from Department Headquarters giving the names of the instructors; this would be a great incentive to work. The same rule should hold for theoretical instruction. At the beginning of each drill season, an examination should be held in each battery, and the proficient men should be excused from the laborious part of the work.

I do not altogether agree with Captain Chester concerning theoretical instruction in the use of "ballistic formulæ," that is, I do not think it should be made compulsory for all gunners. In the first place, as I hope soon to show, all the "ballistic formulæ" can be arranged in "*graphic tables*" in such a manner that all the data spoken of by Captain Chester can be determined mechanically. Every gunner should be perfectly familiar with the use of such tables, and be able to work out the data promptly and accurately: but I do not consider it essential that they should know how to use the formulæ. However, I would not entirely drop such instruction from the schedule, but make it optional, and forming an advanced course, those qualifying in the *advanced course* to be styled *master gunners.*

I would suggest that to obtain a special grade of pay for non-commissioned officers of artillery will be difficult; of course the pay of all non-commissioned officers is too low, but I fear Congress would not make a special exception for the artillery.

Why not make this increase of pay depend upon *qualification.* A gunner to receive two dollars a month above the pay of his grade, and a master gunner five dollars a month. This I think would appeal to the common sense of members of Congress. The increase is not asked for any particular military grade or rank, but as a reward to any soldier, whether sergeant, corporal or private, who is able to qualify for a particular degree of proficiency.

In connection with this subject permit me to call attention to a peculiar anomaly in our drill. The ballistic work about a gun instead of being a function of the chief of piece, presumably the best instructed non-commissioned officer, is the function of the gunner, a corporal, who, by the way, instead of being allowed to attend to this duty, is occupied for the best part of his time in the highly *intellectual duty of serving vent.* It is one of the things "*no fellow can ever find out,*" why it is entirely within the intellectual capacity of a private to serve the vent of a field-gun, but requires the more advanced knowledge of a corporal to perform the same duty for a sea-coast gun.

All this should be changed; the chief of piece should be responsible for the *ballistic service of the piece*, and the "gunner" should have command of the cannoneers and superintend the loading, &c. Why not change this title of "gunner" for this position—call him *corporal of the gun* as we say "corporal of the guard." We would reserve the terms *master gunner* and *gunner* to indicate a grade of proficiency.

In conclusion, has not Captain Chester forgotten one very important feature, viz: the instruction in the care, preservation and knowledge of ammunition? Not only should a gunner be familiar with the proper ammunition for each gun, but in case the proper grade of powder is used up, he should know how to determine what powder to use.

Sarrau's formulæ may be graphically arranged in charts so that, given the characteristics of the powder, which should be marked on each barrel, any gunner can determine at a glance what pressure it will produce, and what velocity it will give in any particular gun, and also what is the proper charge to use for this particular grade of powder.

Surely if so much time is to be given to the instruction in the formulæ of "exterior ballistics," some little time should be given to the much simpler formulæ for "interior ballistics."

However, with these slight exceptions I heartily concur in Captain Chester's views, and congratulate him on the most admirable method of instruction which he has suggested.

Captain *Frank W. Hess*, Captain 3rd Artillery.—Captain Chester's paper on this subject is practical and full of suggestions. While all will not agree with him as to the scope and direction of his theoretical instruction of gunners, it must be admitted that he has struck the key note of success by throwing away text-books.

The mental training of the average citizen who seeks to honor himself by service in our sea-coast forts, has been such that the sight of a text-book with its discussions of circular functions, theory of logarithms, etc., produces mental nausea, and, when their study is insisted on by the captain, the first thing the young non-commissioned officer wants is to be reduced to the ranks, and then a transfer to the infantry. This is not the case when the method outlined by Captain Chester is pursued; its practical workings have fallen under the observation of the writer, and the results attained have been astonishing.

"The best recitations in drill are those delivered to a detachment" is a truth strongly and plainly put. How often have we seen those who acquitted themselves excellently at a recitation in the section room, fail on the drill ground and at the battery. To recite well is purely a matter of memory, often short memory; while to instruct others, orally, well, is a matter of thought, reason and judgment.

The tendency in our service to require the officer to do the work of a non-commmsssioned officer, gets a heavy and well deserved rap. It has lowered the dignity of the lieutenant and destroyed the efficiency of the sergeant, by relieving him of the responsibilities belonging to his office, and has a tendency towards making him ridiculous among the men of his battery. I have heard of one 1st sergeant who was dubbed by the men of his battery the "roll call sergeant," because he was permitted to do little else in the company. Responsibility is a spur which all men need in order that they may produce the best work.

Horace Greely's trite direction for resuming specie payments, meets with its counterpart in the captain's method of teaching the gunner how to command and drill a detachment—*make him do it.*

I have seen a non-commissioned officer forced to drill a detachment in mechanical maneuvers, mounting a 10-inch mortar on a mortar-wagon, when he protested that he was not prepared to do it. He did it wretchedly, but the next day I was pleased to see that he surrendered a goodly portion of a valued "pass" to sit on a pile of cannon balls and observe another do it. He was not even permitted to surrender his responsibility when he wanted to, and the lesson told on him.

The apathy complained of into which our artillery people have fallen extends only to *artillery*; we have always been fairly good infantry. The apathy is not wholly the fault of the corps. It has arisen largely from the fact that we have until recently, had too many old soldiers in the artillery who never saw any or but little artillery material. We have had them in the wrong places; some of us are there yet. But the dawn of a brighter day is upon us, and the paper under consideration as well as many others which have recently appeared, show that we have within our gates men who are prepared for the artillery renascence.

Our term of enlisted service is now a short one. We cannot hope to retain a large percentage of our men for more than three years, and, while there is so much of a practical character outside the field of ballistics which it is absolutely necessary for our gunners to know, the wisdom of entering that domain at all will not be apparent to many thoughtful and excellent officers.

In the instance cited, the practical utility of the information given the captain by his ballistic 1st sergeant is not plainly seen. The number of inches of iron or steel that his projectile will penetrate has been arranged by other powers long before the captain or his sergeant appeared on the scene. He can neither add to nor subtract from this. The hostile ship is there. His duty is plain. It is to get the range and "hit, hit, hit." The 1st sergeant's calculations might be discouraging to the captain, and he would be better off without them.

His method of teaching elementary ballistics, however, to men who only know how to "read, write and cipher" is simplicity itself, and shows the born teacher; its suggestions can not but prove valuable to those who wish to try it.

If the captain is ever beguiled into writing text-books on military subjects, let us hope he will call them "Guides to Teachers" and pursue the same methods he has in this article.

Captain *E. T. C. Richmond*, 2nd Artillery.—I agree with Captain Chester that the standard for gunner should be much higher than now fixed; but I believe with the material now on hand, that his standard is much too high. There are not six men in my battery who can take out a logarithm, and what could they do at taking out interpolated values of V, $I(v)$, $S(V)$ &c., or $\frac{\delta}{\delta_{i}}$? If I should attempt to teach these things, I would soon find myself fôrced back to teaching the simple rules in arithmetic, and Captain Chester's twenty minutes would be taken up in teaching how to point off decimals, and I believe there are many batteries which are no better equipped.

Captain Chester gives very simple problems; those in which the functions can be taken directly from the tables, and thus he makes it appear quite easy, but in practice such do not occur.

When our private soldiers are paid eighteen or twenty dollars per month, and the non-commissioned officers thirty or thirty-five dollars, we may hope to have men who will be able to take in the entire scope of his article, but not till then.

The matter of attendance on recitations is also of great importance, and I have had great difficulty in this matter. It takes as long to explain a subject to one man as to ten, and when one is absent, Captain Chester's alloted time must be doubled to accommodate this one man. At ten recitations with ten men in a class, there will not be an average attendance of seven men.

First Lieutenant *H. J. Reilly*, 5th Artillery.—Captain Chester has shown his usual ability in his treatment of the subject. It is a pleasure to find one's self in accord with the greater part of his scheme, and it is with considerable diffidence that I feel compelled to express a candid disagreement with that portion which proposes the study of ballistic formulæ by the gunners, and advocates their computation by non-commissioned officers while in action.

I can conceive of no duty properly pertaining to the grade of gunner, using the designation in its largest sense, which will require a knowledge of such formulae, or their computation under such circumstances.

If a gunner is properly and fully instructed, he will be familiar with the range table of his gun, and in action, on the announcement of the object and its distance, it will be necessary for him to glance at a printed copy of it, only to make sure of the elevation, deviation and time of flight; to apply these, and correctly and promptly lay the gun, especially on a moving target, will entirely absorb all his intelligence. If he does that successfully it is all that is necessary, or that can reasonably be expected of him.

In the case cited by Captain Chester the battery commander will have his range-tables, and, in default of better, say a copy of Brassey's Annual: from the latter after war is declared, he can memorize the distinctive marks, armament, thickness of armor, &c., of any or all of the enemy's vessels liable to be brought against his defenses. From the former he can determine the exact range at which his guns will be effective, and then give his orders accordingly.

No computations of ballistic formulæ are necessary; the range is given from the plotting-board; if he does not recognize the ship, there is no other method of ascertaining the thickness of her armor that I am aware of, hence, the formulæ for penetration are not needed. If he does know the thickness of her armor, the range at which his gun will penetrate it is stated in the range table.

Now who will prepare the range-tables referred to, the gunners? Certainly not; those tables should be the result of the most careful, deliberate and accurate computation; they should be based upon and compiled from the annual practice reports. These reports should cover with scientific exactitude every condition of atmosphere, powder, gun, density of loading, &c., which in any way will affect the range.

The gunners are now instructed in the theory and practice of the instruments used. They are taught how changes in the atmosphere and other conditions affect the range, and they must assist in obtaining the data upon which the range tables are based; these, with the other duties prescribed by existing orders *when carried into execution* fully occupy their time, and will result in the creation of a corps of competent gunners.

It seems to me that the time which Captain Chester proposes to devote to the study of ballistic formulæ, would be much more advantageously used if spent in practicing the gunners in the accurate estimation of distances over water, and especially in giving them sufficient exercise in doing it, to make them expert in correctly aiming and firing their pieces (sub calibres superimposed or inserted in the bore should be used for the purpose) at moving targets.

Captain Chester's paper should, as it undoubtedly will, be given the most careful consideration by those who, as we are given to understand, are now engaged in preparing a manual of instruction which is much needed for our gunners.

First Lieutenant *W. A. Simpson*, Adjutant, 2nd Artillery.—Captain Chester's article is an excellent and most timely one. This is a subject of the greatest importance to the artillery and calls for careful study by artillery officers. Of the necessity for systematic training of gunners there is no question, and this training should be carried as far as the capacity of the men will permit. The views of Captain Chester as to the proper spheres of duty of officers and enlisted men are generally concurred in, and the methods of instruction are excellent.

The main point upon which many artillery officers will disagree with Captain Chester, is as to the possibility of finding in any one battery a sufficient number of men capable of taking the course he lays down. If laid down as the result of his experience with his own battery, his experience is believed to be exceptional, partly due, perhaps, to Captain Chester's exceptional capacity as an instructor, which is well known. Other captains, thoroughly interested in their work, and very desirous of having their gunners well instructed, have been very much discouraged by the quality of material they had to work upon. Much faithful and careful instruction work by capable officers, pursued through long periods, has not produced the results desired. As an officer despairingly said in reference to a formula similar to one mentioned by Captain Chester, "How can you make a man learn what a sine of an angle is, if you cannot make him thoroughly understand what is meant by an angle?"

As a rule the material is not to be had, or if you get it you cannot keep it. Captain Chester says, "If incapable men are assigned to a battery the fact should be made known to the proper authority and an inspection asked for." Of what use would that be? We cannot keep our batteries up to the authorized limit as it is. Captain Chester says due diligence is not used. It is thought he is mistaken. Officers have gone out into New England to recruit for their own regiment. They have devoted their whole time to the work. They have used every effort to get good men. They have established rendezvous where the chances seemed best, and changed them from time to time as occasion required. Yet enough acceptable men, let alone capable men, cannot be obtained to fill vacancies.

The Adjutant General has lately complained that the number of recruits obtained by the general and regimental recruiting services, does not equal the number of men going out under the new laws.

It is a matter of dollars and cents. Tell a likely applicant that his pay will be thirteen dollars a month, but that he will get but nine dollars a month the first year, and he declines to enter. Though you show him that he gets his board, lodging, clothes, &c. besides, and that four dollars a month go into a savings bank and draw interest, he thinks of only nine dollars a month in cash, and is not tempted to enlist.

Suppose he does enlist, is a first rate man and improves under instruction. At the end of three years he is tempted to leave by a bonus of say eighty dollars (three months pay, clothing money and commutation of rations), and the better he has been made by his instruction, the better position he can obtain in civil life, and the more likely he is to go. They have the same trouble in the navy. Classes of men are sent, for instance, to the torpedo station for instruction. When their time is up they can, as a result of their instruction, command much more pay from electrical companies. They do not re-enlist, and their services which have now become valuable, are lost to the government because it does not pay the market price.

Too much instruction has its drawbacks. Many a good, efficient non-commissioned officer, whom his captain would be glad to keep, has re-enlisted in another arm of the service, so that he would not have to go to school, but would have as much pay.

So the matter comes again to dollars and cents. We are all as anxious as Captain Chester to have a well trained, well educated corps of gunners, but many of us do not think it possible to obtain them under existing conditions. If artillery non-commissioned officers must know more and be of a higher order than infantry or cavalry non-commissioned officers, they must get more pay. This of course requires legislation, which we should endeavor to obtain; legislation different from that of the last Congress, which not only deters men from entering the service, but tempts them to leave.

First Lieutenant *C. D. Parkhurst*, 4th Artillery.—The practicability as well as the desirability of the scheme of theoretical instruction outlined in the article with the above title may well be questioned. The necessity therefor is very doubtful: for to my mind the gun in action should be controlled by data determined long before the action takes place, while the gun is being tested and proved and used at the target range in time of peace, and all these data be tabulated into simple tables of fire which embrace all the conditions likely to obtain under the most extreme conditions of weather, variation in weight of projectile, range, or any other factor likely to occur in action

The infantry and cavalry sharpshooter, firing at the target range, has ammunition and a rear sight which has been prepared for him by the expert in that line of business. He does not have to take a book of logarithms and of tables and compute the value of "*C*" for any variation of barometer or thermometer, or other change in any of its factors. He learns by *practical experience* that, under certain conditions of temperature, light, position or what not, he must vary his elevation from day to day to make good shooting. In the course of a time of greater or less length he learns to almost instinctively give somewhere near the proper allowance for the first or trial shot, and to make the proper alteration to correct any inaccuracies observed in this trial shot, and once on the target he can stay there indefinitely.

Admitting at once that heavy gun practice does not agree exactly with small arm firing, particularly in the cost of ammunition, and that for the latter reason if no other every shot should be made to tell if possible, the question arises how to make this a possibility?

Captain Chester would solve the problem by a course of theoretical instruction, in which each and every non-commissioned officer is to be taught the mathematical application of the ballistic formulæ applicable to the case, from the data taken on the spot by the observation of instruments of precision that determine temperature, height of barometer, &c., &c.

This might be very well in peace times and for target practice where time is of but secondary importance. But books of logarithms and ballistic tables have about as much place in action in my opinion as glass houses. I think that in action the computation that must be made should be done by reference to tables that have been computed and compiled by the expert long before; that contain any and all of the possible conditions so arranged that they can be readily referred to, and be engraved or stamped upon plates of brass or other metal, and be permanently attached to the gun or gun-carriage for ready reference.

In heavy gun practice upon land we have a steady and reliable platform, if the latter has been properly laid. There is therefore no element of instability except the variation of the human eye as it looks through the sight. The varying atmospheric condition, the variation in weight of projectile and of charge, variation in density of loading and in light and shade, all which must be considered, all these, except the variation in density of loading and light and shade, can be and should be provided for in the tables of fire.

Small arm ammunition has been brought to a high state of perfection to obtain as nearly as possible uniform results. In the same way, heavy gun cartridges should be made with extreme care, so as to always have the same length and the same diameter with absolutely the same weight; or, if this be impossible, to be within certain limiting conditions that can be embraced in the tables. Density of loading should be an almost invariable factor with our modern breech loaders, carefully prepared projectiles and cartridges, and with *practical instruction in just how far home to seat the projectile every time* in order to give uniform capacity of chamber. All loading devices to load by power should be so constructed as to seat the projectile *just so far and no farther every time;* then with the cartridge of proper length and diameter, and with as near as possible the same absolute amount and manner of making up the cartridge bag, the density of loading will be under control, something that does *not* now obtain with cartridge-bags made anyway and anyhow, some of which cannot be entered into the chamber without deformation, distortion and absolute crushing of the powder grains.

In my opinion these are matters that need more attention than theoretical intsruction of non-commissioned officers. The tool maker knows from his experience and the best practice of his profession that a lathe needs variable speed to provide for the proper handling of varying diameters and varying kinds of metal. He therefore provides the requisite cone pulleys upon counter-shaft and live spindle to give these variations. He also knows that screws and feeds of varying pitches will be needed in actual practice; he therefore provides the necessary change gears to cut any and all of the standard or odd sizes, or to give all the variation in feed that experience shows may be called for. The practical machinist *may*, but *generally does not* receive instruction in the theory of the thing. *Practical experience* and the tables provided upon all such machines, planers, shapers, milling machines and the like, tell him what to do at a glance, where he has to make a change, and he makes it mechanically, without reference to formulæ, logarithms, or anything else but the plain practical table that the expert has provided for his use.

That the gunner as well as the machinist should know how to use his tools goes without saying. He should know all about a vernier, and be so perfected in its use by practice as to read it at a glance, or set it absolutely every time; that is one tool by which he lays off the elevation he has obtained by reference to the tables which are among his other tools.

A word as to elevations. Should they not be in yards instead of degrees? An elevation of 3° 29′ conveys no impression as to distance. If the small arms and navy guns can be graduated to yards of range why cannot our heavy guns? Certainly our ballistic experts can work them out for us, and give us a positive sight upon which yards can be laid off as well as degrees and minutes.

I think then that the ballistic expert should be the one to provide the tools. and the gunners be taught their practical use. Time is saved thereby; all computation except those of the simplest nature are avoided and better results become possible, than by theoretical instruction looking to the use of formulæ that even experts stumble over sometimes in the quiet of peace practice, to say nothing of what they might do under fire and in the confusion of battle.

I object to the scheme of theoretical instruction on another ground, and that is the spirit of pedantry and pedagogy that it would be bound to foster. We are scientific enough now in certain ways, and need to become somewhat more practical instead of more scientific. The science of our art should be developed and worked out while we are in garrison at peace; be put to practical proof at the same time, and the results be put in such shape as to be practically useful in war, allowing us then to lay aside formulæ and to roll up our sleeves and go to work. Whistler's tables are a move in the right direction. His scheme should be worked out to its logical end for any gun we are to have in service, and his, or similar tables be provided that can be used by any one without any science except the "rule of three," and accurate observation of the tools of our trade being necessary. We then can learn to shoot somewhat in the same manner as the sharpshooter with his hand rifle, or the field-battery with its field-guns, with the advantage over both that science has foreseen the difficulties to be met, and has provided the corrections therefor in advance, as aids and assistants to experience and memory that now are the main reliance of the sharpshooter and field-artillery.

I heartily agree with Captain Chester that studies of drill should be practical and not by recitation. I have seen the men who made the best of recitations, who could memorize everything in the lesson, fail most ignominiously at practical drill; while the best drill master made the worst recitation. I would also give the non-commissioned officers practical work in plenty at all times at the gun and in manœuvers to teach them responsibility, independence and the value of their positions; but I do not believe that a battery commander can divide up his battery into platoons, sections or detachments, and turn them over to lieutenants or sergeants for discipline. They may be so divided for instruction, but for discipline the battery commander should be alone responsible as the one head of the organization I have seen this tried. and the organization was about the worst in the command and the method had to be abandoned.

Is it too much to say that practical soldiers are what we need, and not "book sharps" or mathematical experts? Do our men enlist to become the former or the latter? Can they be induced to stay even for larger pay, when they find that they are to be forced into unfamiliar paths of knowledge, or will they "take their time" and re-enlist in some less scientific but more practical branch of the service?

First Lieutenant *E. A. Millar*, 3rd Artillery.—Among the many suggestions in Captain Chester's article on the "Theoretical Instruction of Gunners," the following have impressed themselves upon me during an experience of eight months in instructing the enlisted mens' division of the Artillery School.

First.—That those instructed in the subjects required of the artillerists and gunners should start with a fair common school education, preparing the candidate if necessary at the post school.

Second.—That the instruction should be for a short time each day, four times a week.

Third.—That the instruction should be oral with the instruments described, and blackboard illustration.

Fourth.—The need of frequent examinations. Basing calculations on the twenty-six corporals and ten privates who have been under my observation, I consider that as far as capability is concerned, eleven per cent. could learn and would take great interest in the subjects required in the artillerist's curriculum. That thirty-six per cent., including those just mentioned could learn the gunners' curriculum, and fifty per cent. if an intelligent use of tables previously calculated were required, instead of the calculation using ballistic formulæ.

It is to be hoped that some suitable compensation and some such uniform courses of instruction as suggested by Captain Chester, suited to men of different mental capacity, will soon be required throughout the artillery.

Captain *Charles Morris*, 5th Artillery.—I think that the subjects we essay to teach our artillerymen are unnecessarily numerous. The tendency is to overdo the thing; the result will be failure. The secret of success lies in the correct conception of what constitutes efficiency; but unfortunately no two standards of proficiency or no two methods of attaining desired proficiency are the same. Hence, our system—of theoretical instruction in particular—lacks the inestimable merit of uniformity. And so long as we pursue a course of theoretical instruction, burdened as it is with its multifarious exactions, it is difficult to even conjecture how we can obviate the unfortunate absence of desired uniformity in our work and in our results.

The futile endeavor to inculcate scientific thought and reasoning in the untutored minds of our cannoneers is a sheer waste of valuable time, that might otherwise be profitably employed. The study and application of scientific principles in artillery affairs, is an occupation advantageously and successfully pursued by artillery officers, as such. But in the artillery service of to-day, each one has his circumscribed and legitimate sphere of usefulness, within the limits of which he is useful indeed, and beyond which he is less so. The carpenter's "helper" is surely not the carpenter, neither is the carpenter the builder, nor is the builder the architect, and yet the fruits of their united labors are made manifest in the perfected structure. So may it be with artillery work and artillery results.

A dangerous tendency of our prevailing instruction is the apparent assumption that artillery officers are to be invariably absent, and that their duties are to devolve entirely on enlisted men. Absenteeism is the bane of our artillery service of to-day ; has been so in the past—disastrously so in time of war—and will be so in the future if methods be adopted that encourage it.

Desirable efficiency in our heavy artillery service demands that at least two officers and seventy-five, not twenty-five, per cent. of the enlisted men of a battery should be present with it at each and every artillery exercise. Some writers on artillery instruction seem to contemplate such an abnormal condition, but indeed it is far more fanciful than real. Nevertheless, we should individually or collectively, contend for that that we regard to be essential to the accomplishment of desired results, disregarding existing adverse conditions of service that may now render such endeavors ineffectual. And to obtain such results we should strive to harmonize conflicting opinions held among ourselves, so that our work may be wisely systematized and conscientiously conducted under our adopted uniformity of action which, to render its potency complete, should prevail throughout the artillery branch of service.

In the matter of theoretical instruction of artillery gunners, the use of "Whistler's Graphic Chart" is of inestimable value to all concerned. It is as unique as it is comprehensive. Its merit lies chiefly in its simplicity. It is as accurate as is the gun itself, and far more so than any hasty mathematical calculations made on the spot. It effectually quiets many conflicting opinions regarding the theoretical instruction of gunners, and as such, is a boon that requires only to be utilized to be appreciated.

A conspicuous evil of our present methods of artillery instruction is that we recognize the battery organization as such, when in truth we should ignore it and work together as a corps. This evil is apparent at every artillery post where such methods are practiced. Battery competitions as such, are at once the natural enemies to corps work, for the reason that battery success, competitively considered, is directly dependent on individual battery endeavor. The instruction and proficiency of our gunners should be confined strictly to the requirements of defense of our artillery posts, and to the performance of strictly artillery duties thereat. Artillery troops should not be stationed at posts where artillery duties, pure and simple, cannot be the artilleryman's chief, if not his only occupation.

The study of "Luce's Seamanship" should, so far as it may apply to artillery matters, be pursued in our artillery service. The instant recognition of every type of vessel and the knowledge of every nation's distinguishing flag, is of paramount importance in the conduct of coast artillery exercises.

Selected artillery gunners of sufficient intelligence to qualify them for the duty, and in numbers best suited to meet the needs of artillery service, should undergo a course of instruction in the shops of our army arsenals ; upon the completion of which course they should be sent back to such artillery stations as might be thought proper. As the artillery through the contribution of its lieutenants, unstintingly bestows upon the ordnance what the ordnance regards as the artillery's best young blood that is eligible to transfer to it, the ordnance can do no less, perchance, than gracefully observe a merited reciprocative inclination to serve the artillery, if even in a small way.

May we hope that the artillery gunner's efficiency may be accomplished through the attainment of a proficiency, wisely graded to render his service most valuable and attaining that end at the expense of those multifarious "post details" that are the bane of our service in their positive antagonism to artillery efficiency, but which, may we trust, will vanish before the onward advancement of those unmistakable necessities that must render the future occupation of the typical artilleryman at once unique and incontestable.

Captain *James Chester*, 3rd Artillery.—I am gratified at the general tone of comment on "The Theoretical Instruction of Gunners," although somewhat sorry that the consensus of opinion is so unmistakeably against instruction in ballistics. The appearance of Captain Ingalls' Handbook seemed to open the door into a new field, and the writer made an honest effort to give his non-commissioned officers the benefit of it. The effort was successful, and the methods pursued were laid before his brother officers in the paper under discussion. It is no fine-spun theory of what might be done, but a plain statement of what was actually accomplished.

No doubt the mental capacity of artillery recruits is, or perhaps I ought to say, is assumed to be somewhat narrow. But what efforts are ever made to ascertain its extent or even its existence? If Dr. Johnson had enlisted in the United States Artillery, assuming that it was possible for him to do so, his slovenly habits and bad temper would have consigned him to the rear rank or the guard-house during his enlistment. All recruits are awkward at first, and if they are "ugly" as well as awkward, no amount of mental capacity will float them. The smart man, not the intellectual one is selected for corporal, and Ingalls' ballistic tables become as impossible as Greek. But that proves nothing, except the truth of the old saying that "the handsome man is never burdened with brains." I venture to say that if mental capacity were earnestly looked for it would be found in sufficient quantities even among artillery recruits. Lieutenant Millar has had considerable experience as an instructor of non-commissioned officers, and he states that thirty-six per cent. of them were competent to take the course prescribed for gunners in the paper under discussion, and that fifty per cent. of them could be taught the use of the tables. Now, shall we grade up to the higher half or level down to the lower?

Of course the theoretical instruction of gunners, as of every other grade in the artillery hierarchy is a peace maneuver, and no new thing in the army. A certain number of months are, by order or regulation devoted to it every year, and the question arises—what is theoretical instruction? Is it merely memorizing the drill-book? I think not, and most of the commentators seem to agree with me. There is something especially attractive in the position of Lieutenant Parkhurst on this question. He says in effect, that theoretical instruction should be practically imparted. I wish we knew how to do it. I have always believed that the years of tutelage are years of apprenticeship, and that observation and experience are better than books. The lieutenant is an apprentice to the art of command, in addition to all the specialties of his arm of the service. The sergeant must acquire the power of control, and so much of the artillerist's art as pertains to his grade, and so on. The question is, how can it best be done? Can it be accomplished by means of recitations from a text-book?

The ingenuity of Lieutenant Whistler has produced a graphic method of solving problems in ballistics, which, as he claims, is simpler than Captain Ingalls' method. If that be so, he has laid the artillery, and especially the artillery non-commissioned officer under great obligations. The best and simplest method will certainly be adopted in the end.

A STUDY OF THE EFFECTS OF SMOKELESS POWDER IN A 57$^{MM.}$ GUN.

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The advent of the new explosives classed generally as smokeless powders, has enabled the artillerist to greatly increase the velocity of existing guns, and to obtain with specially designed pieces, velocities unthought of a few years ago. These results are obtained without exceeding the maximum pressures heretofore observed with the black and brown powders. It is evident, however, that the pressure curves have greatly changed in form. Here arises a question of the greatest importance, for we may be endangering the chase of a gun, whilst the crusher gauge at the breech is indicating very moderate pressures. Until, therefore, we have some idea of the law of the pressures in the bore, we are in doubt as to the extent to which we may utilize the possibilities of the smokeless powder in existing ordnance, and as to the profile we should give to the chase of a new gun.

The present tendency of artillery seems to be towards extremely long guns, and while a piece of thirty-five calibres length of bore was not long since considered remarkable, we now see guns of forty-five and even fifty calibres. A knowledge of the law of development of velocity in the bore is necessary to form a judgment of where it is advisable to limit this length.

The experiments about to be described were undertaken with a view of throwing some light on these questions. They consisted in cutting successive lengths from the chase of a 57 mm. gun, and observing the velocities of a series of rounds fired with each resulting travel of projectiles. Subsequently a similar gun was lengthened to fifty calibres travel, and from the firings with this piece another point on the velocity curve was obtained.

From the velocities observed for each length of bore, an empirical formula for the velocity as a function of space was deduced by the method of least squares. From this formula an expression for the corresponding pressure in the bore was obtained by differentiation.

In a previous paper* attention was called to two objections which might be raised to this method of experimenting:

First.—The velocities at the different points of the bore are not determined from the same round, but from several rounds fired under conditions which it is impossible to make absolutely identical.

Second.—The initial velocity is not obtained directly from the firings, but is computed from velocities observed at a considerable distance from the muzzle. This is the greatest cause of error, for it is known that the maximum velocity occurs not at the muzzle but at a certain distance beyond it, while the usual methods of calculation presuppose its maximum at the moment the projectile leaves the bore. It is probable, however, that the errors resulting from this cause are sensibly proportional to the observed velocities, in which case the form of the velocity curve would be but little affected.

Description of the Material.

GUNS.

Plate I.

The two guns employed in the experiments were all-steel 57 mm. Hotchkiss Rapid Firing Guns. Of these No. 265 was of the standard pattern, and its construction is clearly shown by Fig. 1. It had been fired 73 rounds previous to the experiments, and was in perfect condition. Gun No. 249 was precisely similar in every respect, except that its chase was a few inches longer, to permit screwing on a false muzzle as shown by Fig. 2. The

* *An Experimental Determination of the Velocities and Pressures in the Bore of a 65 mm. Gun*, by Laurence V. Benét, Ph. B. See report of the Chief of Ordnance, U. S. Army, for 1890, Appendix 42.

principal data of the standard gun are as follows:—

Calibre	57	mm.
Area of cross-section of bore	0.2592	dm^2.
Equivalent diameter	0.5745	dm.
Net volume of powder chamber	0.887	dm^3.
Total length of the piece	2480	mm.
Total length of bore	2280	mm.
Length of rifling	1953.5	mm.
Angle of rifling at origin	1°	0′
Angle of rifling at muzzle	6°	0′
Total weight of the piece	360	kilos.

The gun was rifled with an increasing twist, making an angle of 1° 0′ with the axis of the bore at the origin, and of 6° 0′ at 253.5 mm. from the muzzle; for the remaining distance the twist was uniform (6° = 1 turn in 29.9 calibres). The development of the increasing portion was an arc of a circle of 19.523 mm. radius. The profile of the rifling is shown by Fig. 3.

CARRIAGES.

Throughout the firings the guns were mounted on a standard Hotchkiss "non-recoil" mount. This carriage through its elasticity permits the gun to recoil about 20 mm.

PROJECTILES.

Plate I.

The projectiles employed were cast-iron common shell loaded with sand. Their form and dimensions are shown by Fig. 4. The bands were made of solid-drawn and annealed brass tubing; a section of the band on an enlarged scale is shown by Fig. 5.

Weight of loaded shell	2.720 kilos.
Principal radius of gyration	20.8 mm.
Coefficient of form	0.8

CARTRIDGE CASES.

Plate II.

The cartridge cases were for the standard Hotchkiss built-up pattern, and require no special description. Their construction is shown by Fig. 1. When using a crusher gauge a hole is drilled through the head of the cartridge, and counter-bored from the outside to provide a seat for the copper gas-check G.

POWDER.

Two brands of the same type of smokeless powder were employed, both of which were manufactured at the *Poudrerie Nationale de Sevran-Livry*; they were designated as B N 1 and B N 144. These powders are in the form of thin strips, which are scored longitudinally on one side with a series of parallel and very narrow grooves. In color the powder is a yellowish grey, and in texture resembles a fine grained sand-stone. Unfortunately the chemical composition is unknown, and only the following data can be given:

	BN 1.	BN 144.
Length of strips	76 mm.	85 mm.
Distance between scores . . .	1.4 mm.	1.6 mm.
Thickness of strips	0.5 mm.	0.6 mm.
Specific gravity	1.57	1.78

It may be added that B N 1 is the standard smokeless powder for the 57 mm. gun, and that BN 144 was a sample submitted for trial in the same piece, but found too quick.

CONDITIONS OF LOADING.

To form the charge, the strips of powder were made up into compact bundles or fagots of such size as would enter the mouth of the cartridge-case, and secured with twine. The fagots were then placed one above the other in the cartridge, the twine being removed at the moment of insertion. An igniting charge of five grammes of sporting powder contained in a thin muslin bag, was placed over the primer of the cartridge. The charge of B N 1 powder was made up of three fagots of 141 grammes and one of 37 grammes; that of BN 144 was composed of two bundles of 170 grammes and one of 60. The space between the top of the charge and the base of the projectile was filled with felt wads. The elements of loading were as follows:

	BN 1.	BN 144.
Weight of charge	0.460 kilos.	0.400 kilos
Density of loading	0.519	0.451

INSTRUMENTS.

Plate II.

The velocity was measured by means of two chronographs on independent circuits. Of these No. 207 was a Boulengé of the original model; No. 91 a Breger of the latest type. Greater reliance was placed upon the indications of the latter instrument, and a weight of one was given to the readings of No. 207, and of two to those of No. 91.

The pressures were observed by means of a crusher gauge seated in the breech block of the gun, the arrangement of which is shown by Fig. 1. *B* is the anvil which is grooved longitudinally and on its rear face, to allow the air between it and the piston *E* to escape freely through the channel *A*. *C* is the copper cylinder, which is centered by means of the rubber ring *D*. Above the piston is placed the brass gas-check *F*, and the space between this and the face of the breech-block is filled with tallow.

The Firing Record.

The following table gives an abstract of the observations made during the experiments. The initial velocities were computed by means of Tables I and IV of the *Hand Book of Problems in Exterior Ballistics* by Captain James M. Ingalls, U. S. Artillery. The velocities and pressure underscored were thrown out as abnormal, after testing with Chauvenet's criterion.

When the travel of projectile had been reduced to 8.80 dm. the shell tumbled, bringing the experiments to a close. With this final length of bore the angle of rifling at the muzzle was only 3° 23′ 20″, or one turn in 53 calibres. It was due to the lack of stability of the projectile that the second screens were missed in round 39 and the velocity lost.

It may be observed that throughout the experiments the BN 144 powder was fired with the gun clean, and the BN 1 with the bore foul; the fouling of these powders is however almost insignificant.

From the firing records of the two guns, we obtain the following table giving the velocity of the projectile corresponding to each length of travel in the bore.

Velocity in the bore with BN1.	Travel of Shell.		Velocity in the bore with BN144
Metres.	Decimetres.	Calibres.	Metres.
682.1	28.45	49.91	632.8
648.3	20.20	35.44	600.7
636.5	17.92	31.44	591.0
622.3	15.64	27.44	573.5
612.6	13.93	24.44	565.0
595.0	12.22	21.44	553.1
574.4	10.51	18.44	534.9
543.1	8.80	15.44	503.7

Taking the means of the observations we find the maximum pressures at the breech to have been:

BN 1 powder, $P_0 = 2547$ kilos. per cm.^{2}.
BN 144 powder, $P_0 = 2543$ kilos. per cm.^{2}.

Empirical Formulæ.

We shall adopt the following notation:

V = The velocity at any point of the bore in metres per second.

α = The acceleration of velocity at the same point in metres per second.

P = The pressure at the same point in kilos. per cm^2.

μ = The travel of the projectile corresponding to V in dm.

S = The volume of the powder chamber in dm^3.

a = The area of the cross-section of the bore in dm^2.

p = The weight of the projectile in kilo-grammes.

$\bar{\omega}$ = The weight of the charge in kilo-grammes.

FIRING RECORD OF 57mm. HOTCHKISS RAPID FIRING GUN No. 265.

PROJECTILE—COMMON SHELL OF 2.720 KILOS.

PROJECTILE—COMMON SHELL OF 2.720 KILOS.

Number of Rounds.	Date.	Barom.	Therm.	Nature of Powder.	Weight of Charge.	Travel of Shell.		Pres're at the Breech.	Range at which Velocity was observed.	Observed Velocity.		Mean Instrumental Velocity.	Initial Velocity
						Decimetres.	Calibres.			Chronograph No. 207.	Chronograph No. 91.		
		mm.	C		Kilos.			Kilos.	Metres.	Metres.	Metres.	Metres	Metres
1	1891 Sept. 5	765.2	18.0	BN144	0.400	28.45	49.91	2433	39.635	. . .	625.0	625.0	632.8
2	"	"	"	BN1	0.460	"	"	2476	"	668.4	671.7		
3	"	"	"	"	0.460	"	"	2506	"	679.0	674.2	673.7	682.1
4	"	"	"	"	0-460	"	"	2480	"	672.1	676.2		

g = The acceleration of gravity = 98.051 dm. per second.

M = The modulus of the common system of logarithms = 0.43429.

It was sought to deduce an empirical formula which would best express V as a function of μ in accordance with the results obtained with BN1 powder. In the following table are shown the different formulae assumed, both in their general forms, and with the most probable values of the constants as determined by the method of least squares. In the fourth column of the table is given the probable difference between an observed and a computed velocity.

The following formula for the velocity as a function of the travel of projectile was adopted, as giving the closest agreement with the results of the firings:—

$$V = N\, 10^{-0.6723 \left(\frac{S}{S + a\mu}\right)^{\frac{5}{4}}} \quad \ldots \ldots \ldots \ldots (1)$$

For BN1 powder

$$N = 747.64.$$

To find the pressure on the base of the projectile we proceed as follows:

Noting the fundamental expressions

$$\alpha = \frac{V\,d\,V}{d\,\mu} \;\ldots\; (2) \text{ and } P = \frac{p\,\alpha}{a\,g} \quad \ldots \ldots \ldots (3)$$

let

$$A = -0.6723 \left(\frac{S}{S + a\mu}\right)^{\frac{5}{4}} \quad \ldots \ldots \ldots \ldots (4)$$

whence from (1)

$$V = N\, 10^{A},$$

or

$$\log V = \log N + A.$$

Differentiating

$$d\,V = \frac{V\,d\,A}{M} \quad \ldots \ldots \ldots \ldots (5)$$

Differentiating (4) and reducing, we have

$$d\,A = 0.8404\, \frac{S^{\frac{5}{4}}\, a\, d\,\mu}{(S + a\mu)^{\frac{9}{4}}} \quad \ldots \ldots \ldots \ldots (6)$$

Substituting (6) in (5) and multiplying by $\frac{V}{d\mu}$, we have

$$a = \frac{V\,d\,V}{d\,\mu} = 0.8404\,\frac{V^2 S^{\frac{5}{4}} a}{M(S + a\,\mu)^{\frac{9}{4}}} \quad \ldots\ldots \quad (7)^*$$

Substituting (7) in (3)

$$P = \frac{p\,a}{a\,g} = 0.8404\,\frac{S^{\frac{5}{4}} p}{M\,g}\,\frac{V^2}{(S + a\,\mu)^{\frac{9}{4}}} \quad \ldots\ldots \quad (7)'$$

Letting

$$K = 0.8404\,\frac{S^{\frac{5}{4}} p}{M\,g} \quad \ldots\ldots \quad (8)$$

we have finally

$$P = K\,\frac{V^2}{(S + a\,\mu)^{\frac{9}{4}}} \quad \ldots\ldots \quad (9)$$

For the 57 mm. gun

$$\log K = \bar{2}.66473.$$

Applying formulæ (1) and (9) we obtain the following table of velocities, with the corresponding pressures on the base of the projectile for the BN1 powder:—

Travel of Shell.	Velocities.		Differences.	Pressures.
	Observed.	Computed.		
dm.	metres.	metres.	metres.	kilos.
28.45	682.1	679.9	—2.2	185
20.20	648.3	651.0	2.7	332
17.92	636.5	639.0	2.5	402
15.64	622.3	623.9	1.6	494
13.93	612.6	610.0	—2.6	585
12.22	595.0	593.1	—1.9	697
10.51	574.4	572.1	—2.3	841
8.80	543.1	545.5	2.4	1051

The agreement between the observed and computed velocities is very satisfactory, the greatest difference being less than one-half of one per cent. of the quantities considered; moreover, the differences follow no apparent law.

* As V is expressed in metres, and the remaining quantities in decimetres, to obtain a in metres we must multiply (7) by 10; this operation is performed in (7)' by expressing a and g in decimetres This avoids any confusion of units in the formulæ.

Number	Remarks.
1	
2	u's monomial formula.
3	u's binomial formula.
4	's or Gâvre formula.
5	curve expressed by this form- has a point of inflection at $\mu = 25.58$ dm.
6	
7	
8	
9	ula adopted.
10	

The pressures given above are those necessary to produce the acceleration of velocity of translation of the projectile ; they may however, be taken to represent the corresponding pressures in the bore without sensible error. In the previous paper already referred to, a method was given for computing the pressure necessary to produce the acceleration of velocity of rotation of the projectile, and it was shown that this pressure might be neglected. As to the pressure necessary to overcome the passive resistances, there is every reason for believing that it is much smaller still.

Verification of the Formulæ.

Let us now apply the formulæ to the results obtained with the BN144 powder. Substituting in (1) the corresponding values of μ and V for each round, we obtain a series of values of N. Taking the mean of these quantities we find

$$N = 692.98.$$

As in the case of BN1 powder

$$\log K = \bar{2}.66473.$$

Applying now formulæ (1) and (9) we may compute the following table of velocities and pressures in the bore :—

Travel of Shell.	Velocities		Differences.	Pressures.
	Observed.	Computed.		
dm.	metres.	metres.	metres.	kilos.
28.45	632.8	630.1	−2.7	159
20.20	600.7	603.5	2.8	285
17.92	591.0	592.3	1.3	345
15.64	573.5	578.3	4.8	425
13.93	565.0	565.4	0.4	503
12.22	553.1	549.7	−3.4	599
10.51	534.9	530.2	−4.7	723
8.80	503.7	505.6	1.9	882

The differences between the observed and computed velocities are in no case as great as one per cent. of the quantities considered, and do not vary among themselves according to any law. The verification in the case of BN 144 powder may therefore be considered quite satisfactory, especially as only one round was fired with this powder for each travel of projectile.

In some firings with smokeless powder in a 10 cm. Hotchkiss Rapid Firing Gun, the pressure was measured at 40 mm. from the muzzle by means of a special form of crusher gauge. The data of the 10 cm. gun are as follows:—

$\mu = 35.15$ dm. $a = 0.80035$ dm^2.

$S = 6.0093$ dm^3. $p = 15.000$ kilos.

The following are the results of five rounds fired under similar conditions:—

Initial velocity . . . . 674.8 metres.
Pressure at the breech . . . . . . 2357 kilos per cm^2.
Pressure 40 mm. from the muzzle . 451 kilos per cm^2.

Substituting the observed velocity in (1), we find

$$N = 805.05,$$

making

$$\mu = 35.15 - 0.40 = 34.75,$$

we find for the point at which the pressure was observed:—

$$V = 673.4 \text{ metres.}$$

Substituting known quantities in (8) we have

$$\log K = 0.44488.$$

Now applying (9) we find

$$P = 458 \text{ kilos. per cm}^2.$$

The difference between the observed and the computed pressure is insignificant.

Had we performed the above calculation in the reverse order, that is assumed $P = 451$ kilos., substituted in (9) and found N from the resulting value of V, we should have obtained from (1)

Initial velocity = 669.8 metres,

the difference between the observed and the computed velocity being less than one per cent.

While it is regretted that no further verification of the formulæ has been possible, these last results seem to warrant us in employing them with a certain degree of confidence.

Comparison of the Effects of Black, Brown and Smokeless Powders.

The 57 mm. Hotchkiss Rapid Firing Gun was originally designed for black powder, and for many years the French C2 was exclusively employed. On the appearance of the brown or cocoa powders, a special brand of this type designated as Brown C2 was developed for the gun at Sevran-Livry. A further advance has now been made in the adoption of the BN1, and it will be of interest to compare the effects of these three natures of powder.

The results obtained in the standard gun are as follows:—

		C2	Brown C2	BN1
Weight of charge	$\tilde{\omega}$ =	0.885	0.920	0.460
Weight of shell	p =	2.720	2.720	2.720
Initial velocity	V_0 =	553.0	600.0	651.0
Pressure at the breech	P_0 =	2550	2550	2550

It may be noted that each change of powder has given an increase of velocity of about 50 metres; similar results have been observed in all Hotchkiss guns, and the employment of a suitable powder of the BN class may be roughly estimated to give 100 metres velocity above that obtained with the standard black powder, the maximum pressure being the same.

To compute the velocities and pressures in the bore with C2 and brown C2 powder, we shall employ Hélie's well known formula. This may be written as follows:—

$$V = N\,10^{-0.6}\left(\frac{S}{S+a\mu}\right)^{\frac{1}{2}} \quad \ldots \ldots \ldots \ldots (10)$$

and by differentation we obtain

$$P = K'\frac{V^2}{(S+a\mu)^{\frac{3}{2}}} \quad \ldots \ldots \ldots \ldots (11)$$

wherein

$$K' = 0.3\,\frac{pS^{\frac{1}{2}}}{Mg} \quad \ldots \ldots \ldots \ldots (12)$$

That the above formulæ are perfectly trustworthy for the black powders is well known, and in a previous paper we have shown that they may be relied upon in the case of the brown C2 as well.

Entering (10) and (12) with the data of the 57 mm. gun, and the velocities obtained with the black and the brown powders we find

For black C2 $N = 935.6$
For brown C2 $N = 1015.1$

$\log K' = 2.25642,$

whence we are able to compute the following table :—

TRAVEL OF SHELL.	Charge $0.^K 885$ C2.		Charge $0.^K 920$ Brown C2.		Charge $0.^K 460$ BN 1.	
	Velocity.	Pressure.	Velocity.	Pressure.	Velocity.	Pressure.
dm.	metres.	kilos.	metres.	kilos.	metres.	kilos.
28.45	595.0	269	645.6	317	679.9	185
20.20	553.0	364	600.0	429	651.0	332
17.92	538.1	402	583.8	473	639.0	402
15.64	521.1	446	565.3	525	623.9	494
13.93	506.6	486	549.6	572	610.0	585
12.22	490.3	532	532.0	626	593.1	697
10.51	471.8	585	511.9	689	572.1	841
8.80	450.4	649	488.7	764	545.1	1051

The above results are shown graphically on Plate III, the velocities observed in the experiments being designated by the small circles. It will be observed that the curve of pressures for the BN1 powder crosses and falls below the curves for both the brown and the black C2. This result was not at all anticipated, and is contrary to the generally entertained opinions regarding the pressures developed by the new powders. A little reflection will, we think, explain the result. In the case of the black and the brown powders, the products of the explosion are partly gaseous and partly liquid, and at the moment of explosion they have the same temperature. As the gas expands with the movement of the projectile, a loss of heat occurs due to the work done upon the projectile, and to the cooling effects of the walls of the gun. The liquid portion of the products of the explosion constitutes a reserve supply of heat, and tends to compensate for these losses, and to keep the temperature of the gases sensibly constant during their expansion. In the case of the smokeless powders, it is generally admitted that the products of the explosion are purely gaseous; hence, the loss of heat during expansion must be much greater than in the case of the older explosives.

When the maximum pressure at the breech is the same, the weight of the charge of smokeless powder is about one-half the weight of charge employed with the black and brown, so that in the former case we have about the same cooling influences acting upon one-half the mass of gas. It is clear, therefore, that the absolute cooling effect must be much greater in the case of the new powders.

While it is not intended to offer any theories concerning the form of the velocity and pressure curves beyond the limits of the experiments, it may be remarked that the smokeless powders evidently produce their great ballistic effects more by a long sustained period of maximum pressure, than by an approach to a uniform pressure along the bore. This result is of great practical value, as it will appear that in general all existing guns may employ with perfect safety maximum charges of the BN powders. It is more than probable that the same will hold true for the other varieties of smokeless powders as well.

Having examined the effects of the three service charges in the standard gun, it will be interesting to see what would be the result of giving each charge the same number of expansions. The following table is readily computed by means of the foregoing formulæ.

Number of Expansions.	Charge $0.^K885$ Bl'k C2.			Charge $0.^K920$ Br'n C2.			Charge $0.^K460$ BN1.		
	μ	V	P	μ	V	P	μ	V	P
	dm.	metres.	kilos.	dm.	metres.	kilos.	dm.	metres.	kilos.
17.959	57.896	675.1	130	60.321	737.0	146	28.45	679.9	185
13.310	42.023	640.4	183	43.820	699.0	206	20.20	651.0	332
12.026	37.639	627.9	205	39.263	686.5	231	17.92	639.0	402
10.741	33.252	613.5	232	34.701	671.1	262	15.64	623.9	494
9.778	29.963	601.2	256	31.284	657.8	289	13.93	610.0	585
8.814	26.764	587.6	285	27.862	642.8	323	12.22	593.1	697
7.850	23.381	571.1	321	24.441	625.5	364	10.51	572.1	841
6.887	20.093	552.3	366	21.022	605.2	415	8.80	545.5	1051

From the table we see that for equal expansions the BN1 powder gives higher pressures than either of the others, velocities sensibly equal to those of the black, but considerably lower than those of the brown powder. The conclusion to be drawn from these results is that the *raison d'être* for very long guns existed to a greater extent in the days of black, and especially brown powders than it does now. That is, if a given gun be lengthened, say

10 calibres, the gain in velocity may be expected to be greater if we employ black or brown powder, than if we use one of the new explosives of which BN1 is a type.

Let us finally compare the effects of equal charges of black, brown and BN1 powder in the 57 mm. gun. From Sarrau we know that in the case of the former powders, V varies as $\bar{\omega}^{\frac{1}{4}}$, hence 0.K460 of C2 and brown C2 would give respectively in the standard gun

$$V = 375.4 \quad \text{and} \quad V = 389.1,$$

and we would obtain the results shown by the following table. It may be noted that the three charges being equal, the number of expansions will be equal for like travels of projectile.

Travel of Shell.	0.K460 Black C2.		0.K460 Brown C2.		0.K460 BN1.	
	Velocity.	Pressure.	Velocity.	Pressure.	Velocity.	Pressure.
	metres.	kilos.	metres.	kilos.	metres.	kilos.
28.45	403.9	124	418.6	133	679.9	185
20.20	375.4	168	389.1	180	651.0	332
17.92	365 3	185	378.6	199	639.0	402
15.64	353.7	206	366.6	221	623.9	494
13.93	343.9	224	356.4	241	610.0	585
12.22	332.8	245	345.0	263	593.1	697
10.51	320.3	270	331.9	290	572.1	841
8.80	305.7	299	316.9	321	545.5	1051

The above table brings out strongly the superior ballistic effects of the BN1 powder, but it should be observed that with a slightly longer gun the brown powder would give a higher pressure at the muzzle. This is evidently due to the cooling effects as already noted, and because the BN1 powder has done more work on the projectile than has either of the others.

In the 57 mm. gun we have observed that the BN1 powder gave lower pressure at the muzzle, than either the brown or black C2 when firing full charges. This is of course only a special case, and it should be noted that the 57 mm. gun has a relatively small chamber and great travel of projectile. Let us now examine the effects in the 10 cm. Hotchkiss gun, the data of which have already been given.

Brown powder has never been employed with this gun, but the service charge of black SP2 is 5.K500, and gives to the 15 kilos.

projectile a velocity 571.3 metres, with a maximum pressure at the breech of 2510 kilos. The following are the velocities at 40 mm. from the muzzle with black and smokeless powders :—

	Black.	Smokeless.	
$V =$	569.7	673.4	metres.
$P =$	426	457	kilos.

Here the smokeless powder gives a slightly higher pressure than the black, but it is evident that a suitable brown powder would give a higher pressure than either.

The 10 cm. gun is hooped to within 1573 mm. of the muzzle ; at the end of the hooping we find

	Black.	Smokeless.	
$V =$	491.8	588.3	metres.
$P =$	625	962	kilos.

At this point the smokeless powder gives over 50 per cent. more pressure, but the gun, as is generally the case, has been given a greater section along the chase than is necessary to resist the internal pressures in order to assure stiffness, and accuracy of fire, and is amply strong for the increased strain.

The 10 cm. gun has 42 calibers length of bore ; suppose it were proposed to lengthen it to 50 calibres. With smokeless powder we would increase the velocity from 674.8 metres to 698.2 metres, a gain of about 3½ per cent. With SP2 powder the increase would be from 571.3 metres to 599.2 metres, a gain of 5 per cent. As already shown, the increase in velocity is greater with the black than with the smokeless powder, but in neither case does it seem to warrant lengthening the gun.

The above is a good example of a gun with a medium size chamber and travel, firing a relatively heavy projectile. The application of the formulæ to a very long gun, having a large chamber and firing a relatively light projectile gives similar results, and shows higher *muzzle* pressures with brown than with smokeless powders. It also appears that some of the new guns have been given lengths of bore which do not appear to be warranted by the gain in velocity. The inconvenience of very long guns, both ashore and afloat hardly needs to be mentioned, and it is evident that an increase in length which does not give a very considerable gain in effect at the fighting ranges is inadmissible.

Formulæ for English Units.

Let

V = The velocity at any point of the bore in feet per second.

P = The pressure at the same point in tons (2240 lbs) per square inch.

μ = The travel of the projectile in inches.

S = The volume of the powder chamber in cubic inches.

a = The area of the cross section of the bore in square inches.

p = The weight of the projectile in pounds.

g = The acceleration of gravity = 32.16 feet per second.

M = The modulus for the common system of logarithms = 0.43429.

Formulæ (1), (10), (9) and (11) do not change, but (8) and (12) require modification in the numerical co-efficient.

For BN powder we shall have

$$V = N\,10^{-0.6723\left(\frac{S}{S+a\mu}\right)^{\frac{5}{4}}} \quad \ldots\ldots\ldots\ldots (1)$$

$$P = K\frac{V^2}{(S+a\mu)^{\frac{9}{4}}} \quad \ldots\ldots\ldots\ldots (9)$$

$$K = 0.0045\frac{S^{\frac{5}{4}}p}{Mg} \quad \ldots\ldots\ldots\ldots (13)$$

For black and brown powders

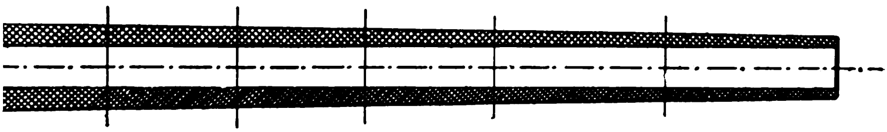
$$V = N\,10^{-0.6\left(\frac{S}{S+a\mu}\right)^{\frac{1}{2}}} \quad \ldots\ldots\ldots\ldots (10)$$

$$P = K\frac{V^2}{(S+a\mu)^{\frac{8}{2}}} \quad \ldots\ldots\ldots\ldots (11)$$

$$K = 0.001607\frac{S^{\frac{1}{2}}p}{Mg} \quad \ldots\ldots\ldots\ldots (14)$$

Conclusion.

While the formulæ we have deduced will not enable us to compute the velocities and pressures for the full length of the bore, they may be employed with a certain degree of confidence for calculating the velocities and pressures along the chase. This portion of the pressure and velocity curve is the most interesting in studying the adaptability of existing ordnance to the new pow-



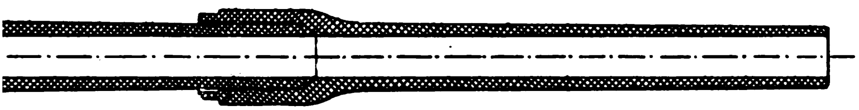
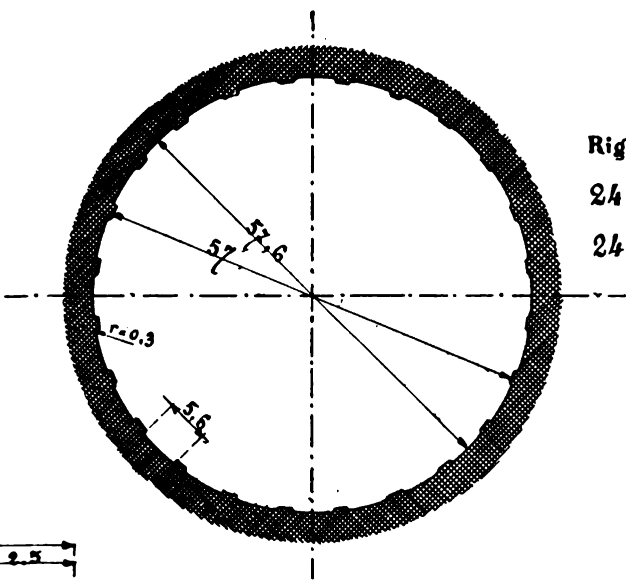


Fig. 3.

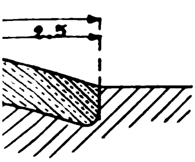


RIFLING.

Right hand twist.

24 Grooves.

24 Lands.



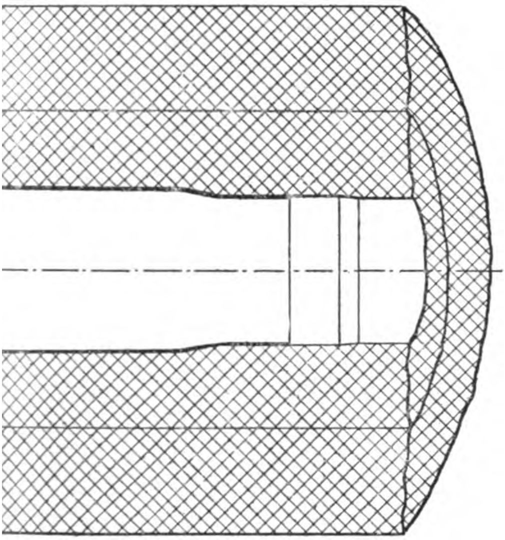
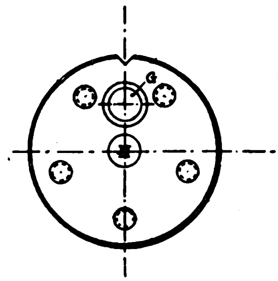
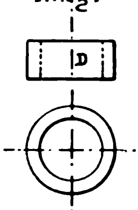


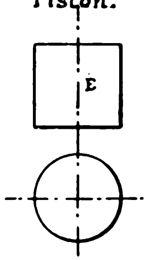
Fig. 2.



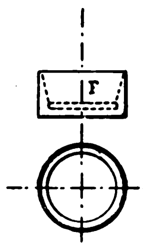
Rubber Ring.

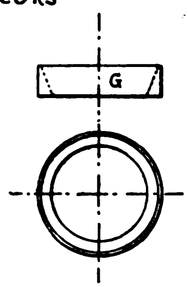


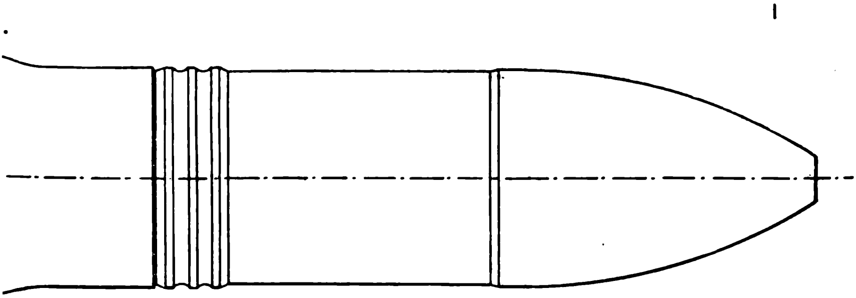
Piston.

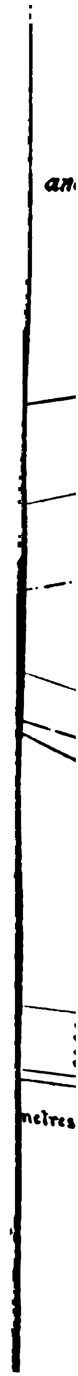


Gas - checks



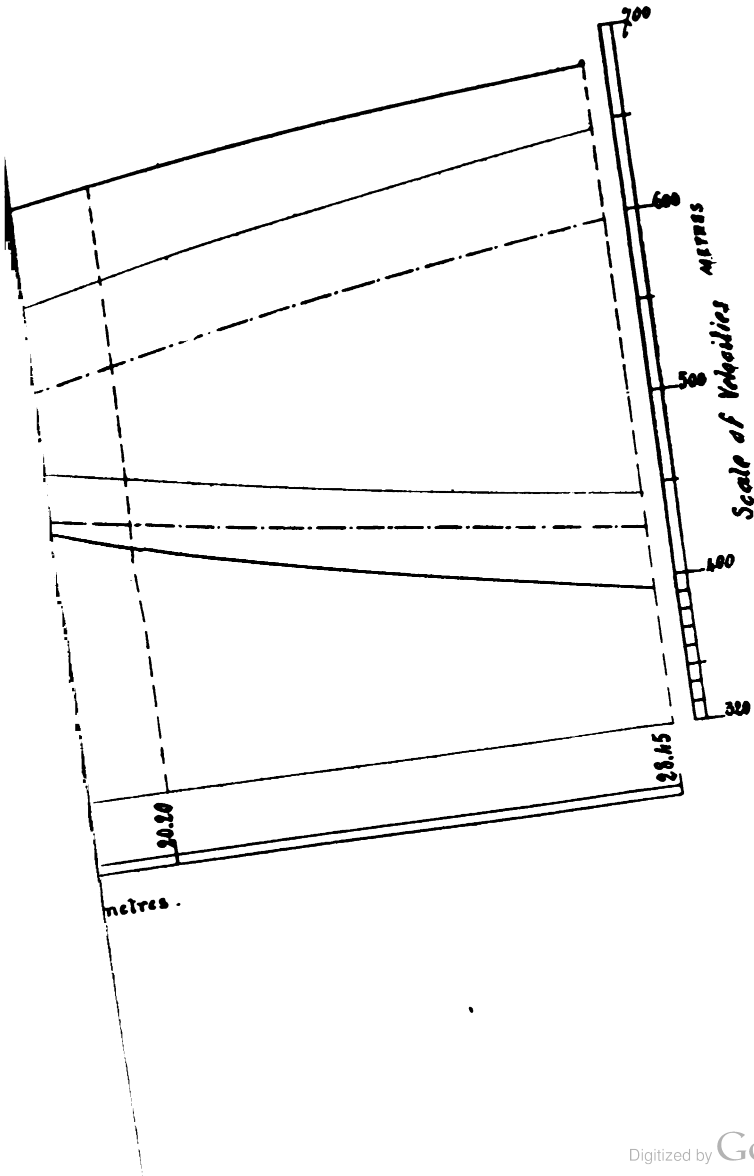






...and Pressure.

Plate III.



ders, or in the design of a new gun. By adding a second term to the velocity formulæ as indicated in a previous paper, it may be employed in the computations relating to hydraulic recoil checks for gun-carriages.

We find in general that with existing guns, the BN powders give lower muzzle pressures than do the brown powders, and most existing ordnance may employ with safety charges of BN, giving the same pressure at the breech as the service charge of brown powder.

We also learn that if a given gun be increased in length beyond a certain point, this increase will give a greater gain in velocity with the old powders than with the new. Finally, we see that by changing from the older powders to the new in a given gun, we have the choice of the following:—

First.—We may maintain the same maximum pressure, and obtain a large increase in velocity, while reducing the weight of the powder charge by about fifty per cent.

Second.—We may maintain our present velocity and reduce greatly the maximum pressure, and consequently the strain on gun and carriage. The weight of the charge will be still more reduced in this case.

Third.—We may maintain our present velocity and maximum pressure and shorten our gun very considerably, at the same time reducing the weight of our powder charge by almost one-half.

An innumerable number of combinations may be made between the variables at our disposal, and our choice must be guided by the work our gun will be called upon to perform.

DEPARTMENT OF CHEMISTRY AND EXPLOSIVES, U. S. ARTILLERY SCHOOL.

By First Lieutenant WILLOUGHBY WALKE, Fifth Artillery, U. S. A.

Previous to 1888, when the course of instruction at the U. S. Artillery School was reorganized and rearranged, comparatively little attention was devoted to practical instruction in the applied sciences.

The so-called chemical and electrical laboratories were little better than nothing at all, while the courses of instruction in these departments embraced five lectures and five days of laboratory work in each.

The object of this sketch is to outline the development of the Department of Chemistry and Explosives during the past four years, and to give some idea of the present course of instruction, together with the facilities afforded by the new laboratory for original research and investigation.

According to the programme of instruction published April 23, 1889, the department was designated as the Department of Chemistry and High Explosives, and the course of instruction was divided as follows:

CHEMISTRY.

Time required: 7¼ weeks, a.m. and p.m. hours.
Second year, December 1—January 31.

Lectures. — Chemical philosophy, qualitative and quantitative analysis; laboratory apparatus, description and use. (5 lectures.)

Laboratory work.—Analysis of crude sulphur, crude nitre, and gunpowder.

Densimetry.—Theory and use of the densimeter.

All student-officers, in groups of five to laboratory work as above.

Advanced course in Laboratory.—Analysis of iron ores; commercial tests for iron and steel; (and optionally of ores of copper and lead.)

The advanced course only for six student-officers of greatest aptitude in preceding laboratory work.

HIGH EXPLOSIVES.

Time required, 6 weeks:

Second year, February 1—February 28, a.m. and p.m. hours.
March 1—March 14, a.m. hours.

Lectures.—(I) Chemistry of bodies entering into the manufacture of high explosives (2); nitro-glycerine, manufacture, chemical and physical properties (3); the various high explosives prepared with nitro-glycerine, their properties, etc. (3); other varieties of high explosives (3); force and effect of explosive bodies (1); directions for manipulating and using explosives (2); application of explosives to military purposes (1); in all 15 lectures.

Laboratory work.—Analysis of bodies entering high explosives, and the manufacture of some type of explosive on a small scale. Student-officers in groups of four to four days' work.

Experimental work.—With high explosives, all student-officers working 12 days.

In submitting this project, three all-important factors had to be considered.

First, the brief time allotted to the course of instruction;

Second, the laboratory and its equipment; and

Third, the personnel of the class under instruction.

To one who has had any experience in laboratory work, it is hardly necessary to suggest that, in order to undertake the most insignificant investigation, such as a simple qualitative determination, time is necessary; and in proportion to the importance of the investigation and the thoroughness with which it is executed, the importance of the time element is correspondingly increased.

The totally inadequate character of the laboratory and its equipment has been alluded to, and it is not necessary to enter into details at this point.

With regard to the personnel of the class, it is only necessary to to state that in two classes containing 37 officers, only four had had any laboratory training previous to entering upon the course at this school.

The first and third of these conditions still maintain, but fortunately the second no longer presents the almost insurmountable obstacle to proper laboratory instruction. Whereas formerly, in in order to accommodate the class, the officers were grouped into sections and the sections further subdivided so as to provide desk room and apparatus, all such difficulties and drawbacks are now removed, and the newly equipped laboratory can to-day afford facilities for 30 students, working independently of each other and, if necessary, pursuing entirely different lines of investigation. Early in the spring of 1891 the handsome brick building which had previously been used as an arsenal by the Ordnance Department was turned over to the Artillery School for school purposes, and at the same time a sum of $8000 was allotted to fit it up.

The portion of the building assigned as the chemical and explosive laboratory was the extreme north end, and had previously been used as the blacksmithy of the arsenal.

Notwithstanding the accumulated filth of the forges, etc., the section assigned for the laboratory was extremely well adapted to the purposes for which it was intended, and after thoroughly washing, and brooming the rafters, and excavating and removing nearly 3000 loads of coal dust, the work of "fitting up" was begun. The floor (1¼" pine) as it now stands, rests upon joists, 2" × 12", braced diagonally, which are notched into beams, 6" × 12", which in turn rest upon brick pillars, 16" × 16", placed 10' apart from centre to centre. There is an uninterrupted air space beneath the floor of 27 inches, to which fresh air is admitted by means of side-wall ventilators. The current of air is kept in circulation by means of an air-chamber attached to the hood (to be described later), finding an exit through the flues which discharge through the ridge of the building. For a better understanding of the internal arrangement of the laboratory a rough sketch of the ground plan is attached.

Reference to this sketch shows one principal partition extending across the laboratory, 17½ feet from the north end, leaving a general working room $42\frac{1}{2} \times 50$, while a second partition, at right angles to this last and $17\frac{1}{2}$ teet from the west face of the building, gives two rooms, one $17\frac{1}{2} \times 17\frac{1}{2}$ feet, and the other $17\frac{1}{2} \times 32\frac{1}{2}$ feet. The former is the instructor's laboratory and office; the latter the balance and densimeter room.

The entire laboratory is ceiled in yellow pine and oiled, presenting a bright, airy appearance. The pitch of the room is 18 feet.

The small laboratory used by the instructor is absolutely complete in itself, having a small balance and microscope room attached, and being supplied with a large thoroughly appointed desk, with all accessories, such as water, gas, hood, filter pump, etc. The balance and microscope stand in this room, as well as all of the balances and densimeters in the general balance room, are supported by extra heavy brick piers ($16'' \times 16''$) which are built through, and entirely independent of the floor, and rest upon stone slabs, ($36'' \times 36'' \times 4''$), set in cement 18 inches below the surface of the ground. These rooms are fitted with double sashes, heated by steam, and ventilated by means of overhead and side-wall ventilators.

In the general balance room there are eleven independent balance stands, ten for ordinary analytical balances of 100 grammes capacity and sensitive to one milligramme. The extra balance is a very handsome Troemner apparatus, used in determining the gravimetric density of large grained powders, and has a capacity of 100 pounds and answers readily to one grain.

In addition to the balances, this room is furnished with a large DuPont densimeter for the determination of the specific gravity of large grained powders, a Mallet densimeter for similar work with small grained powders, and a Dupont gravimetric balance for the gravimetric determination of cannon and mortar powders. In all of its appointments this room may be considered perfectly equipped.

In "fitting out" and equipping the general laborotory, the special line of work to be pursued therein was particularly considered, and, while in some matters of detail, the arrangement may differ somewhat from that found in general laboratories, still these changes are not material, and in no way interfere with a student, who, having completed the regular course of instruction, may desire to pursue any line of investigation whatever.

The general laboratory is lighted by six large windows (4′ × 12′), and eight desks are arranged, two on either side of a window, while between the desks, and built out from the recessed window, is the sink with its accessories.

By utilizing the window recess in this way, each student gains additional desk room, and the water and gas fixtures, while independent of the desk proper, are most conveniently at hand. The desks have a surface 4′ × 2½′ and are fitted with a double set of drawers and cupboards below. The object of this arrangement is that, as the students attend in two sections which alternate daily, each officer has practically a desk to himself, to which he is assigned, while all unfinished work may be left in his particular cupboard to remain undisturbed until his return. In the same manner two officers are assigned to each balance in the balance room, but, as just explained, neither is ever interrupted by the other during his work. Each desk is completely equipped with the apparatus required for any ordinary chemical investigation, while in the cases distributed around the room is to be found the principal apparatus required for special research.

In addition to the eight desks referred to, there are four others arranged similarly along the southern wall, which separates the laboratory from the machine shops belonging to the Department of Steam and Mechanism. In separating the desks, it was sought to reduce to a minimum the danger inherent to work in explosives of all classes, so that an accident at one desk need not involve in its results the student at the adjoining desk, as would probably be the case, were the desks continuous as is usual in general laboratories. Instead of attaching a filter pump to each desk, it was thought advisable to fit up a separate filter table, where that operation could be conducted, or rather allowed to proceed by itself without interfering with other work which can generally be carried on simultaneously. In short in all of its appointment, an effort was made to arrange and equip the laboratory so as to utilize every possible moment while the class was under instruction. The filter table is equipped with six Chapman pumps which are regulated by valves so arranged that one or all can be used at a time. Another feature introduced on account of the main object of the laboratory investigations—the determination of the properties etc. of various explosives—is a heavy iron anvil (3000 lbs.) resting upon a block of granite which is set in cement and projects through the floor. Upon this anvil is built the percussion gauge, and a piece of apparatus to be used in connection with the Quinan pressure gauge in the determination of the absolute force of explosives.

The hood is constructed so as to afford the greatest facilities to the greatest number of students working together, and at the same time so as not to interfere with the space necessary for lecture purposes. Presenting a working surface of 10'×5', six students can conduct their manipulations without in any way interfering with each other, while an outdoor hood (to be described later) easily accommodates two more students. The principal hood is fitted with an air-chamber which, connected with the air space beneath the floor, causes a continuous current of air to pass through the hood, which serves to rapidly carry off the heaviest, densest fumes.

To utilize as far as possible this invaluable adjunct, the lower part of the hood is also fitted as acid closets which are also connected with the air-chamber, so that all escaping acid fumes also find exit through the flues. The flues, two in number, extend from opposite ends of the roof of the hood (which is a truncated pyramid) upward at an angle of 72°, and unite after a second change of direction (72°) to discharge through the ridge of the building. In all weathers, hoavy storms, hot sultry days, etc., this hood has never failed to work perfectly. Only a few unimportant details of the general laboratory call for passing mention.

The large lecture table fitted with gas, water, etc. can be readily converted into laboratory desks to accommodate at least six additional students, should the emergency arise. The cases containing apparatus and *materiel* are distributed around the room, while small tables are at hand everywhere for taking notes during lectures, or reducing notes during an investigation.

When the work of converting the "blacksmithy" into a laboratory was planned, two additions were to be made to the main building, the first a vestibule, entrance and coat room on the west face; the second was a more extensive wing, on the east face, to contain, first, an independent laboratory to be devoted to gas analysis, and the investigation of especially dangerous explosives, those readily decomposed by the direct rays of sunlight, those evolving fumes readily inflammable, etc.; second, the gas room for the plant required to manufacture gas to be used as fuel, etc. in the laboratory; and lastly a large hallway to be used as the rear entrance to the laboratory, and general wash-room for apparatus, etc. The first room is equipped especially for the object in view.

In addition to an extra large desk extending the entire width of the room, fitted with water, gas, etc., there is an arrangement by means of which distillation, etc. may be carried on with the aid of steam; while a heavy shutter with an adjustable slide can be manipulated so as to admit as much or as little light as may be desired, or to cut it off altogether.

The gas room contains a small plant of the Smith and Goldthorp system. This system of lighting is the same as was introduced at Frankford Arsenal some years ago, and gave such perfect success. It employs partially refined petroleum, which, upon passing through a properly heated retort, is converted into a very permanent highly carburetted gas. In the plant installed at the Artillery School, the supply of oil is poured into a tank contained (as a precaution) in a hood, outside and independent of the building. Thence it is led by a small (¼") pipe into the gas-room and fed into the retort through a trap.

The retort is annular in shape and is contained in a cast-iron generator, which is practically a heavy cast-iron stove. The generator is fired up and as soon as the retort is heated up to a bright "cherry red", the petroleum is "turned on", and upon entering the retort, is immediately converted into gas which passes through a washer (cast-iron box) where it is washed and cooled, and passes thence into the gasometer.

The out-door hood, already referred to, contains the small oil supply tank, and is also used to store dangerous material under process of manufacture or investigation. As has been stated, the inadequacy of the old laboratory and its equipment presented obstacles in the way of laboratory instruction which were practically insurmountable, and the course of instruction had to be modified accordingly.

Under the changed conditions, however, these drawbacks were removed; in fact, so far as the facilities afforded were concerned, the field was open to indefinite development.

Unfortunately the first and third conditions still existed, and in the proposed project of instruction, due regard was given thereto. This project contemplated two separate and distinct courses of instruction, the first to be included strictly in the curriculum of the Artillery School and to be pursued by every efficer regularly detailed to go through the school course; the second a strictly *post graduate* course, in which the student was to be allowed the same latitude of choice as to the line of investigation he desired to pursue as was accorded in all *post graduate* institutions.

In elaborating the details of the curriculum course, it was decided to limit the lines of investigation to one subject, and that the subject bearing most directly upon the artillerist's arm of the service, namely "*explosives*", their composition and constitution, their manufacture and analysis, their manipulation and use from an artillery stand point.

With this object in view, a manual was prepared ("Lectures on Explosives") in which it was sought to present logically and systematically within a small compass the prime essentials of the subject. This manual was to be supplemented by notes and lectures by the instructor from time to time.

Beginning then on the first day of December, according to the programme, the first week is devoted to lectures on laboratory methods and apparatus, and chemical manipulation generally. Thereafter the manual is followed strictly, each officer, as a rule, working independently, and keeping a daily record of his work in a note book furnished for the purpose, and which, upon completion of the course, becomes his personal property.

No daily task is imposed. The subjects, as they are taken up, are subdivided to aid those who prefer to check off their work from time to time, but, broadly, so many days are assigned to each subject, and each officer is expected to complete it within the allotted period.

While permitted to consult the text, and having full access to the various books of reference to be found in the instructor's room, each officer is expected to thoroughly post himself before entering the laboratory for his daily work upon the subject he is about to investigate.

The instructor is always at hand to be consulted, and to explain or supplement the text.

The various experiments are printed on slips of paper, and each officer, upon entering the laboratory, secures the necessary slip or slips, pastes it or them in his note book, and then proceeds with his work.

It may be well to introduce here an outline of the present course.

Chemistry and Explosives.

Time required: $13\frac{4}{7}$ weeks, a.m. and p.m. hours.
Second year, December 1—March 14.

A. Laboratory work.

I. CHEMISTRY.

1. Lectures.—Chemical symbols, nomenclature and equations; Chemical philosophy; Principles of Analysis; Laboratory Apparatus, and how to use it.

2. Analysis.—Sulphur, charcoal, nitre, nitrates, chlorates, nitric and sulphuric acids, glycerine, etc.

3. Thermo-chemistry.—In its relations to explosives and explosive material.

II. EXPLOSIVES.

1. Classification and theory of.
2. Synthesis and analysis of, and tests for various explosives as follows:

a. Explosive Mixtures.

α. *Nitrate class.*—Tests for gunpowder, including analysis of and densimetry.

β. *Chlorate class.*—Powders and fuse compositions.

b. Explosive Compounds'

α. *Nitro-substitution products.*—Picric acid and derivatives, nitrated hydrocarbons of the aromatic series, and derivatives.

β. *Nitric ethers or esters.*—Gun-cotton and derivatives, nitro-glycerine and derivatives.

c. Smokeless Powders.

d. Explosives of Sprengel Class.

e. Fulminates, Amides, and similar compounds.

3. Manipulation of high explosives.
4. Use of high explosives for military purposes.
5. Determination of the strength of explosives.
6. Destruction of material.
7. Explosion by influence.

III. SPECIAL ANALYSIS.

(optional as time permits).

B. Practical experiments on the firing ground with large masses of explosives, as follows:

1. Determination of the sensibility of various explosives to the impact of the service bullet.
2. Effect of confinement upon various explosives.
3. Determination of liability of various explosives to sympathetic explosion.
4. Destruction of material.
   a. Cutting down trees and palisades.
   b. Destruction of wooden beams.
   c. Destruction of iron beams and plates.
   d. Destruction of railway tracks.
   e. Demolition of masonry, walls, etc.

Text books.—Notes on chemical analysis, compiled by the instructor. Lectures on explosives. *Walke.*

Books of reference.—Treatise on chemistry, *Roscoe & Schorlemmer.* Chemistry, *Bloxam,* Manual of chemistry, (12th edition) *Fowne.* Chemical philosophy, *Cooke.* Qualitative and Quantitative analysis, *Fresenius.* Leçons sur la synthèse organique et la thermochimie, *Berthelot.* Lectures on chemistry and explosives, *Munroe.* Submarine mines, *Abbot.* Les explosives modernes, *Chalons.* Sur la force des matiéres explosives d'après la thermochimie, *Berthelot.*

In pursuing the course of instruction as just outlined, each officer (or group of officers) makes, tests, or analyzes at least one, and generally several, of the various explosives of each class, extending from the ordinary gunpowder mixture of the nitrate class to the most sensitive nitro-glycerine compound. In this work particular attention is given to the investigation of those explosives which are especially adapted to military purposes. Particular attention is also given to the service tests of various explosives to determine their condition as to stability, etc., as well as to the manipulation of masses of explosives under service conditions.

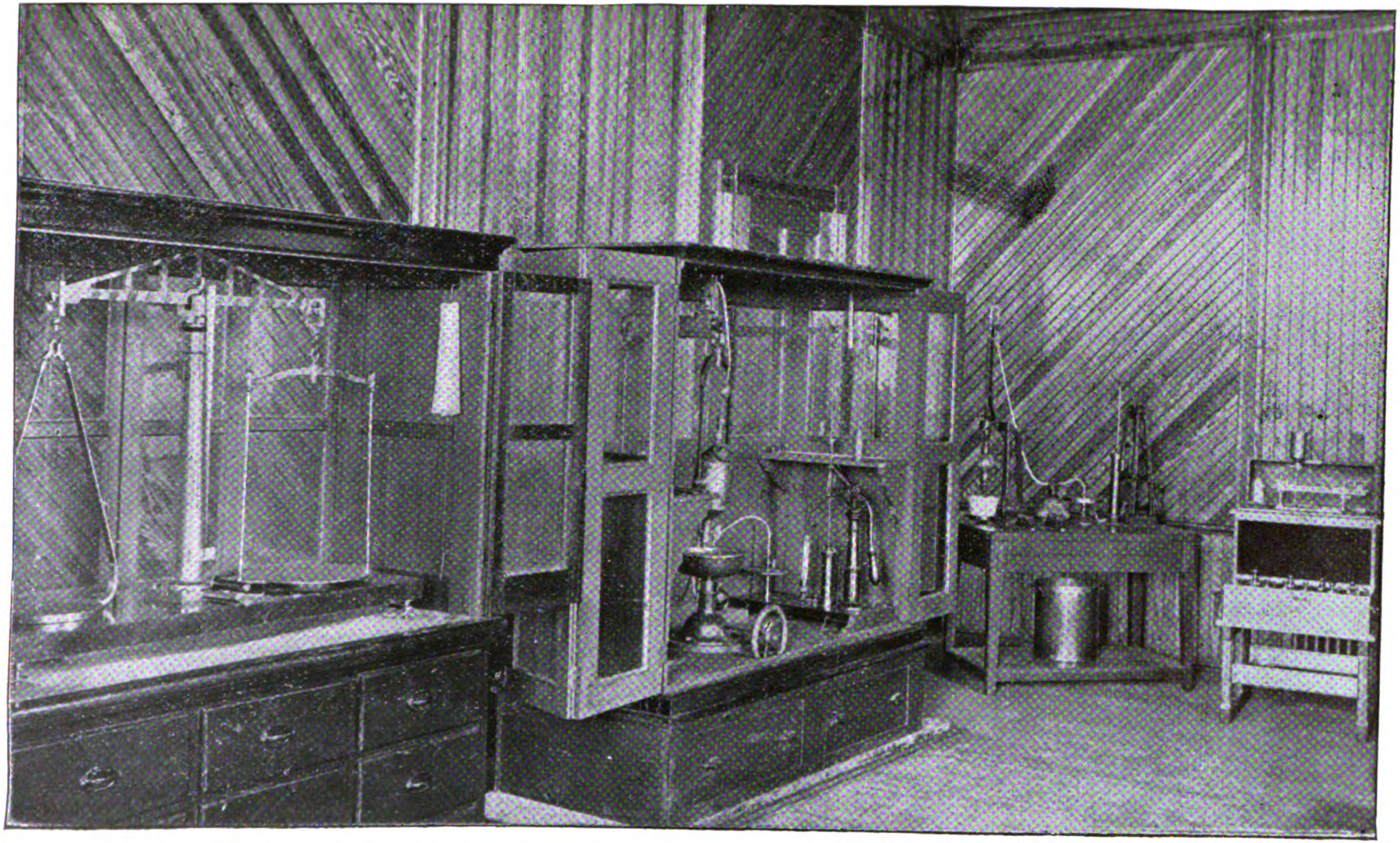
It is to be noted here that throughout this work, no accident, worthy of remark, has as yet occurred.

In conclusion a few lines may be devoted to the proposed post-graduate course. This is an entirely new departure and is at yet untried, therefore its success is problematical. It is believed, however, that the future development of the Artillery School lies along this line. There is no desire nor reason to decry a curriculum course at the Artillery School, but it is thought that a supplementary course in the departments of applied sciences is not only desirable but absolutely necessary. In the allotted time, it is impossible to undertake to do more than thoroughly ground the students in the fundamental principles of the science; the practical application of these principles can be learned and appreciated only through a liberal laboratory course.

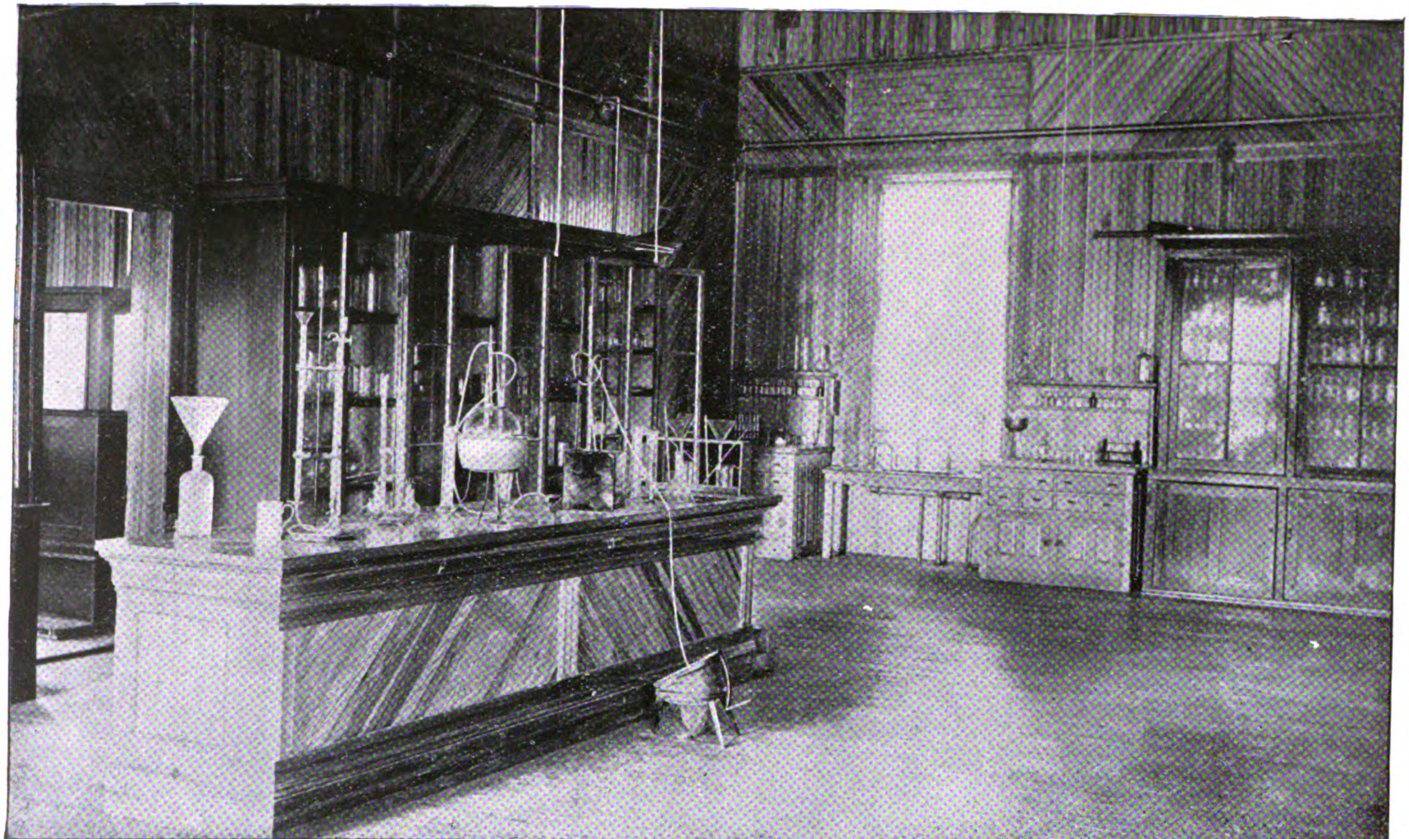
The proposed course is to furnish this additional instruction, first to those officers, who, having recently passed through the regular course, desire to remain to pursue a specialty; secondly, to those officers, who, having passed through the school under the old régime, desire to return to take advantage of the facilities afforded by the school to-day in one or more particular branches to which they have devoted special attention.

The details of such a course in the department of chemistry and explosives have been elaborated, and can be put into operation at a moment's notice.

This proposition has, I believe, received the sanction of the War Department, and awaits only the removal of temporary obstacles to become a prominent feature of the school.



BALANCE AND DENSIMETER ROOM.



MAIN LABORATORY.

THE EFFECT OF ACCELERATING AND RETARDING WINDS UPON PROJECTILES.

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

The subject to which I would call the attention of artillerists in the following paper, is the application of Ingalls's formulae to the determination of the effect of head or rear winds, upon the flight of projectiles.

In this paper I shall use the term accelerating for both head and rear winds, considering the latter as negatively accelerating; and to avoid the use of the term "*accelerating component*", I shall consider all winds as either head or rear winds. Therefore by the term *accelerating wind* I mean either a head or rear wind or the accelerating or retarding component of a diagonal wind. I shall designate all these winds as $\pm W$ and $\pm w$ winds, W being velocity in miles per hour and w in feet per second; $+W$ or $+w$ indicating a rear wind; that is, positively accelerating; and $-W$ or $-w$ a head wind, negatively accelerating.

As will be seen by the formulae used the method as herein stated applies only to direct fire; the same principles may however be applied to curved or high angle fire.

For a thorough comprehension of the subject it must be remembered that Ingalls's method is based upon the flight of a projectile "through quiescent air of uniform density", and this air is assumed to be at rest as referred to the earth; therefore the values of V or v are the same whether referred to the air or the earth. Such however is not the case when a shot is projected into a moving atmosphere of uniform density. Here the values of V and v referred to the moving air, differ from their values when referred to the earth.

In order to determine the amount of air through which a projectile must pass to reduce its velocity from V to v by Ingalls's method, we must refer the flight of the projectile to the air, and not to the earth. As V is ordinarily known as referred to the earth, we must obtain a formula whereby its value referred to an atmosphere which is moving at $\pm w$ feet per second can be ascertained.

The same is true of the angle of departure, that is the angle with which the projectile leaves the muzzle; this angle is equal to the angle of elevation plus the jump.

The *angle of departure* is the inclination of the curve of the trajectory at its origin. Now the shot traces a curve in the moving atmosphere, the initial inclination of which differs from that of the curve of the trajectory in space. In order to discuss this latter curve, and to apply Ingalls's formulae to determine its elements, we must know not only the velocity of the moving point which describes it, but also its inclination at the origin. We must therefore know or be able to ascertain the muzzle velocity as referred to the earth, and to the moving atmosphere; and also the angle of departure into space, and the corresponding angle referred to the moving atmosphere.

Let $V =$ muzzle velocity referred to the earth; $V' =$ the corresponding velocity referred to the moving atmosphere; $\varphi =$ angle of departure referred to the earth, $\varphi' =$ the same angle referred to moving air.

Consider a shot fired into a $(-W)$ wind, muzzle velocity V, angle of departure φ, and let $X =$ range in feet obtained (measured upon the earth) in T' seconds time of flight.

Now while the shot has been travelling through this horizontal distance X, the air has moved in the opposite direction through $w\ T'$ feet.

Let $X' = X + w\ T'$. Then $X' =$ range measured in air; that is, the shot passed horizontally through X' feet of air, while traversing horizontally X feet of space measured upon the earth.

If we knew V' and φ' we could apply Ingalls's formulae and determine X' and T' when as w is known we could readily obtain X the range in a $(-W)$ wind.

As V and φ represent the muzzle velocity and angle of departure referred to the earth, the *horizontal component* of the muzzle velocity referred to the earth will be $V \cos \varphi$ and the *vertical component* will be $V \sin \varphi$.

As V' and φ' represent the same data referred to the moving atmosphere, we have *horizontal component* of muzzle velocity referred to the moving air $= V' \cos \varphi'$, and the *vertical component* $=$ $V' \cos \varphi'$.

Now the horizontal velocity of the air referred to the earth is w.

Therefore $V' \cos \varphi' = V \cos \varphi + w$ . . . . (A).

As the air is assumed to have only a horizontal motion, the vertical component of muzzle velocity is the same whether referred to earth or air.

Therefore

$$V' \sin \varphi' = V \sin \varphi \quad \ldots\ldots \quad \text{(B)}.$$

Dividing (A) by (B) we have

$$Cot\ \varphi' = \frac{V \cos \varphi + w}{V \sin \varphi} \quad \ldots\ldots \quad \text{(C)}.$$

And from (B) we obtain

$$V' = \frac{V \sin \varphi}{\sin \varphi'} \quad \ldots\ldots \quad \text{(D)}.$$

From Eqs. (C) and (D) we readily obtain V' and φ' when V and φ are known.

We can now readily obtain the range in a $(-W)$ wind by Ingalls's Auxiliary Tables.

Determine A' as follows

$$A' = \frac{\sin 2\varphi'}{C} \quad \ldots\ldots \quad \text{(E)}.$$

Enter Table (A) with this value of A' and V' obtained from (D,) and we obtain z'.

Substitute this value in the followiug

$$X' = Cz' \quad \ldots\ldots \quad \text{(F)}.$$

We then obtain the value of u' from the following

$$S(u') = z' + S(V') \quad \ldots\ldots\ldots\ldots \text{(G).}$$

We then obtain $T(u')$ from Table 1, and substitute in the following

$$T' = \frac{C}{\cos \varphi'} \left\{ T(u') - T(V') \right\} \quad \ldots\ldots \text{(H)}$$

As V', u', z', A' and φ' are all referred to the air T' is the time of flight required to pass through X' feet of air.

Then

$$X = X' - w\,T' \quad \ldots\ldots\ldots\ldots \text{(I)}$$

from which we obtain the value of X, range in a $(-W)$ wind.

For convenience of reference, represent the values of V and φ, as referred to the air in the case of a rear wind $(+W)$ by V'' and φ'', Then for a rear wind we must use the following formulae.

$$\cot \varphi'' = \frac{V \cos \varphi - w}{V \sin \varphi} \quad \ldots\ldots\ldots\ldots \text{(C')}$$

$$V'' = \frac{V \sin \varphi}{\sin \varphi''} \quad \ldots\ldots\ldots\ldots \text{(D')'}$$

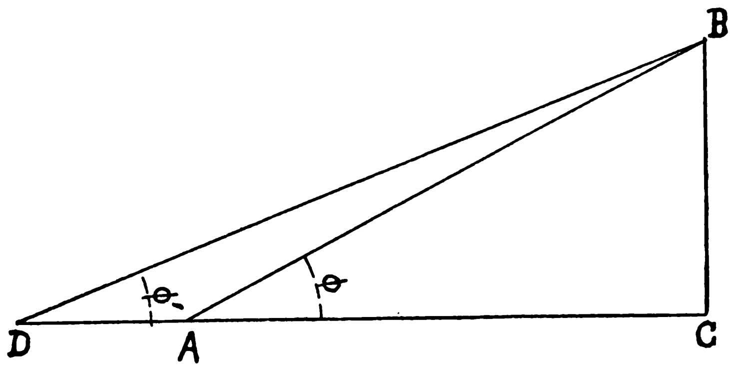
$$X = X'' + w\,T'' \quad \ldots\ldots\ldots\ldots \text{(I')}$$

To obtain $\Delta X'$ or $\Delta X''$, that is, the variation in range due to a head or rear wind; subtract range in calm from range in wind.

Formulae (C) and (D) may also be deduced in the following manner.

Let $BAC = \varphi$, be the angle of departure of a shot fired in a wind, referred to the earth. Assume that the velocity remains constant during the interval of time dt. Let AB be the space that would have been traversed by the shot had it continued to move as it was moving when it left the muzzle of the gun, for the time dt, then will $AB = ds$ in which s refers to the trajectory in space.

Now while the projectile under this hypothesis has been moving from A to B, assume that the air has moved from A to D, *i. e.* the particle of air which was at A when the projectile started would have reached D when the shot reached B had the velocity of the shot remained constant. (The word velocity as used here includes direction). As the air is moving w feet per second, $AD = wdt$. Then DB is the path which the projectile would have traced through the air, had it continued to move as it was moving when it left the muzzle; consequently $DB = ds'$, in which s' refers



to the curve traced through the air. The angle $BAD = \varphi'$ that is, the inclination of this latter curve at its origin.

From the triangle ABD we have

$$AB : AD :: \sin\varphi' : \sin(BDA = \varphi - \varphi')$$

or

$$ds : wdt :: \sin\varphi' : \sin(\varphi - \varphi')$$

and

$$w = \frac{ds}{dt} \cdot \frac{\sin(\varphi - \varphi')}{\sin\varphi'}$$

but

$$\frac{ds}{dt} = V \text{ and } \sin(\varphi - \varphi') = \sin\varphi \cos\varphi' - \cos\varphi \sin\varphi'$$

therefore

$$w = \sin\varphi \cot\varphi' \, V - V\cos\varphi$$

$$\cot\varphi' = \frac{V\cos\varphi + w}{V\sin\varphi} \quad \ldots\ldots\ldots\ldots\ldots \quad (C)$$

From the triangles BDC and BAC we have

$$BD \sin\varphi' = BC \text{ and } AB \sin\varphi = BC$$

therefore

$$BD\ sin\ \varphi' = AB\ sin\ \varphi$$

or

$$ds'\ sin\ \varphi' = ds\ sin\ \varphi$$

dividing by dt we have

$$\frac{ds'}{dt}\ sin\ \varphi' = \frac{ds}{at}\ sin\ \varphi$$

but

$$\frac{ds'}{dt} = V'. \text{ And } \frac{ds}{dt} = V.$$

therefore

$$V'\ sin\ \varphi' = V\ sin\ \varphi$$

$$V' = \frac{V\ sin\ \varphi}{sin\ \varphi'} \quad \ldots\ldots\ldots\ldots (D).$$

FORMULAE FOR CHECKING AND SIMPLIFYING WORK.

In calculating the values of $\Delta X'$ or $\Delta X''$ the following formulae are useful for checking work.

From C and C' we obtain

$$cot\ \varphi' = cot\ \varphi + \frac{w}{V\ sin\ \varphi}$$

$$cot\ \varphi'' = cot\ \varphi - \frac{w}{V\ sin\ \varphi}$$

therefore

$$cot\ \varphi' + cot\ \varphi'' = 2\ cot\ \varphi \quad \ldots\ldots\ldots\ldots (K)$$

By this formula we readily check the value of φ' and φ''. From the same formulae, remembering that $V\ sin\ \varphi = V'\ sin\ \varphi'$ ete., we obtain.

$$V'\ cos\ \varphi' = V\ cos\ \varphi + w.$$

and

$$V''\ cos\ \varphi'' = V\ cos\ \varphi - w$$

adding we have

$$V'\ cos\ \varphi' + V''\ cos\ \varphi'' = 2\ V\ cos\ \varphi$$

dividing by $cos\ \varphi$

$$V'\ \frac{cos\ \varphi'}{cos\ \varphi} + V''\ \frac{cos\ \varphi''}{cos\ \varphi} = 2\ V$$

For direct fire and winds less than fifty miles per hour $\frac{\cos \varphi'}{\cos \varphi}$ and $\frac{\cos \varphi''}{\cos \varphi}$ do not sensibly differ from unity.

We may therefore write

$$V' + V'' = 2V \quad \ldots \ldots \ldots \ldots \ldots \ldots (M)$$

examine values of V' and V'' in table.

We also have

$$\text{Range in wind} = C \left\{ S(u') - S(V') \right\} \mp wT'$$

$$= C \left\{ S(u') - S(V') \right\} \mp \frac{w\,C}{\cos \varphi'} \left\{ T(u') - T(V') \right\}$$

Therefore as φ' is $f(\varphi, V)$ only, for a given value of V, φ and w, the range in wind is directly proportional to C. As this is equally true of a range in a calm it follows that for given values of V, φ and w the values of ΔX are directly proportional to C.

Therefore for given values of V, φ and w in standard atmosphere the value of $\Delta X'$ or $\Delta X''$ is directly proportional to C. Therefore having calculated and tabulated the values of $\Delta X'$ and $\Delta X''$ for any gun for various velocities, with φ and V as arguments, we may readily construct tables for these guns by the following simple proportion.

$$\Delta X' : \Delta X_1' :: C : C_1$$

in which the values without subscript, refer to the gun and table, already calculated, and those with subscript, to the required table and gun.

APPLICATION TO 8″ M. L. RIFLE.

We shall proceed to calculate the values of $\Delta X'$ and $\Delta X''$ for the 8″ M. L. Rifle, for $V = 1350$ f. s., $\log C = 0.45627$ $\varphi = 15°$, and for every 10 miles of wind velocity up to 50 miles per hour. This gives the extreme case of direct fire; to economize space the full work is omitted.

$\varphi = 15°$. $T = 18''.33$. $V = 1350$. RANGE = 5778 YARDS.

HEAD WINDS.

W m'l's p'r hour	φ'	V'	RANGE feet	T'	$\Delta X'$ yards
10	14° 50′ 26″	1364	17124	18″.296	− 72
20	14° 41′ 03″	1379	16905	18″.244	−143
30	14° 31′ 51″	1393	16706	18″.190	−209
40	14° 22′ 50″	1404	16499	18″.134	−278
50	14° 14′ 00″	1421	16282	18″.077	−351

REAR WINDS.

W	φ''	V''	RANGE feet	T''	$\Delta X''$ yards
10	15° 09′ 50″	1336	17549	18″.383	+ 71
20	15° 19′ 55″	1321	17862	18″.463	+143
30	15° 30′ 15″	1307	17991	18″.534	+219
40	15° 40′ 50′	1293	18211	18″.597	+292
50	15° 51′ 40″	1279	18439	18″.662	+365

VALUES OF $\Delta X'$ AND $\Delta X''$ COMPARED.

MILES PER HOUR.	10	20	30	40	50	
Head winds	72	143	209	278	351	One minute elevation at this range is equivalent to 12 yards variation in range.
Rear winds	71	143	219	292	365	
Mean value	71.5	143.0	214.c	285.0	358.0	
Per mile of wind	7.15	7.13	7.13	7.12	7.16	

In the three preceeding tables we have taken the extreme case of $\varphi = 15°$, and calculated the values of $\Delta X'$ and $\Delta X''$ for every ten miles of wind velocity up to fifty miles per hour.

In the first and second tables we find that the values of $\Delta X'$ and $\Delta X''$ are not directly proportional to wind velocity, although approximately so.

In the third table we have placed the two values of the increment in the two first lines for the purpose of comparison.

Now one minute is about the smallest change of elevation that can be used in practice. At this range 5778 yards it is equivalent to a variation of 12 yards of range. And as the maximum difference between $\Delta X'$ and $\Delta X''$ is but 14 yards, we may use the mean of two, for either a head or rear wind, and still be within the smallest reading of our sights.

This *mean value of* ΔX is found in the third line, and by examination of the fourth line, where the value of this mean is given, per mile of wind, we find that the values of $\Delta X'$ and $\Delta X''$ are almost *directly proportional to wind velocity.*

This approximation is sufficiently close for use as a working principle.

Now Captain Ingalls in his hand-book page 42 arrives at a diametrically opposite conclusion. This is undoubtedly due to the fact that he used the same value of T for calculating the value of ΔX for both head and rear winds. Had he used different values, he would have discovered that not only were the values of ΔX approximately proportional to wind velocity but, that the mean value of the two increments could be used without (important error) in practice.

Now by taking the mean values of the ΔX calculated by Captain Ingalls page 42, we eliminate the error of using the same value of T as $T' + T''$ is sensibly equal to $2T$.

The values of $\Delta X'$ and $\Delta X''$ calculated by Captain Ingalls for the 3.2 inch gun, for 1000 and 2000 yards, together with the mean value, are given in the following table.

W_p ft. per sec.	1000 YARDS.			2000 YARDS.		
	$\Delta X'$	$\Delta X''$	Mean value	$\Delta X'$	$\Delta X''$	Mean value
10	− 7	+ 6	6.5	− 21	+ 35	28.0
20	−15	+13	14.0	− 50	+ 63	56.5
30	−21	+20	20.5	− 78	+ 90	84.0
40	−27	+25	26.0	−105	+119	112.0
50	−34	+32	33.0	−133	+147	140.0
60	−44	+38	41.0	−165	+174	169.5

It will be seen that the mean values are almost exactly proportional to wind velocity, particularly at the longer range.

The idea that the same time of flight could be used without error, is an extremely natural one, and in fact Colonel Maitland asserted it as a principle that, inasmuch as the horizontal motion of the atmosphere did not effect the height to which a projectile would rise, it did not alter the time of flight.

I propose that the mean value of $\Delta X'$ and $\Delta X''$, be used in practice for either head or rear winds, and I have called this mean value the *Coefficient of Acceleration*, inasmuch as it is the coefficient by which you multiply the velocity of the wind, in order to determine the allowance to be made for its accelerating effect, and moreover the term "*Coefficient of Deviation*" introduced by Captain Zalinski, has become so familiar to the service that it would seem well to use a similar nomenclature for head and rear wind effect.

Appended to this paper will be found a table of coefficients of wind acceleration for the 8″ M. L. rifle for every fifty feet of muzzle velocity.

COEFFICIENTS OF WIND ACCELERATIONS.
8 INCH M. L. RIFLE.

I. V.	1250 f. s.		1300 f. s.		1350 f. s.		1400 f. s.		1450 f. s.	
RANGE.	Coefficient of acceleration	Value of 1' elevation	Coefficient of acceleration	Value of 1' elevation	Coefficient of acceleration	Value of 1' elevation	Coefficient of acceleration	Value of 1' elevation	Coefficient of acceleration	Value of 1' elevation
Yds.	Yds.	Yds.	Yds.	Yds.	Yds.	Yds.	Yds.	Yds.	Yds.	Yds.
1000	0.26	7.7	0.24	8.3	0.22	8.3	0.21	10.0	0.21	10.0
1100	0.30	7.6	0.28	8.3	0.26	8.3	0.25	9.0	0.25	10.0
1200	0.35	7.5	0.33	8.2	0.31	8.2	0.30	9.0	0.30	10.0
1300	0.41	7.4	0.39	8.1	0.37	8.1	0.36	9.0	0.36	10.0
1400	0.48	7.3	0.46	7.9	0.44	8.0	0.43	9.0	0.42	10.0
1500	0.57	7.2	0.56	7.7	0.53	8.0	0.52	8.3	0.51	9.0
1600	0.67	7.1	0.65	7.6	0.62	7.9	0.61	8.3	0.60	9.0
1700	0.79	7.0	0.75	7.5	0.71	7.7	0.70	8.3	0.69	9.0
1800	0.91	6.9	0.86	7.4	0.80	7.7	0.79	8.3	0.78	9.0
1900	1.04	6.8	0.97	7.3	0.89	7.7	0.88	8.3	0.87	9.0
2000	1.17	6.7	1.08	7.1	0.99	7.7	0.98	8.0	0.96	8.7
2100	1.30	6.7	1.20	7.0	1.09	7.5	1.08	7.9	1.06	8.5
2200	1.43	6.6	1.32	6.9	1.20	7.5	1.19	7.7	1.17	8.3
2300	1.57	6.5	1.44	6.8	1.31	7.4	1.30	7.7	1.27	8.3
2400	1.71	6.4	1.56	6.7	1.43	7.1	1.41	7.6	1.38	8.0
2500	1.85	6.3	1.69	6.7	1.55	7.0	1.52	7.5	1.49	7.9
2600	1.99	6.2	1.83	6.5	1.68	6.9	1.64	7.2	1.60	7.7
2700	2.14	6.0	1.97	6.3	1.81	6.7	1.76	7.1	1.71	7.7
2800	2.29	5.9	2.11	6.3	1.95	6.7	1.88	7.1	1.82	7.7
2900	2.44	5.9	2.25	6.3	2.19	6.7	2.00	6.9	1.93	7.7
3000	2.59	5.9	2.40	6.1	2.23	6.7	2.13	6.7	2.05	7.7
3100	2.75	5.9	2.55	6.0	2.38	6.5	2.27	6.6	2.18	7.1
3200	2.91	5.8	2.71	5.9	2.53	6.3	2.41	6.5	2.31	6.9
3300	3.07	5.7	2.87	5.9	2.68	6.0	2.55	6.4	2.44	6.8
3400	3.24	5.6	3.03	5.9	2.83	6.0	2.69	6.3	2.57	6.8
3500	3.41	5.5	3.19	5.9	2.99	5.9	2.83	6.3	2.70	6.7
3600	3.58	5.3	3.36	5.8	3.16	5.9	2.98	6.3	2.83	6.7
3700	3.75	5.1	3.53	5.6	3.33	5.9	3.13	6.3	2.97	6.5
3800	3.92	5.1	3.70	5.4	3.50	5.7	3.28	6.1	3.11	6.4
3900	4.10	5.0	3.88	5.3	3.67	5.5	3.43	6.0	3.25	6.3
4000	4.28	5.0	4.06	5.3	3.85	5.5	3.58	5.9	3.39	6.3
4100	4.46	5.0	4.24	5.2	4.03	5.5	3.75	5.8	5.54	6.1
4200	4.64	4.9	4.42	5.1	4.21	5.4	3.92	5.7	3.70	5.9
4300	4.82	4.9	4.60	5.0	4.39	5.3	4.09	5.6	3.86	5.8
4400	5.00	4.8	4.78	5.0	4.57	5.3	4.27	5.4	4.02	5.7
4500	5.18	4.8	4.96	5.0	4.76	5.3	4.45	5.3	4.18	5.6
4600	5.36	4.7	5.14	4.9	4.94	5.3	4.62	5.3	4.34	5.5
4700	5.53	4.7	5.32	4.9	5.12	5.1	4.80	5.3	4.51	5.5
4800	5.72	4.6	5.50	4.8	5.31	5.1	4.98	5.3	4.68	5.5
4900	5.91	4.6	5.69	4.8	5.50	5.0	5.16	5.3	4.85	5.5
5000	6.10	4.6	5.88	4.8	5.69	5.0	5.34	5.3	5.02	5.5

EXAMPLE SHOWING METHOD OF USING TABLE.

The angle of departure for 2700 yards range for 8″ M. L. rifle for 1400 f. s. initial velocity is 5° c1′, jump 30′. Required angle of elevation to be given in a 30 mile wind $\frac{6}{10}$ accelerating. [Rear wind].

Such a wind is equivalent to an 18 mile rear wind.

From table we find coefficient of acceleration for 2700 yards range, 1400 f. s. I. V. = 1.76 yards. Therefore the increase of range for an 18 mile rear wind will be $1.76 \times 18 = 31.68$ yards. At this range we find that one minute's elevation is equivalent to 7.1 yards, we must therefore reduce our elevation 4.4 minutes. Calling this 4′ we have therefore angle of elevation = 5° 01′—30′ —4′ = 4° 27′.

A PROPOSED DESIGN FOR A NEW BALLISTIC TARGET.

By First Lieutenant JOHN C. W. BROOKS, Fourth Artillery, U. S. A.

The Department of Ordnance and Gunnery at West Point devotes the month of April to practical work; as a month is a short time to devote to this purpose, it is necessary to use every means to expedite the experiments.

Part of the time is spent in determining the velocities of projectiles. The targets first used were the ordinary wire ones, but the repairing of these took so much time that in 1889 Captain Henry Metcalf, Ordnance Department, at that time in charge of the Department of Ordnance and Gunnery, devised a target which was expected to lessen the time required to repair the same and consequently allow more shots to be fired in an afternoon.

His target consisted of a wooden frame, across the top of which ran a strip of copper, through which the electrical current flowed. At intervals of about an inch holes were bored just large enough to allow a service copper cartridge to enter without touching the strip of copper which was broken by the hole, and yet small enough to allow the flange at the head of the cartridge, when the latter was drawn down, to rest on the broken copper strip, thus making the current. Inside of each cartridge was a spiral spring tending to force the cartridge upward; projecting below each cartridge was a wire hook to which was attached, by means of a string, a weight which drew the cartridge down. When a projectile cut a string, the spring in the cartridge forced it up, breaking the current and registering the time of passage of the shot. To repair the target, strings of the proper length were prepared in advance, and it was necessary only to hook one end on to the weight and the other on to the cartridge.

In April 1890 this target was used, and, while it proved quite an improvement over the wire target, still occasionally considerable trouble would arise from the breaking of the current without any apparent reason, and on such occasions it would often require a careful hunt with a galvanometer to locate the break. On account of these difficulties the idea occurred to me that the induction of a secondary current by the insertion of a core in a coil of insulated wire might be utilized in a ballistic target, a coil being the target and the projectile a core. The rapid passage of the projectile through the coil would produce an induced current running in the opposite direction to the primary current and would, I thought, be sufficient to release the rods of the chronograph. After discussing the idea with other officers, we concluded to improve the target we were then trying, and if after a second season it still seemed necessary, we would then try my idea. The experiments during the month of April, 1891, convinced me of the advantage of a ballistic target which would require no repairs. The proposed target presented several difficulties. How long could the coil be made? How many turns of wire would be required to accomplish the purpose? When would the projectile break the current and how far from the center of the coil? The last question is the hardest to solve. I have looked through books on electricity, I have talked to officers whose experience with electricity have been much greater than mine, and I have finally concluded that the questions can be solved only by experiment.

I intend to attempt the solution in the following manner: We have at the proving ground two chronographs, a Boulengé and a Bréger. I shall use both instruments at the same time, and on the same screen I will have both a coil and a wire target. This will give a check on the results. I shall first attempt to use a coil target of the same size as the wire target, but if I find that this will require too many turns of wire, I shall reduce the size of the target and try to ascertain the most convenient size for the coil. I hope that the velocities given by both instruments will prove to be the same, in which case it will show that the projectile breaks the current when it arrives at the center of the target. In case the readings are the same, the coil target could be used with any chronograph; in case they are different, the target could still be used with the Bréger chronograph, since the currents used with this instrument are the same, and consequently the current would be broken at the *same distance in front of each of the two targets,* and the distance between the points at which the currents were broken would be equal to the distance between the targets. In this way the question of how far in front of the target the current would be broken would be eliminated.

FIELD-ARTILLERY, ITS ORGANIZATION AND ITS ROLE.

By First Lieutenant CHARLES D. PARKHURST, Fourth Artillery, U. S. A.

From the sling, with first its stone and then its leaden bullet, the bow in its various forms, the ballista and catapulta, all ancient forms of projectile weapons, to the artillery of to-day is an enormous stride, necessitating constant changes in organization, requiring new tactics, and continually opening out a new rôle as progress was made from one arm to the other, until we of the present day are confronted with the question, what is the best organization for our present arm, and what is to be the rôle of our field-artillery in our future wars. Before considering this question however, a brief glance backwards may be of interest.

The invention of gunpowder, whenever that may have been, marked an important era in the history of all warfare. Its introduction into Europe was almost immediately felt in the added element of strength to the footman as against the knight or horseman, and we find the gradual change in ideas, tactics and organization, which brought the footman forward into prominence as the mainstay of the army, with the knight constantly losing ground, until the cavalry became but a secondary or auxiliary arm.

At the same time a practically new service, that of the artillery was formed upon something of the basis that we now have. Even although cannon appear to have been known to the ancients, their use had practically been lost, and it is not until about the thirteenth century that they are mentioned as in use in European service.

But when once introduced their importance would appear to have received prompt recognition, from the many forms and sizes that were invented and introduced. Being a new service, naturally enough each effort at improvement or organization was but an experiment, and also naturally enough many failures must be recorded before any thing like success was attained. But, working with the best light that they had, the early gun-founders builded even better than they knew, for the breech-loader is by no means the modern idea so many consider it. Breech-loaders and those too of a pretty fair type, jointed guns, and many forms that now are receiving so much attention as the gun of to-day or of the near future, were all foreshadowed in the early guns, and their failure and abandonment was not because of any inherent defect in principle, but rather because of the wretched powder and the poor class of mechanical skill, judging from our standpoint of automatic machines and steam power.

Introduced experimentally, and against the most powerful disapproval of the higher classes of knights and lords, the artillery of the day had much to contend with before its usefulness or excuse for being could be established. And yet, in spite of all, by the fourteenth and fifteenth centuries it had become fully established, and the French Artillery was fully classified in the sixteenth century during the reign of Francis I. The artillery then comprised six pieces, varying from the cannon weighing 5000 lbs. throwing a projectile weighing 33lbs. and drawn by 21 horses, down to the "falconet" weighing 410lbs. and throwing a bullet of 14 ounces.

The English were much slower in introducing artillery than either the French or Germans. It was not received with favor when first introduced, and it is not until the time of Henry VIII that it received any considerable improvement. Being at first exclusively used upon fortifications, later from semi-portable frames or carriages it was considered quite an achievement when Henry VIII and Francis I mounted their guns upon travelling carriages drawn by horses, so as to accompany the army in the field, instead of being hauled with the baggage train by oxen. And about as strong a contrast as one could wish is presented on comparing this first "field artillery" with that of to-day. Drawn by seventeen horses tandem, with no limbers, but trail shaft instead, the seven pounders of Louis XIII could be but a cumbersome and slow moving affair, while what we have to-day we all know; when we consider the increase in power as well as in mobility, the improvement becomes all the more striking, entirely altering the style of service, the tactics and the rôle, and leading us to expect the greatest benefit to be derived from its use.

Passing by the minor improvements which led to it, we all know of the great improvement of Gribeauval, and the immense benefit it was and has been to the artillery service. Like Columbus' egg it looks simplicity itself when once it was introduced, and one wonders why it was not thought of before. One wonders too why in later years the same principle was not followed out in the early introduction of uniform calibre for all field-guns, particularly of the same battery, so as to avoid the confusion that obtained in the manufacture and supply of ammunition. Yet the lesson had not been learned even so late as our own civil war, and confusion worse confounded was sometimes the result. But we at last appear to have learned the lessons taught by such experience, for it appears now that all of our field-artillery is to be of uniform calibre for the same class of guns.

Passing by the conflict as to material, and only mentioning incidentally the warfare between bronze and cast-iron, we finally have practically abandoned both, and placed our faith and hopes upon steel. The muzzle-loader is of the past, the smooth bore is obsolete, and the rifled breech-loader is the gun of to-day, whatever may be the gun of the future.

Without entering at length upon the subject, it may be of interest to say that the artillerist was looked down upon with contempt. In England particularly, did he have a hard struggle to obtain or maintain his place, and it was only after a long and hard struggle that finally the artillerist and his service was recognized as upon a par with that of the other arms.

Our artillery dates from the Revolution, and our first organization was naturally copied from the English, with certain modifications. Organized for an active campaign and not as a "peace establishment," the field artillery was formed into "battalions," equivalent to our regiments though all were field-artillery. Each battalion had twelve companies, each company one captain, one captain-lieutenant, four lieutenants, six sergeants, six corporals, six gunners, six bombardiers and twenty-eight matrosses; each company to manœuvre two pieces, with three ammunition wagons. At this time and for many years later the guns were manœuvred by drag-ropes by the matrosses, who occupied the grade now equivalent to that of the private soldier. At this time the organization appears to have been fairly complete, the proper officers with proper rank, and a proper staff having been provided. A chief of artillery also existed and, considering the state of the finance of the colonies, the times themselves and the overwhelming difficulties it had to encounter, the artillery of the Revolution was nothing to be ashamed of. It did good service, was officered and manned by as brave and patriotic a body of men as any other arm, and many a lesson can be learned from the devotion to duty that it exhibited.

From the Revolution to 1812 the history of the artillery has but little interest, except as a record of want of policy upon the part of the government as regards organization. An expensive service to maintain, it is but natural to expect its reduction upon the close of active operations; but first combined artillery and infantry, then artillery and engineers, organization and re-organization can but be characterized as rather chaotic, and as not tending to advance the efficiency of the artillery. But when we think of the want of military knowledge or ideas upon the part of the successive administrations, the poverty of the states, the difficult nature of the service upon the frontier, it is not to be wondered at that a chaotic state should exist. The country had yet everything to learn. With an inherited jealousy of everything military, even to-day, though we may have learned, or should have learned a great deal from our past experience, the jealousy still exists, and the army is the last to receive consideration, just as it is the first to be called upon when danger menaces.

In 1808 the light artillery was first organized as a regiment. The regiment comprised ten companies, each of one captain, one 1st lieutenant, one 2nd lieutenant, two cadets, four sergeants, four corporals, two musicians, eight artificers and thirty-eight matrosses. It was not mounted however, and the question of its equipment was not even decided; it differed from the other artillery only in name, and as soon as formed each company was, with one exception, marched off with muskets. One company was organized as field-artillery proper, with two 6-pounders, one ammunition wagon and one light horse wagon. But this was short-lived, and in 1809 the company was dismounted, the horses being sold by auction as too expensive to maintain. Thus ended the first attempt at field-artillery as a *peace* organization, an experience repeated later I am sorry to say, on more than one occasion.

When the war of 1812 opened we were without field-artillery except in name, and except for some material which had been fabricated for possible future use. The attempt, necessarily a failure, was made to create an efficient field-artillery from untrained officers and men, with untrained horses and untried material, with no organization and no ideas as to how or when artillery could best be used. Need we therefore be astonished that the results of this war were comparatively nothing so far as field-artillery is concerned? Birkhimer well says that "the condition of the light artillery at the commencement of the year (1812) demonstrated the impossibility of combining the duties of that arm with that of infantry. The attempt failed; it was asking to obtain something from nothing, to have the moral effect and prestige of this powerful arm without paying for it."

From 1812 to the Mexican War is again a period of organization and reorganization. Now a corps, now by regiments, now combined with the ordnance, now separated therefrom, the period is yet marked by a gradual change of ideas and an improvement in the arms and material for the artillery service. In 1849 a complete artillery system, the result of experiments, and of visits to Europe by commissions for that purpose, was formally adopted. A greater part of this system had been tried some years before, and practically the field-artillery of the Mexican War was equipped accordingly.

And it is refreshing to turn to a record of which the artillery may well be proud—the deeds and the daring, the dash, enthusiasm and devotion to duty of all of the field-artillery in the war with Mexico. Though the armies were small, the service peculiar.

the operations as nothing compared to those of later days, yet the spirit was there, and for the first time in our history the field artillery came prominently forth as an indispensable fighting force. Here perhaps first of all upon this continent the light artillery proved its independence of the heretofore considered indispensable support, and proved that its own fire, even at short range was enough for its own preservation, and enough to defeat the attack and save the day.

From the Mexican War to 1861 the field-artillery practically remained unchanged. Before the Mexican War the organization as we now have it had been adopted, the organization having practically been adopted in 1821 when the light artillery regiment ceased to exist. In the Mexican War the necessary field-artillery was formed by the field-batteries of each regiment, and they were partly dismounted upon the close of operations. But owing to its brilliant deeds in Mexico it had taught the country its usefulness, and the false economy was short-lived, and soon the field-batteries of each regiment were again mounted, and from this time (1849) to 1861 there was something like permanence in the policy of the government, with a corresponding benefit to the service. But still the service had much to contend with in the ideas varying from one administration to another. Having no head of its own to look to its interest and keep up a constant and consistent policy of method and of instruction, it necessarily suffered with change of ideas with change of administration. It was called upon, unavoidably perhaps, to perform service not in its rôle; now as cavalry, scouting for Indians, now again as artillery, now mounted and then again dismounted, now with one gun now with another. Scattered at isolated posts or engaged in desultory campaigns upon the frontier, the service lacked the coherence that alone could give it efficiency, and at the outbreak of the civil war it was not only not available but absolutely useless. The batteries in Texas only escaped the enemy by sacrificing their horses and material.

The immediate necessity for a large force of field-artillery in 1861 led to the transformation of all, or practically all of the then foot batteries into field-artillery. This was in accordance with the apparent policy which yet exists, from which cause the field-batteries have been "schools of instruction" since 1841. To form this field-artillery therefore, batteries from the interior as well as the sea-coast were taken, with the consequent effect of producing a large mass of field-artillery, formed from regular troops armed and equipped, but yet wholly untrained in the management or care of horses, ignorant of the particular drill or service as field-artillery, and with no time except the time of war in which to learn. The wonder is that the service did as well as it did, for practically except in the matter of military discipline all the batteries were raw recruits, with all their trouble before them in an entirely novel service, calling for perhaps more training than any other.

In the Revolution the organization was upon the basis of a company, with two or three guns to each infantry brigade, the rest was held in reserve. The artillery of the Revolution, however crude and mean it may appear to us and however faulty it may have been, yet enjoyed the benefit of having an efficient head and chief of its own, with the rank and ability to have some effect in looking after its interest and efficiency. Under his orders the artillery was attached to the brigade for fighting purposes only, and was then under the exclusive order of the brigade commander. During the inactive season the artillery was massed into one park, and in disciplinary matters and in administration the chief alone had control.

During the 1812 war the lack of such organization was apparent. An attempt was made at an organization based upon the revolutionary method, but it was short-lived and of no practical benefit, and during the war the artillery was scattered with no semblance of system. Artillery officers of any merit were detached from their proper service and ordered elsewhere, leaving the service to be performed by those of indifferent merit, or by details from other arms of the service.

During the Mexican War, from the increase of knowledge and interest in military matters, arising from instruction at the Military Academy and elsewhere, the artillery was better handled, better understood, and performed most brilliant service. But the field was contracted, the force small, the enemy by no means one to bring out any such display of force or of knowledge as would now be necessary, and the lessons learned were of but little use for application to large campaigns. During this war the artillery of Taylor's army was attached one battery to each brigade of infantry of about 1200 men. In Scott's army one battery to each *division* of about 2400 men. Nothing is said about reserves.

Following then in 1861 such precedent as we had to follow, the plan of brigade artillery was first tried. Many of the volunteer regiments had a battery of artillery attached; but this was all speedily abandoned as practically useless; the system broke down as wholly inadequate for either administrative or fighting purposes. No attempt was made to form an artillery reserve, and the presence of a battery manned by drag-ropes at the first battle of Bull Run, looked more like the methods of the eighteenth than of the nineteenth century.

In the other part of the army of 1861 the same organization was at first adopted. This led to the sacrifice of concentration, and the artillery fire was just what it should not have been, scattered and weak. We had yet to learn that concentration alone can make it effective or formidable. Confusion worse confounded arose from the question of supplies not being understood. Brigade commanders knowing little and caring less about what should be done, could not or would not give their battery the proper supervision, and the system broke down throughout the entire field of operation.

It was now if ever that an efficient chief of artillery, with proper rank was needed. Such an office should have been provided long before by law, and such an office should now have been authorized, to provide in some measure for the necessities of the service. Yet this was not done, and the best that could be done in the absence of law to legalize such an appointment and give it the proper rank and dignity, was to appoint a chief of artillery upon the staff of the generals commanding armies. This was done by McClellan, and under the advice of his chief of artillery General Barry, the following scheme for organization was adopted:

"*First.*—The proportion of artillery should be in the ratio of at least two and one-half pieces per 1000 men, to be expanded if possible to three pieces.

Second. • * * * * *

"*Third.*—Each field-battery to be composed if practicable of six, and none to have less than four guns, those of each battery to be of uniform calibre.

"*Fourth*—The field-batteries to be assigned to divisions and not to brigades, in the proportion of four to each division. * * *

"In the event of several divisions being united into an army corps, at least one-half the divisional artillery to be withdrawn from the divisions and formed into a corps reserve.

Note.—This was afterwards done, the corps reserve being formed when the army was on the Peninsula.

"*Fifth.*—The reserve artillery of the whole army to consist of 1000 guns, comprising besides a sufficient number of light mounted batteries, all the guns of position, and until the cavalry is massed, all the horse-artillery."

This is believed to have been the first comprehensive American scheme for organizing field-artillery to accompany a large army in the field. It was modeled in part at least upon the best practice in the armies of Europe.

This was the groundwork, and though not followed in its entirety, the Army of the Potomac when it embarked for the Peninsula was accompanied by 49 batteries, aggregating 299 guns, of which 100 were in the reserve.

Partly from experience gained in campaign and in battle, and partly from the caprice and ideas of the individual commanders who in turn had command, this organization was changed as time went on, and the change is outlined as follows:—

First.—An increase in the number of army corps caused a draught upon the reserve artillery which almost annihilated it.

Second.—On the Peninsula McClellan's three corps were increased so as to form ten divisions. Four months later at Antietm there were six corps and one cavalry division, total nineteen divisions. At Antietam there were sixty-two batteries, seven in the reserve and fifty-five distributed to divisions and to the twelf.h corps, the latter having its seven batteries organized as corps artillery and not as divisional artillery. The cavalry division had four batteries of horse artillery.

In 1862 General Barry was succeeded by General Hunt, and the latter officer remained in position as Chief of Artillery during the rest of the war.

Third.—At Fredricksburg Burnside had six corps, each of three divisions and of two cavalry divisions. He had sixty-seven batteries, nine in reserve. The fifty-eight batteries attached to the troops were with the divisions, a number varying from one to four being with each, depending upon the arm of the service and the strength of the division. In the cavalry service each division had one horse battery, drawing upon the reserves when more was needed.

Fourth.—At Chancellorsville Hooker had eight corps in all, total twenty-three divisions. Of the seventy-one batteries present twelve were with the reserve; the rest, except two attached to the provost guard were with the divisions. In the eleventh and in the cavalry corps, half the artillery was formed into a corps reserve. Of the twenty-three divisions fourteen had two, five had three and four had four batteries attached. The effective strength of the division averaged about 5000 men, of the corps 15000 men. The average number of guns including the general reserve was three for 1000 men.

Experience, which had caused the change in the plans first adopted of regimental, then brigade and now divisional artillery, made it evident that the division must give up the artillery to the corps.

This was done after Chancellorsville, the batteries of each corps being organized into brigades; these brigades varied in strength with that of the corps to which attached. Of the eight corps at Gettysburg, the first battle after the organization was made, four had five and two had four batteries to a brigade; the sixth corps brigade had eight batteries, the cavalry corps had nine of horse artillery, the latter in two brigades of four and five batteries respectively. Four-fifths of the batteries had six guns the rest four guns each.

The advantages to be derived by this organization were, that the batteries were better cared for and capable of more efficient service in battle. As a result fewer guns could do the same amount of effective work. In 1864 therefore, the number of guns was reduced to two and one-half per 1000 men.

We were not alone in perfecting this organization. The Confederates had early seen the necessity, and before us, in 1862, they began to form their organization, drawing their batteries together into battalions of from three to five batteries, forming a complete battalion organization, perfect in all its parts, with field officers, staff, and all the proper and needful working force for its complete administration.

And they were wiser than we, in that their laws allowed general and field officers of artillery at the rate of a brigadier general to every eighty guns, a colonel to every forty, a lieutenant-colonel to every twenty-five and a major to every twelve.

This law may not have been carried into full effect, but it recognized the *proper principles* which should obtain, giving the proper rank to the commander of such large and important organizations of fighting men, and providing the proper means for administration; while in our own service, although our artillery brigades were equivalent in importance and in fighting power to a division of infantry commanded by generals, they were commanded by captains and lieutenants.

A most invidious distinction and discrimination was followed constantly against the artillery and the rank of those in its command. All of our actions seem to have been based upon the idea that the battery is the unit both for fighting and administration, while one might as well say that the set of fours is the unit, hence the company or troop needless, or the company or troop the unit, hence the uselessness of the battalion and regiment. This led to the conclusion that there was nothing about the service higher than the battery, which could legitimately be the subject of command. Contrary as this was to the facts as shown by the experiences above narrated, which caused the formation of divisional and then of corps artillery, with it brigades, &c., the doctrine was announced in orders in 1862, which provided that "as a general rule artillery will be called for and received by batteries, thus rendering the field and staff unnecessary." Hence there were no staff and no field officers. When the brigades were formed the field and staff were wanting and had to be drawn from captains and subalterns, thus increasing their duties and giving the commands of the brigades to those whose rank (and pay) was in no wise commensurate either in dignity, or power with their commands. This discrimination was most unjust, took away all hope of promotion, and caused many of the best of our artillery officers to seek other service with its hope of reward.

It is not my purpose to follow further the organization of the field-artillery in the civil war. Enough has been narrated to show the defects that at first existed and how these defects were remedied. Let us now turn to the rôle of field-artillery as shown at different epochs.

It is believed that the field-artillery has ever tried to be equal to or in advance of the range of the best infantry weapons of the day. In the days of the old "Brown Bess" the range and accuracy were anything but what they are now, but the field-artillery was fully up to its work, and could be relied upon to do its share at the battle ranges. Those were the days of the bayonet, of cavalry charges and "shock tactics" generally, and the battery as all the other arms of the service had to take its chances at close quarters. Its rôle would appear to have been that of an auxiliary, used now here, now there as occasion called to strengthen this place, to reinforce and aid some weak point heavily pressed, and by its mobility and dash to be here, there and everywhere, or ready to respond to urgent call. It was used indiscriminately against all arms, and these were the days of individual dash, of brilliant action of single batteries, rather than the concentrated effort of many guns.

But early in the present century lessons began to be learned looking to another rôle for the field-artillery. More perhaps the result of accident than of deliberate design, various causes tended to show the effect of a heavy concentrated fire. Among them may be mentioned the action of Prussick-Eylau in 1807. The French found themselves in an entanglement between the Russian Cavalry and Infantry in the obscurity of a snow storm. Kept in masses by the efforts of the Russian Cavalry, Augereau's corps was so heavily bombarded by a battery of forty guns that it was completely demoralized, and was dissolved after the battle.

Again at Friedland the right man at the right time and place was General Senarmont, commanding the artillery of Victor's Corps. Seeing a crisis, against the protests of the division commanders, he massed their thirty-six guns, hurried them to 400, 200 and finally 120 yards, and turned imminent defeat into brilliant success. This was under Napoleon's eye who sent to caution Senarmont to be careful, showing that even Napoleon did not at first take in the situation. But later he saw the point, and two years later at Wagram he collected one hundred guns under Drouot, preceded the infantry and cavalry, and at close range silenced the Austrian artillery on a mile front, smashing his masses of infantry and repulsing all his cavalry attacks with canister.

Instances might be multiplied to show that thus early in the century a new era had opened for the field-artillery, and the time had come for its use in large masses as a separate arm, as well as an auxiliary for special purposes.

And we need not be surprised that we were slow to learn this lesson. We are not a military people, and the Military Academy educates but a very small percentage of our inhabitants, and it is a question sometimes whether the education that is given is the best that could be to make good soldiers. The cadet gets general ideas only, upon military matters, and those very imperfectly. He is filled with mathematics but not with grand tactics. He learns the drill of all three arms of the service, but the drill only; study and labor for years after graduation, are necessary to keep him up to the progress made in the art of war as shown by modern battles.

To digress a moment, and yet as bearing upon this point, an officer of my acquaintance was engaged in the civil war. Being young and enthusiastic, and desirous of learning all he could, he procured and carried in his knapsack for many a day a text-book that was studied at the academy when I was a cadet in 1871–2. Wondering why he did not see the principles and methods therein laid down carried out in field-practice, he inquired the reason, and was told that his text-book was long since obsolete; that they were making tactics, laying down new engineering principles, creating a new art of war as the circumstances directed, and yet as I said, the book he had and had obtained for that very reason, was a text-book at the academy then, and it was also ten years later when I studied it.

So at the outbreak of the civil war we were behind the age. Apparently the lessons to be learned from European wars had not been taken home, and the old methods of the Revolution were those first followed, leaving it to a stern experiment to teach new ideas and bring out new methods.

Though this will be undoubtedly true in every war, each bringing out something new or unheard of yet the lessons learned from previous campaigns should be our guides until something better arrives, and thereby much loss, and perhaps disaster may be prevented.

It is to be much regretted that since our civil war, no great writer has arisen to collect and give us his ideas upon the various defects, and their remedies as shown by the light of mature deliberation upon the war experiences. How different in that respect we are as a nation and as an army from the Germans! They in 1866 had a brief but bloody conflict with Austria. Their artillery did not come up to the expectations that had been formed of its efficiency, and the moment the campaign was over they went to work to study the cause, to remedy the defect, and the results are shown in the brilliant and decisive action of their artillery in the campaign of 1870–71.

We went through one of the greatest wars the world has ever seen. In point of numbers, in valor, in patriotism, in hard fought battles, in extent of country engaged, our armies and our campaigns were the peers of any. Much dearly bought experience was gained by those who won and held command. Much could be learned from those who held subordinate positions, and yet, except for general works and here and there some scattered articles, there have been no such works as those of foreign authors upon their wars. The rising generation of officers in our service have not the teachings of their superiors and predecesors who fought from '61 to '65; that generation will soon pass away, leaving nothing behind in the way of comment or criticism upon what was, what should have been or what might be, leaving us to learn it all for ourselves in the stern school of war when the occasion calls.

As an instance however of one exception to the above, let me quote from General Hunt's article on "artillery administration," the excellence of which causes it to be much regretted that he did not leave more such writings upon the defects of the artillery service and remedies therefor. The quotation is as follows:—

"The methods to be pursued vary with circumstances, and must be learned by study and by experience, *no man can know* them *intuitively*. Artillery should be used only against large bodies of men, rarely against small groups, never in cannonading individuals, which is too often done, especially if they ride white horses. Besides the artillery attached to army corps or divisions for the foregoing purpose, a reserve is necessary for the general service of an army, to reinforce that army corps in battle, to occupy positions, to protect the laying and taking up of bridges, and for other purposes. To this reserve is generally attached the "grand park" for ammunition and ordnance stores, for repairs, etc., and sometimes also the siege trains.

"What is called the moral effect of artillery is proportional not to the noise it makes, but to its actual destructive effects. If these are great and sustained, artillery becomes a terror to the enemy, and a wonderful inspirer of confidence to its own troops, while ineffective practice or its misapplication tends to bring the arm itself into contempt with both friend and foe."

Certainly no one was better qualified to speak from experience and study than General Hunt. All that we can hope to do who have not had experience in actual war, is to study and to gain what we can from experience in time of peace, and this naturally leads me to another branch of my subject.

It has been mentioned above that the evident policy of our government where a large force of field-artillery is needed, is to create it from the foot batteries by mounting them as was done in the Mexican and civil war, or else why the "school of instruction" for subalterns which now obtains in our service?

The question naturally arises, is this a good or a true policy? Can we hope to thereby create efficient field-artillery at a moment's notice, and is the study and experience one gains while with the light-battery sufficient?

We all know the law and regulations upon the subject, and the manner in which our field-batteries are arranged and maintained. We have ten scattered at various posts over the United States, the greatest concentration at any one post being the three batteries now at Fort Riley, Kansas. Time was when the captain was not permanent, but was relieved every three, and later every four years. This has now been changed by making the captains permanent. At first the lieutenants remained for only one year. This was changed in 1844 by orders which made the 1st lieutenant permanent, only the 2nd and brevet 2nd lieutenants being relieved annually. And it is to be remarked that the brilliant deeds of the artillery in the Mexican War are to be partly attributed to the permanence of the 1st lieutenants, bringing as it did trained and efficient officers into field service, officers who had had time to learn their duties and gain some experience from peace duty at least, of what a battery should be and how its duties should be performed.

In my opinion the present method of instruction is faulty for the following reasons:—

First.—Admitting the necessity for instruction so as to provide as many especially trained officers for field-artillery as possible, the time is too short. It takes more than two years to learn one's full duty, for the full duty calls for more than a simple knowledge of the drill; that can be learned in six months if need be, and is one of the least of the duties to be learned.

Field-artillery necessarily has horses as a component part of its internal organization. The use, care, proper training and management of the horse therefore, forms part of the officer's necessary duty and education; not only in garrison, at the usual and ordinary drill and ceremonies, but also in the field, on the march or campaign, in heat and cold, rain and sunshine, in sickness and in health, with full forage and on short allowance, with loaded limbers and caissons and with empty boxes, all are what he must expect to encounter and to be master of, and to provide for as best he may according to emergency or necessity.

It is submitted that the horse alone is the study of a lifetime. To succeed, the officer should have a love for the horse, be interested in him, like to be with him, and not find his care and attention a nuisance and burden.

Second.—The very fact of the temporary nature of the detail causes a lack of interest in proper instruction, and a looking ahead to the time when the two years will be up, and the officer will be free to return to other and perhaps more congenial service.

Third.—The fact that the batteries are scattered, except as above mentioned, gives the officer the opportunity of seeing but his own battery, and he therefore learns only the methods of his captain, and he has no chance to broaden his knowledge by contact with other batteries. Besides this he sees only one battery handled, does not learn anything but battery drill, and unconsciously learns to look upon the battery as the "end all and be all" of field-artillery, whereas the battery is but a part of the brigade, the true unit for fighting and administration.

Fourth.—Again the fact that all are subject to detail is a point against the present system. We are constantly driving round plugs into square holes and square plugs into round holes, trying to make everybody everything and failing in the attempt. To many men mounted service is a positive torture. They hate and fear a horse; they know nothing and care less about his nature, anatomy or management. To all such the two years with the light-battery are two years thrown away, and never from choice would such men become field-artillerymen in the event of a campaign.

And in my opinion the service would be greatly benefited if the present organization of two field-batteries to each regiment was abandoned, and they were all consolidated into a field-artillery regiment of two or more brigades, with proper organization of field and staff officers. The assignment of officers to such service should be permanent in the greater part at least. If instruction must be given, it could be to officers attached for such purpose for at least four years, the captain and at least two lieutenants being permanent.

I know the objections. I am aware how slow the promotion would be if promotion was made regimental, and I know also how small a nucleus this would give us upon which to build any enlargment. But I am speaking for the good of the particular service as it stands. If organized as a separate corps it would have one head instead of five to look after its interests. It would probably be organized and concentrated instead of being disorganized and scattered. It would have its field and staff, and soon an *esprit de corps* of its own, instead of being so many isolated batteries, with hardly a common interest as is now the case.

Within the last few years we all know that a tactical board has been at work devising new drill-books for the three arms of the service. With infinite labor and the most conscientious desire to provide the best possible, it is yet to be regretted that a greater consideration was not given to the lessons to be learned from our own and from foreign war experience, and the drill and everything connected therewith simplified to the utmost.

What may be the final result in the adoption of the new drill book for field-artillery, what that book may have become since its experimental use of last year I cannot say. As first issued for experimental use it had, however, much that could be well omitted, as well as much that was a decided advance upon old methods.

And in a *drill-book* for whatever arm of the service it may be, if tactics are to be introduced they should be in accordance with the lessons of the past, and be an advance upon old methods. We should not retrograde or cling to old customs and ideas that have proved defective. Yet in the new infantry drill-book it was laid down that field-artillery is to be attached to brigades and divisions, following the course found to be wanting in our late war as above narrated, thus retaining an obsolete and worse than obsolete idea; for setting it up as a principle that the infantry brigade or division is to have its artillery, and stamping that with the authority of the government's approval, at once establishes it as a fixture that the brigade or division commander insists upon as his right, making it just so much the harder to overcome when the correct principle is sought to be established.

In my opinion a drill-book is not the place in which to lay down grand tactics or the final organization of our army; such principles should be reserved for other and more advanced works, leaving to the drill-books the simple detail of the mechanism of all movements from the file to the complete troop, battery or company, the battalion, the artillery brigade, the regiment, &c. Infantry brigade or division drill approaches grand tactics, and when it is to be considered something more than mere evolution has at once to be taken into account.

If our war taught anything, it taught that artillery to be useful must be under the control of the higher commanders. The corps was the smallest unit that finally was found to which artillery should be attached. This consolidated it, placed it under the command of the corps commander and his chief of artillery, and made it as it should be, at once available for concentrated and united effort, without anyone's having the right to interpose objection or protest, as was the case too often even after the artillery had been assigned to divisions and to corps. Instance after instance of such protest and bitter objection, and the delay attending where artillery was called for first from brigades and then divisions for concentrated work, could be given to substantiate my position. The brigade commanders having become used to having artillery, parted with it with the greatest reluctance when it was drawn in to be assigned to divisions. The division commanders likewise raised the most bitter objection and protest when it was consolidated for attachment to the corps, and these protests and objections in a great measure nullified the good effect that otherwise would have attended this concentration and assignment to corps alone.

It is disheartening to have always to draw comparisons, and to refer to foreign example to draw an inference or learn a lesson. But how different the conduct of affairs in the Franco-Prussian war from that in our war of '61 to '65! There we find continually the reenforcement of the artillery of one corps by that of another. There we see the mutual support and the concentration of artillery taken from any source. There guns marched to the sound of guns, without orders, yet without confusion, and without protest and objections, each commander doing his best to bring about the success of the whole engagement, heartily and eagerly joining in under whatever command he chanced to encounter to swell the tide that overwhelmed the enemy.

Here, alas! objection, protest and delay were the rule rather than the exception. Brilliant exceptions there are it is true, but more than one projected attempt towards overcoming the enemy was abandoned because of the want of this mutual support, division commanders being unwilling to make what they considered a sacrifice, unable to see that concentration alone was their real salvation and the solution of the problem, and so we dragged along, using up men, material and money in a useless and needless frittering away of effort.

It must be remembered too that, although the weapons used in our late war were a decided advance upon those of previous campaigns, they still fall far below those of to-day in precision, in range, and in power. All the more reason therefore for the organization of our field artillery in such a manner as to be readily available under as few heads as possible. If assigned to brigades, yes and even to divisions it will be scattered here, there and everywhere along an extended line. Owing to the topography of our country, much of our field artillery might therefore be out of action, unable to find a place on the line or anywhere near it from which to deliver its fire; and yet at other places more than that at hand could well be used, or might be absolutely needed. Time, distance, the necessary diversity of command, and the impossibility therefore of ordering might prevent the necessary concentration being even attempted, causing disaster to one part of the line for the very want of guns that are lying idle somewhere else. Whereas, with a smaller number of guns, under the immediate command of corps commanders, with a reserve under the exclusive order of the general commanding, better service, heavier fire, more concentration would be possible, the artillery thus being able to do what it would always gladly do, to give ready and efficient aid and support to the other arms, and to bear its share of the burden or the dangers of every engagement.

To refer again to the drill-book and more particularly to that part which affects the individual battery, much that now obtains could well be omitted, or if kept in the book for the purposes of exercise should be set apart exclusively as such, and but the fewest and simplest manœuvres be retained for the battle-field.

The time was when "fine feathers made fine birds," when music parade, glitter and noise, and the Charles O'Malley type of soldier and officer were in the ascendant; when rigidity of manner, faultlessness of manœuvre and complicated evolution were all considered as part of the art of war. But to march and to shoot are now of more importance and the more easily these ends are compassed the better.

Therefore, although parades, ceremonies, glitter and show still have their usefulness in awakening the popular enthusiasm and should be provided for, the evolutions for the field of battle should be made as simple, as easily learned and executed as is possible, and such that no time or needless energy is expended in their execution. For actual work, marching and shooting are the only ends the battery has to attain, the only excuse for its being.

The drill therefore is but a means to an end, and is not in itself the "end all and be all" that so many consider it. In all drill this end should be continually kept in view, and men, horses, material and everything pertaining to the battery should all be trained and used with reference to that end alone, everything else being discarded as obsolete or superfluous.

It might be possible then to have such artillery as the service demands. Plain, common-sense, practical in every way, no noise, no hurry, no confusion in its management or in its work, characterized by a "deliberate haste," if I may be allowed the expression, every move would count, no nervous energy would be exhausted in worry, in confusion, in restlessness or in abortive work, and such a battery would tell its own story when the time came, in its power to give and its endurance to receive, hard knocks without faltering or wavering from its place and duty on the battle-field.

Ever since artillery was first organized, it has been the almost invariable custom to retire from the line of battte for refitting as soon as the battery became in any way greatly damaged, or as soon as ammunition became exhausted.

The Germans have learned and applied their lessons. In 1866 battery after battery retired to "refit," in 1870 none; and the moral effect upon the rest of the line more than paid for any sacrifice that may have been made by a battery's remaining on the line after its ammunition was gone, or it was partly disabled.

Now can we not learn something for every day application from this? We have mechanical manœuvres, changing wheels, dismounting guns, &c., &c., and they are carefully taught as a part of the regular routine instruction. But when are they ever put to practical use? Who in these "piping times of peace" ever saw a wheel disabled so as to require changing? And therefore, because we apparently have no practical need to apply these manœuvres they never are applied, even though taught, and when the time comes for their practical application, the necessary readiness in execution of the manœuver is found wanting.

Now if we are to stay on the line as we should do, we must be able to make repairs to any damage that can be repaired. We should be able to make use of any part from anywhere and utilize everything that remains uninjured, and that promptly too, so as to have as many serviceable guns and limbers as possible at all times. To do this requires drill, and the drill is but the practical application of the manœuvres previously learned. This drill would be found a great relief from what may be otherwise monotonous, and be productive of the best results. A gun here, a carriage there, a limber yonder; this team, such and such drivers, cannoneers and gunners may all be designated as damaged and unserviceable. Then let the best be made out of what remains by those left to do it, and see how soon and how perfectly it can be done. Let it not be done once or twice but frequently, and as a part of the regular drill, and it will be surprising, first how slow the men are to grasp the idea, and second, how readily they learn when once the idea is grasped, how rapidly damages may be repaired, and consequently of what little moment a considerable damage may be on the field of battle.

If to march and to shoot are the most prominent functions of a battery, then marching and shooting must form part, and that a prominent one of the daily routine of instruction.

Instruction in marching not only teaches the men how best to undergo fatigue, and how to ride and drive so as to save their teams, but it hardens them and puts them in training for field work. It accustoms them to long stretches at slow or rapid gaits, so that when the time comes for extra exertion they are not found wanting, and have no lessons to learn. This marching too has the best effect upon the horses. It puts them in training, teaches them to work together at the walk or the trot for long distances, and enables them to bear the necessary fatigue and to make the necessary exertion when occasion calls. On the march too, errors in adjustment of harness, faulty construction of the same, or in the adjustment of implements are brought out, and the necessary corrections can be made quietly from time to time until everything is ready for sudden and hard work over any road or kind of country, with no fear of a breakdown, or of anything happening to prevent the accomplishment of the object calling for the march, or the movement from one part to another of the field of battle.

But with everything at the highest point of perfection, if, when the battery or batteries arrive at their point of action they cannot shoot, of what good are they? Better not have them at all than to have them useless and powerless, and just so much impedimenta and food for powder, as well as a demoralizing element from their inability to shoot *and to hit.*

If our cavalry and infantry need the thorough course of training at the target-range that they now receive; if medals and badges are necessary to bring out the competitions for our Army, Department and Division teams; if rewards, flags, &c., &c. are to be given for the best battery work with heavy guns, what does not the field-artillery need, and what is it to receive as a reward for its proper work in practice firing?

Unfortunately field-artillery practice costs money, and with our limited appropriations, and with the difficulty of providing or procuring proper ammunition for our new 3''.2 gun, but little if any suitable practice has thus far been had. Even at the best the allowance of rounds per gun is but limited, and something else must be looked for to give the men proper instruction in the gunner's art, to teach them to shoot *and hit* and so render valuauable service when such service is required.

Most unfortunately we have no system that I have been able to discover. We are poverty str'cken for books of our own, for rules, regulations, and the proper ideas to govern the effective delivery of fire, and again we have to turn to foreign works to gather the information we seek.

In France and in Germany, in fact in all the European Armies care and attention from the best minds have been given to this most important subject. Experiments and new ideas are being continually essayed, and everything possible is done to bring artillery fire up to the point of perfection it should attain.

But the lack of a system, or the authority to use either this or that, German, French, or any other idea leaves us all at sea. Each battery commander is his own judge of what he shall do and how he shall do it, with therefore about as many methods as there are battery commanders.

In my opinion the practice should all be by a regular system, and that system should be to teach the battery to shoot *as a battery* and not as individual guns. Captain Chester has recentiy given us instances of the disastrous effect of individual gun shooting, as compared with what might have been the result from collected fire.

In the French service the firing and the mechanism of the piece for elevation are in accord. So many turns or parts of a turn of the elevating screw means so many yards of range, plus or minus, as it may be turned down or up. With us our Ordnance Department has constructed our guns, our sights and our elevating screws; but the latter has no direct connection with the range and no rules are given us how to regulate fire by a manipulation of the screw, so as to correct shots (all having been laid) after the first, second or other piece has been fired.

Now would it not be better to adopt some system, even if we had to borrow it from abroad, than to drift on aimlessly in more senses than one, as we are now doing? Instead of trying to teach individual gunners, with no system of concerted laying, would it not be better to teach the battery to shoot as a battery, just as though the battery commander had laid all the guns himself, and had done everything except pull the lanyard when the gun is fired?

By this means he would know how to regulate his fire, particularly when picking up the range as piece after piece was fired. If the first went low he would know that all would go low and *vice versa*, and could correct for elevation, drift, and wind in the shortest possible time. As it is now a miss of any gun may mean a poor shot from that gunner, to be followed by a hit or miss from the next and so on, each gunner laying according to his idea and judgment, even though given the range, the allowance for wind, &c., for no two lay alike, this one taking a fine, the next a coarse and another a medium sight and so on.

The infantry and cavalry as well as the heavy artillery have their gallery practice, and why should not the field-artillery?

The use of a sub-calibre barrel is no new idea but we can well adopt it, and by arranging the Springfield rifle to be used inside of our field-guns, unlimited target practice could be had at all seasons. In the open season the regulation Springfield cartridge could be used, and at ranges up to 1000 yards and over, a special sight, or special use of the regular sight devised to give the elevation, &c. Practice could then be had in laying the guns, and good practice too in shooting, every element being present except the noise and the recoil from the regular projectile and charge.

In the winter months wherever the winter closes the season, the same sub-calibre rifle with reduced charge could be used under cover. It would take but little calculation or experiment to provide the necessary targets at the various ranges as now obtains in regular gallery practice, and a passable substitute would thereby be given whereby much instruction, particularly in the matter of uniformity of laying could be given.

The consideration of target practice and field firing naturally leads to the consideration of range-finding, and the sight necessary for long range fire.

It is believed that, although artillery will by no means be restricted to long range work, and may yet as heretofore, have to drive in upon the front lines of battle after the battle opens, long range will be the early stage of every future artillery duel. We have, or will have guns that have an effective range of two miles and over. Of what use is such a gun without an adequate means of laying it, and how many precious shots may not be thrown away in picking up a range at such a distance?

The English have their regular range-finders as part of the regular organization of their batteries. The French are at work continually with one range-finder or another. We have done something with such work for our fortifications and for the Navy, but next to nothing for our field-artillery.

Even admitting that the best range-finder is only approximate, will it not give in proper hands results that are better than a guess? At the long ranges under consideration, or before the long range duel opens up, there will probably be plenty of time in which to conduct operations, and even if only correct to within ten per cent. in a two mile range, who can guess within four hundred yards of such a distance? It would be a poor outfit indeed that did not come within ten per cent., and that was taken as a very poor result and yet well within the limit of "guessing."

The limit of human vision is well known to lie at about 2500 yards when sighting a gun. In fact it is getting to be hard work when one goes beyond 1000. The eye was not built to focus and accommodate itself to such extremes as those presented by the breech and muzzle sight close at hand, and an object at an extreme distance. Hence what use to have a gun capable of being shot within a barn door at a two mile range, when you cannot see the door? The eye must have aid, and the telescopic sight becomes an absolute necessity. It can be made to "stand the racket" of field work, and the trouble of its care will be more than repaid by the excellence of the shooting it permits. When the battle gets hot and fierce, when guns as well as other troops are being crowded up to the front, then the field-telescope becomes superfluous, the open sight is all sufficient. But the other sight need not be laid aside because of the telescope, and even if lost, destroyed or thrown away in the later engagement, it will have paid for itself and its place can be supplied at small expense.

From time immemorial in artillery history the ammunition wagon or the caisson has formed part of the battery of manœuvre, and has had its place upon or close upon the line of battle.

It is now an open question however whether this should continue to be the case. Many think the caisson should no more be allowed upon the battle-field than the army wagon, and our new drill-book is to have, or did have a special drill for the guns alone, independent of any caisson.

Certainly if it can be done and the question of ammunition supply can be solved without them, the absence of the caissons will be a great relief to the battery. Probably they will be retained, in fact it is contemplated to give an extra caisson to each platoon for the field-battery, to always belong to and accompany the battery upon the march and campaign; but when the action opens to be sent to cover to the rear and no longer be taken on the field. The question is an open one, and one of the greatest importance as affecting field-artillery.

The rank of the officer in charge of caisson is a matter of great moment. When separated from the battery the caissons should be under the command of an officer of experience and judgment so that they may be properly handled, and the battery never left in the lurch for want of proper ammunition supply. In the English service the officer second in rank is in charge of the ammunition wagons. With us in our "assimilated tactics" the junior officer of the battery was chief of caissons. In the new drill-book the senior lieutenant has such charge if I recollect aright, a move in the right direction.

Having now reviewed field-artillery from the Revolution to the Civil War, having seen the defects of our various systems of organization and the injustice done for want of proper officers of proper rank for its command and guidance; having seen how its rôle has changed from that of an auxilary arm, fighting as indi-

TRIALS OF 57mm. (2″24) 80 CALIBER RAPID FIRE CANET GUN, (MODEL OF 1891), AT THE HOC PROVING GROUND, MAY AND JUNE 1892, PREPARED FROM DATA RECEIVED FROM M. CANET, BY Mr. W. H. JAQUES, ORDNANCE ENGINEER, SOUTH BETHLEHEM, PA.

Weight of Projectile.		Kind of Powder.	Weight of Charge.		Initial Velocity.		Pressure.	
kilos.	pounds		kilos.	pounds	metres	feet.	kg. per sq. cm.	tons.
2.700	6	BN	0.800	1.75	648	2125.5	1018	6.5
2.700	6	"	1.100	2.4	791	2593.3	1760	11.2
2.700	6	"	1.200	2.6	854	2802.1	1956	12.4
2.700	6	"	1.400	3.0	948	3110.5	2692	17.1
2.700	6	"	1.450	3 12	981	3218.3	3170	20.1
2.710	6.02	"	1.325	2.85	859	2818.5	2007	12.7
3.000	6.6	"	1.325	2.85	835	2739.8	2069	13.1
3.000	6.6	"	1.400	3.	860	2822.	2117	13.4
2.700	6.	BNG	1.000	2.2	780	2559.	1438	9.1
2.700	6	"	1.200	2.6	906	2972.7	2024	12.9
2.700	6	"	1.300	2.8	958	3143.3	2267	14.4
2 690	5.98	"	1.350	2.9	972	3189.5	2296	14.6
2.700	6	"	1.350	2.9	998	3274.3	2541	16.1
3.000	6.6	"	1.300	2.8	952	3123.5	2508	15.9
2.700	6	"	1.400	3.0	1001	3284.3	2570	16.3
3.000	6.6	"	1.400	3.0	1005	3297.5	3093	19.6
2.700	6	"	1.400	3.0	1013	3322.8	2683	17.0
3.000	6.6	"	1.400	3.0	980	32[illegible]5.	2690	17.1
3.000	6.6	"	1.400	3.0	995	3264.5	2736	17.4

vidual batteries to that of a sister arm as well, full grown and able to care for itself and to bear its full burden of danger or of work, and entitled to its full share of glory—is it too much to hope that in the future it may receive full justice in its proper organization, and full power to honorably perform its duty and fulfil its rôle?

BOOK NOTICES.

The Battle of Spicheren, a Study in Practical Tactics and War Training, by Brevet Major G. F. R. Henderson, Instructor in Tactics, &c., R. M. C. Sandhurst, with numerous colored maps, 300 pages, appendix 12 pages, London, Gale & Polden, price six shillings.

The preface refers to the advantages of a proper study of military history. "It is not sufficient to read or to listen to the account of a campaign or battle. A cursory glance at a variety of incidents leaves little behind. To gain from a relation of events the same abiding impressions as were stamped on the minds of those who played a part in them, it is necessary to examine the situations developed during the operations so closely as to have a clear picture of the whole scene in the mind's eye."

The historical events connected with the opening of the French-German War of 1870–71 are given with sufficient detail. Then follow: Recapitulation of strength of combatants, general description of theatre of war, slow mobilization of the French, and their weakness in and ignorance of the use of cavalry; no patrols, no reconnaissances worthy of the name; traditions of the Great Napoleon forgotten; teachings of Sheridan and Stewart ignored. The French were plentifully provided with maps of German territory, but had none of the districts in which they operated.

The first movements found the French Army dispersed over a length of two hundred miles, with no accurate information of their enemy's movements: the German Army, double the numbers of the French, concentrated on a front of one hundred miles. General description of the German system of mobilization and French want of system. With the French "vanity, thoughtlessness and indolence reigned in high places; army rotten to the core." They had an infantry whose formations were vicious and who could not use their rifles; an artillery who had not been taught to shoot and whose weapons were inferior; a cavalry skilled in parade movements but ignorant of reconnaissance duties; officers neglectful of their men; men disrespectful to their officers. Already in Italy in 1859 had been heard "les épaulettes en avant." There was a want of homogeneousness in their corps of officers; impaired authority of non-commissioned officers; antagonistic spirit between civilians and soldiers. Habits of criticising everything under the civil government had found its way into the army. In Germany respect for authority was hereditary; in the family, school, university or factory. Those who rebelled found no sympathy among their comrades.

Germany's system of field maneuvers supplementing theory with practice, had evinced in 1866 the fact that general principles which regulate tactics in war may often be educed in peace. Their infantry was well instructed in rifle practice, and invariably outmarched the French. The entire army was well infused with the spirit of the initiative, while the French ran to centralization.

In the French advance on Saarbrücken four corps are sent to obtain by a reconnaissance in torce, information which a single brigade of cavalry should have accomplished. The Germans by an effective display of their small force produce the impression that there is a large army present, and in the meantime their concentration is effected. The intentions of the German commanders are made known to their subordinates; the latter act with greater intelligence and effect than if compelled to remain in ignorance and await orders. With the French indecision with its concomitant, orders and counter orders, produces the most demoralizing effect.

This book is the best tactical study which has been presented to the military student in a long while. With a good topographical map of Saarbrücken and vicinity for reference, the author discusses the advantages and disadvantages of each feature of the terrain. The volumes published under the superintendence of the Prussian General Staff, are supplemented by a reference to regimental histories, and the author leads us with the different battalions, and in many cases with individual companies through the different phases of the battle.

From Chapter IX we extract: "And, as regards the strength of the company it is open to question whether 100 rifles are not more easily handled by one man than 240; whether they are not as a body more flexible, more readily reformed, more easily covered, and more adaptable to detached duties such as covering the flanks, outposts and the like." * * *

"It is doubtless true as a rule, that troops in close order cannot be brought up to the front without many casulties; but if troops are thoroughly disciplined, if they believe that no matter how great the slaughter, to give ground or to break the ranks is to incur dishonor, if they are imbued with the idea that annihilation is preferable to retreat and are skillfully defended, the bayonets of the second line will yet decide many a field." * * *

"Those who argue that when they have lost one-third of their number, troops will give way to their own volition, and who base their theories on this are bad teachers. If such is the fact, then there is something wanting in the discipline or mettle of the men. How many instances may be gathered from our own history and from that of our kindred beyond the Atlantic, of soldiers that bore a far heavier loss than this and never flinched? What was the strength of the Fusileer brigade when the great French column at length went rolling down the hill of Albuera? How many of Pickett's men had fallen when his division reached the crest at Gettysburg? We should train our troops for battle, not by complacently telling them that there are limits to their endurance, but by impressing on them that human virtue is equal to human calamity, that what men of the same race have done they can do also: and, whilst weighing the experience of others by recalling our own traditions, then amidst the slaughter of a modern battle-field, the endurance of Waterloo and Inkerman, the reckless valor of Badajos and Balaclava will again assert themselves. * * *

* * * "But it is worthwhile noting the very valuable assistance that a force of mounted infantry would have rendered in reconnoitering the forest tracks, and readers who are interested in the duties of this arm of the service are recommended to study the methods of the American generals and the American horsemen in the Virginia wilderness. Neither Lee nor Grant, although the country in which their campaigns were carried on was far more wooded than the borders of France and Germany, were troubled by the apprehensions which beset the French commanders; but they were both careful to secure early information of the enemy's movements, and were both well served by the officers who led their cavalry. Far and wide, to front and flanks, rode Stuart's and Sheridan's mounted marksmen obstructing the path of the enemy's patrols, laying ambushes for his advanced guards, contesting every inch of ground and penetrating his lines, for in such a country it was impossible to watch every path."

Appendix III comprises a number of beautiful tactical problems referring to the different stages of the battle, affording the reader ample opportunity of exercising his judgment and ingenuity.

C. D.

Das Artillerie-Schiessspiel, Berlin, 1891. Ernst Siegfried Mittler und Sohn. By Colonel H. Rohne, Commandant of the 9th (Schleswig) Regiment of Field-Artillery.

No brief review nor in fact anything short of a careful translation of this work could give an adequate, or even fair conception of its scope, thoroughness and value. So nothing will be attempted here save a bald statement of its purposes, and a mere hint of the methods employed to attain them.

As the title suggests, the book is an exposition of the game of Artillery-Firing, and the author with distinct modesty gives full recognition to the exemplars found in the "Mock-Fire" (*Tir Simulé*) of the French, and the "Artillery-Game" of the Russians, at the same time asserting the originality of much of his work. The French game, as also the Russian, deals with shell-fire only, while Colonel Rohne has extended the subject so as to embrace fuze-shell, shrapnel, moving targets, &c. In a word the book is an exhaustive treatise, conveyed under the guise of an entertaining diversion, on the whole matter of modern artillery-fire; it is essentially the absorbing and exciting game of Kriegsspiel, in so far as the latter pertains to the definite sphere of artillery-fire.

The underlying mathematics (the calculation of the several probability tables for deviation, dispersion, correctness of observation, &c.) is first expounded with much precision and lucidity, though, as the author points out, this part is not necessary to the understanding and playing of the game.

Then follow many examples (under the various subdivisions of the subject) which are explained with all detail necessary or desirable, so that after a single careful reading of the volume, one has a clear comprehension of the aim, methods and practice of the game and a no less clear conviction of its great value to officers of artillery.

Finally there is but one matter (an insignificant one, indeed) calling for animadversion, and even this dissent applies rather to the publisher, viz: the choice of a dress for the book. The delicate, esthetic blue-and-gold would be more becoming for a collection of *Vers de Société*, and might well have given place to a plain and sturdy garb, indicative of the unqualified worth within.

W. P. D.

Sixteenth Annual Report of H. M. Inspectors of Explosives.

A hasty examination of this publication shows the usual compilation of important data and statistics, which has in the past proved so valuable to every one interested in the investigation of explosives.

Of all civilized nations, Great Britian alone has undertaken to regulate the manufacture and manipulation of these powerful agents, and to diligently prosecute those who, through negligence, recklessness, ignorance or any other cause, are responsible for accidents arising from their use.

In these reports not only are the accidents which occur in Great Britain recorded, but as far as possible those occurring in foreign countries are inquired into, and the causes thereof determined.

The manufacture, storage, importation, transportation, experimentation,—in short all possible data on the subject are compiled and tabulated in such form as to be readily available.

There is one new feature to be noted in the last report, and that is the circular letter issued from the Chief Inspector's Office, relative to the installation of electric light plants in explosive factories. This letter contains all the necessary directions as to the precautions "which should be taken structurally and otherwise in electric installations."

W. W.

The Resistance of Guns to Tangential Rupture. Adjutant General's Office, 1892.

Under the designation "Artillery Circular A," the Adjutant General's Office has recently distributed to artillery officers a translation from the Russian of an excellent monograph entitled "The Resistance of Guns to Tangential Rupture," by Colonel Pashkievitsch, Professor at the Michael Military Academy, St. Petersburg, Russia. The translation made by 1st Lieutenant Tasker H. Bliss, First Artillery, aid-de-camp to the Commanding General, bears internal evidence of being very faithful and accurate, and is an evidence of Lieutenant Bliss' remarkable linguistic talent.

The work of Colonel Pashkievitsch is principally a compilation, and must therefore be judged in great part as to its merits as a compilation.

In the first chapter the preliminary definitions and demonstrations under the head "Elasticity of Solid Bodies" are clear and complete.

In deducing the fundamental equations which give the conditions of "elastic equilibrium and resistance of a cylindrical envelope," the author has followed Virgile's method with which we are all familiar, and which is unnecessarily complicated. Colonel Pashkievitsch accepts Wertheim's coefficient ⅓ for lateral deformation as did Virgile in his earlier investigations in this subject; but later Virgile discarded the value ⅓ and adopted as the coefficient ¼ as was proposed by Poisson. The correct coefficient is however so much a matter of doubt that our Ordnance Department yet retains Wertheim's value.

Colonel Pashkievitsch discusses the elastic strength of guns under the two separate views of resistance of stress, regarding each stress as acting independently of other stresses and of resistance to deformations. The resistance to deformation is the combined elastic strength, or the measure of the resistance under the action of all of the forces which tend to rupture or to strengthen the gun. In the treatment of the resistance to deformation the author uses Captain Birnie's modification of Clavarino's coefficients, without giving to Captain Birnie, U. S. Ordnance Department, the credit for these values which were original with him.

The painstaking investigation of Captain Birnie which demonstrated Clavarino's errors, reflect great credit on that officer.

Curiously enough the formulæ of Clavarino in their erroneous form are found in the latest text-book at hand used at the Naval Academy.

The most interesting part of Colonel Pashkievitch's work is in the treatment of the "Elastic Resistance of Reinforced Cylinders" (built-up guns) and of "The Determination of the Difference in the Diameter of the Cylinder for shrinking them successfully, one upon the other," which gives the most complete and satisfactory discussion of this subject known to the reviewer.

J. P. S.

Dynamo Electric Machinery; a Manual for Students of Electrotechnics. By S. P. Thompson, F. R. S. Fourth Edition, 864 pages, 5½x8½, 29 plates. Spon & Chamberlain, New York, 1892.

This is the standard work on the subject of which it treats, and the work, above all others, to which electrical engineers will for a long time look for a record of the art and the theory underlying the construction of dynamos.

G. L. A.

A Dictionary of Electrical Words, Terms, and Phrases. By E. J. Houston, A. M. Second Edition, 562 pages, 7x9. W. J. Johnston Co., New York.

Professor Houston, writer and inventor, has given to the electrical world the only complete and reliable collection of definitions and descriptions arising with the new science so far published. It is perhaps the most valuable single book belonging to the general literature of electricity.

G. L. A.

Magnetic Induction in Iron and other Metals. By J. A. Ewing, 351 pages, 159 illustrations, 5x9. Electrician Co., London.

After the introductory chapter giving the fundamental ideas and terminology, an account is given of the methods which are usually employed to measure the magnetic qualities of metals. Many numerical examples are quoted. One chapter of this classical work is given to magnetic hysterisis and another to the influence of temperature and stress which must prove specially interesting to our ordnance officers.

G. L. A.

The Practical Management of Dynamos and Motors. By Professor F. B. Crocker and Dr. S. S. Wheeler. Electrical Engineer Co., New York.

This is a résumé of weekly articles appearing this year in the New York Electric Engineer, and as a handbook for dynamo tenders and students must prove invaluable. It contains directions for selecting. installing, starting, running and testing machines, and for locating and remedying faults therein.

G. L. A.

Aide-Memoire de l'officier de Marine, par Edouard Durassier, chef de bureau au Ministere de la Marine, et Charles Valentino, ancien officier de Marine, sous-chef de Bureau au Ministere de la Marine. Paris: Librairie Militaire de L. Baudoin, pp, vi, 539.

This work naturally addresses itself chiefly to the naval officer. But there is no risk in saying that it is of almost as great value to the sea-coast artilleryman. It furnishes him with just the data needed, if investigating any question involving naval elements. We have first a concise statement of the main principles of naval international law, followed by the personnel of the various war-navies of the world (pp 1–54). The next division of the book deals with war-ships themselves (pp 55–365). A description by types of the war-vessels of Germany, England, Austria and Italy (pp 55–107) precedes tables giving the armor, guns, draught, coal-capacity, speed, &c.. &c., of every war ship in the world by name, whether afloat, under construction or projected. Not even countries so insignificant as Hayti and Uruguay escape. The armaments of the great powers are next described (pp 366–456), first by systems, as, Krupp or Canet, etc., then gun by gun for each power, in considerable detail. Of course all this information may be got elsewhere, but no where else at the cost of less time and trouble. A list of submarine cables and a French Navy Register (personnel only) complete the work.

The type, though necessarily small is clear; and the comfort of the reader has been consulted in the admirable arrangement of the tables.

C. DeW. W.

Modern French Artillery (The St. Chamond, DeBange, Canet and Hotchkiss Systems), with Illustrations of French War-ships, by James Dredge,. Chiefly reproduced from "Engineering." London offices of "Engineering" 35 and 36 Bedford Street, Strand W. C. New York, John Wiley & Sons, 53 East 10th Street, 1892.

The contents of this book were originally published in "Engineering. "The value of the series being quickly appreciated by military men, it was deemed expedient to reprint them in book form. It is due to this happy idea that we are now able to find in compact shape, this valuable work on French Artillery.

The products only of private firms are considered, and all statements made in connection therewith were referred to the makers themselves, in order that strict accuracy might be obtained. Due care was also taken that no government secrets should be exposed.

The St. Chamond, DeBange, Canet and Hotchkiss systems are explained in detail. The discussion of war material embraces the first eight chapters; the remainder of the book is devoted to the French Navy.

To give a clear idea of the contents of these chapters, we will notice them in proper order and somewhat in detail.

I. *Introductory.*—This is chiefly historical in character and deals with the kinds of guns, projectiles and their manufacture during the twenty years preceding the Franco-Prussian War. Here we find brief mention of Parrot, Armstrong, Hotchkiss and other methods extant during those years. This part of the discussion is short and simply paves the way for the following matter.

II. *Steel Ordnance.*—The complete adoption of steel for guns marks an epoch in artillery problems. It is the function of this part to connect historically the change from cast-iron ordnance, to the built-up steel guns of to-day. We also find some interesting description of methods of testing, and different kinds of data during the transitional period. Types of guns and carriages of this period possess only historical interest for the modern artillerist.

III. *Breech-loading Mechanism.*—Contains a sketch of the interrupted screw mechanism, and treatment of the general subject under the following heads :

First.—Standard French system which is essentially the DeBange system, the latter having been subjected to a few modifications by the officers of the Artillery of the Marine. In small guns this mechanism is worked by hand, but in large guns where it weighs from 1500 to 2000 pounds, a special arrangement is necessary. In all cases a safety device is provided.

Second.—United States modifications of the French system. Our readers are too well acquainted with these modifications to require their explanation.

Third.—The Canet system, which embraces many modifications of the standard system. The most important of these consists in securing obturation by use of a new form of the DeBange plastic wad, designed to avoid hardness and inconvenience in loading. The details of the system are interesting and instructive. A triple form of safety apparatus, operates (1) while the breech is open, (2) when the striker is not over the fuze, and (3) so long as the lanyard is not pulled. An important feature of this mechanism is that in all calibers it is opened by one man continuously pulling a line in a single direction. The design is extremely simple and its efficiency has been thoroughly demonstrated.

In his quick-fire guns the recoil and return of the gun to battery are used to open the breech and partially eject the cartridge case.

Fourth.—The Woolwich System—an old and complicated system.

Fifth.—The Armstrong System. Consists of a modification of the DeBange system, with use of the plastic wad or Elswick cup. In quick-fire guns the block is tapered.

Sixth.—The Krupp System, which is familiar to our readers.

Seventh.—The Hotchkiss System. In all calibres up to 10 cm. the sliding wedge principle is used. Description of the preceding devices is not attempted, attention simply being called to them that the reader may know where to find them.

IV. *The Present Condition of French Ordnance.*—In a short chapter we learn how private firms in France produced little or no war material, until finally encouraged by the government, they began to develop this new industry, and how some of them struggled on, until now they have become dangerous rivals of Armstrong and Krupp. In addition we obtain a glimpse of conflict between the advocates of the crucible and Siemens-Martin process of treating steel. French metallurgists and gun-makers attacked (1) Krupp's crucible steels, (2) his method of constructing the gun and (3) his breech mechanism. Their arguments seem sound and have, we believe, to a great extent been confirmed by experience. By working along their own independent lines and by lavishly calling to their aid both theory and experiment, the French have succeeded in developing a system of ordnance which stands to-day at the head of the world.

V. *The St. Chamond Steel Works.*—This company employs about six thousand workmen, and manufactures on a large scale iron and steel for railway purposes, and war material such as guns, projectiles and armor plates. The Siemens-Martin process is used, and the plant enables the production of ingots of one hundred tons, and contains appliances in accordance with this magnitude. The company makes a specialty of armor plates. Beginning to be an important factor during the war with Tonquin, this company filled large orders from the government, and since then has constantly gained in importance as a manufacturer of modern armament. Soon after the above mentioned war, the St. Chamond company began to turn out original designs, and since that time has taken a prominent part in the development of ordnance and armor.

Guns.—The company claims the following advantages for their guns and carriages :—(1) Production of their own steel which is amongst the best in the world, and the consequent use of the best metal concerning the history of which they have the most accurate knowledge. (2) Special system of longitudinal reinforcing. (3) Suitable, simple and safe breech mechanism. (4) Compactness and simplicity for carriages. The 275 mm. coast-defense gun, central pivot carriage; the 200 mm. coast-defense gun swinging carriage and the 155 mm. naval gun are amongst the leading guns produced by this company.

Armor Plated Forts.—In 1879 a commission carried out a large series of experiments at Gâvre in connection with the defense of France. Four years work of the commission led to the development of many useful inventions, the most important of which was Captain Mougin's armored casemate with masked embrasures. The experimental casemates were made of St. Chamond steel armor. In this manner Captain Mougin and the company became closely connected. The St. Chamond rolled plates proved superior to all others, and resisted chrome steel and melinite projectiles although the melinite shells destroyed all other targets. Captain Mougin's oscillating turret is the latest result and is manufactured by the St. Chamond company. In its normal position the turret has its two embrasures masked by the armored ring around the base of the dome. All operations of loading and training are done in this position. The dome oscillates forward and backward about a horizontal axis through the center of the platform. The guns are mounted directly upon the platform without regular carriages. By use of gearing the cannoneers tilt the turret and gun back until the embrasures are unmasked. The guns are fired electrically on reaching the correct elevation. Six men can fire two rounds in three minutes.

VI. *The DeBange System.*—After the war of 1870–71 France found it necessary to renew her armament. During this period Colonel DeBange rendered his country important service. He made many improvements in the interrupted screw mechanism, especially in the obturation and finally put the new French field-artillery on an efficient basis. He was the first to use the asbestos compressible pad. His method of shaping and shrinking the hoops, while successful for small calibers failed when applied to sea-coast guns. Many objections to the bi-conic method of shrinking are given; this method is obsolete in France. Large orders from other countries for field-guns have been filled by this company since 1882. In addition orders of considerable size for siege, naval and coast-defense guns have been filled. The Engström quick fire gun is made by this company.

VII. *The Forges et Chantiers de la Méditerranée.*—The gun factories of this company have grown up during the last ten or twelve years. Their guns are all made after the Canet system. M. Canet who is now the director of the establishment, received his training in England in the Vavasseur Ordnance Company. We believe it will be safe to say that he has done more in recent years than any other man to further high gun development. He seems to divine the conditions of future artillery problems with a clear vision, and moves to satisfy them by the most direct route. Seeing the inevitable tendencies of artillery questions he pushes them to their logical consequence, and thus reaches at a single stride, a standard, which by more conservative methods would require years to attain. Thus by casting aside all reverence for relics, there results a system of guns which stand far ahead of any other guns in the world. A fundamental principle of the Canet guns is great longitudinal as well as transverse strength, which enables them to withstand not only maximum normal pressures, but also such abnormal pressures as are frequently produced. Another feature is the breech mechanism already noticed. It is claimed for these guns that high initial velocities are obtained without undue strain. The claim is based upon the form of rifling, the methods of utilizing the expansion of the gases and other special characteristics of the gun. The projectiles are lighter than Krupp's and reach much higher velocities. The advantages of this are in substance as follows: The disadvantage of lightness will disappear at the range of future naval battles, while the shorter Canet projectiles with higher velocities are more destructive against armor plates, and at the same time less liable to break up on impact. The advantages of flat trajectory need no comment. His guns range in length from 30 to 50 calibers with intermediate lengths of 36 and 43 calibers, and in size from 57 mm. to 37 cm. There are two types, long and short for each class. The idea of the company is to supply all possible demands. Initial velocities vary in the Canet system from about 2000 to 2887 f. s. The latest reports inform us that recently a 57 mm. 80 caliber gun developed a velocity of 1013 meters = 3323 f. s. The tests for gun steels, inspections during the gun's construction, and firing trials on the proving ground merit the closest study; for it is only by the most persistent attention to practical details that these guns have reached their marvelous standard. One of the most valuable and interesting adjuncts to the gun factories is the Hoc Polygon. It is connected with the shops by railway, and is thoroughly equipped for all kinds of experimental and proving work. The instruments, interior arrangements and facilities for experiment must be studied to be appreciated. Through a lavish use of the proving ground and its auxiliaries only, have these guns been able to obtain their lead over all competitors.

The Peigné Telemeter is used at the Polygon for long range firing at sea. It requires a horizontal base of 200 or 300 metres, and two observing telescopes carrying micrometer hairs which will measure small angular variations from a zero line with great accuracy. The instruments are so adjusted as to make their zero line sintersect at a distance, say of 10000 metres. A shot being fired to reach (approximately) this range, its splash is observed and the small angular variations from the zero lines measured, and the range plotted or computed. It is claimed that this instrument obtains the range to within a maximum error of forty metres. This fact is said to have been demonstrated many times. Just how it was done does not appear. In our opinion the principal error in such work results from the evanescent nature of the splash. The accuracy with which a range-finder will give the range of a fixed and definite object can hardly be taken as a criterion of the accuracy with which it will give ranges of shots fired at sea. A maximum error of 40 in 10,000 is very small, and we may reasonably doubt that observers can measure the distance of a splash with such accuracy. The Boulengé chronograph, crusher gauge and Sebert velocimeter are used at the proving ground. Field, mountain and siege artillery are treated in detail. The greatest care is given to mounting the guns and checking recoil. Extensive comparisons are made with other systems. Canet mortars and howitzers compose twelve different calibers; each caliber has a long and a short type. Among many other details relating to this subject are the discussions of the 15 cm. mortar and howitzer, and the 22 cm. mortar with special naval mounts designed for use on shipboard. The introduction of these guns into naval armaments deserves careful considerations in connection with our coast-defense problems.

The development of the department of howitzers and mortars is thorough and modern.

Quick-fire guns according to given classification are divided into three classes:

(1) Those firing small bullets.

(2) Those of 37, 47, 57 and 65 mm. caliber.

(3) Those of larger calibers as the 10 and 16 cm. guns.

Canet's success in simplifying all parts so as to secure rapidity of aim and fire is truly remarkable. The breech mechanism has been reduced to ultimate simplicity, recoil almost entirely absorbed or turned to some useful purpose, and ammunition prepared for the greatest rapidity of fire, while the aiming apparatus realizes almost perfect control and mobility.

The application of electrical power to the training apparatus of the 15 cm. quick-fire gun, marks an epoch in modern gunnery. The first practical trial of electricity for this purpose was in the above mentioned gun at the Paris Exhibition in 1889. While this experiment may have been the first in point of time, it will be remembered that our own Navy Department was not far behind in applying the electric motor to an 8″ gun. In the 15 cm. gun the elevating and traversing are done by separate motors. By moving a lever the electric or hand gear can be used at will. The gunner stands in rear of the left trunnion and trains and fires the gun while in motion. The absolute necessity for the fulfillment of this condition in sea-coast guns does not seem to have been grasped; in fact does not seem to have attracted any attention. The electric motor for military purposes is receiving great attention in France. At La Seyne works, a branch of the Forges et Chantiers, hydraulic systems of working turrets in three large ships have been supplanted by electrical systems, and the French Admiralty are turning their attention to the same proposition.

Gun-carriages in this company receive the same attention as their guns, and many tests have proven them to possess equal efficiency. It is not their policy to construct accurate and expensive guns, and mount them on indifferent carriages. The diagrams of pressures in the hydraulic cylinders bear testimony to the excellent manner in which the recoil is checked. The large number of carriages constructed so that the axes of the recoil cylinders intersect those of the trunnions, in some cases lying in the same horizontal plane, is a step forward and shows that old methods are passing away.

Turrets, disappearing carriages and various types of mounts are among the products of the company. These are so numerous that few, if any of them can even be mentioned.

Sighting Devices.—The methods of aiming the Canet guns are extremely interesting and useful. We can mention but one or two, by way of illustrating the thought given to this important part of gunnery.

For coast-defense guns Canet uses the Deport sighting apparatus. A suitable motion to cover the fixed or moving object is given to a telescope; the gun and carriage automatically take up the same motion. For night firing Canet uses an electric sight which involves the use of incandescent lamps. In its latest form two small reflectors give two luminous points of red light; the front sight furnishes a beam of white light which can be accurately ranged between the red points mentioned. The color and intensity of the light varying with the darkness is controlled by the resistance in the circuit.

Torpedo Guns.—Considerable space is devoted to torpedoes, and elaborate illustrations of various appliances relating to them are given. The methods, of turning and fixing them are explained in detail.

Ballistic Tables.—These tables give ballistic and other particulars of Canet guns, manufactured by the Forges et Chantiers de la Méditerranée. The data were obtained at the Hoc Polygon principally with smokeless powder, and are valuable since they show what may be expected from use of these new powders. The tables are similar to those of Krupp, and like his publications, furnish convincing proof of the capacity of modern ordnance.

VIII. *Hotchkiss Machine and Quick Firing Guns.*—This system is more familiar to our readers than the preceding, since some of the Hotchkiss guns are used in our own service. These guns to a certain extent supplement those of Canet and other systems, and as a rule fill positions not supplied by them. In this system we find 37, 40, 47, 53, 57 and 65 mm. guns, while it may be observed that the Canet system does not include calibers below 57 mm. This company therefore supplies machine guns and revolving cannon which occupy an essential place in modern artillery. The Hotchkiss Company however, has not limited its products to the above calibers, but also turns out quick-fire guns of 10 and 12 cm., throwing projectiles of 33 and 55 pounds respectively. They have special designs for military and naval purposes.

The flank defense gun deserves mention. It is a revolving cannon with barrels having different twists, so that the gun will cover the entire width of a ditch. Valuable experiments and data relating to this gun are furnished.

The Hotchkiss ammunition will repay time spent in its careful study. Its efficiency as well as that of the guns does not rest upon theoretical assumptions, but has been several times demonstrated in war. The author quotes several paragraphs, giving the opinions of distinguished officers, which leave no room for doubt on this point. We regret not having sufficient space to reproduce tables showing the ballistic efficiency of these guns.

The following numbers will give some idea of the metal used: Minimum elastic limit, 51,000; minimum breaking strength, 94,000; minimum extensions 15 per cent.

A special feature of the Hotchkiss gun is that it is heavier than rival guns or the same calibre. This excess of weight so checks the gun's recoil that their recoil mounts are much lighter than in other guns. As a result the weight of the gun and mount combined is, in some cases, hundreds of pounds less than that of other guns.

Numerous mounts for torpedo boats, naval and military purposes, armored forts, turrets, traveling forts, Creusé de Latouche system of armored forts, Hotchkiss-Schneider armor clad forts, and disappearing turrets are among the many structures described and illustrated.

IX. *The French Navy.*—Table shows the French navy to consist of three classes of vessels armored, unarmored and sailing; in all 394. In progress 72; proposed 8. These three classes are made up of many sub-classes and types. Specifications for each sub-class and cuts of representative vessels are given, so that careful study will enable one to obtain a good idea of the French navy.

In conclusion we will add that the book is a well bound handsome volume, beautifully printed on elegant paper. The page is about the same size as the page of "Engineering" in which the series originally appeared. It has 458 pages, 58 full page plates, besides numerous small illustrations; amounting in all to more than 700 cuts. Every important device mentioned is thoroughly illustrated.

The work is a comprehensive treatise on modern artillery. While the private firms of France only are dwelt upon, their products are compared with all other prominent systems; so that while the discussion purports to describe French artillery, it practically embraces the artillery of the world. It is a book which every artillery officer should possess not merely as a reference book, but as a text book in which would be studied the underlying principles of modern artillery.

Its study makes one thing clear, that in a future struggle any superiority of artillery of one opponent over that of the other will not be against France if her private firms can prevent it.

The author modestly disclaims any originality in preparing his book. However this may be, he certainly has displayed a remarkable amount of energy in its compilation and in many cases this is a more valuable quality than originality. We think, however, that it is only just to give him credit for some originality for the manner in which he has presented the subject. We find, throughout the matter just reviewed, a high appreciation of the value of these new engines of war, and clear vigorous statement of many conditions necessary to satisfy future artillery problems. The thorough understanding of the functions to be fulfilled by future carriages, especially with respect to accuracy and mobility, and the necessity for nice devices for operating and aiming guns are stated with a force and clearness not promulgated before. We, therefore, believe that the reader who studies the book carefully and understandingly will agree with us that much originality is displayed in its pages.

J. W. R.

History of the Mexican War, by General Cadmus M. Wilcox. Washington: The Church News Publishing Company, Pp. x, 711.

This book gives a very detailed and well connected account of the Mexican War of 1846–7. In its introductory parts the causes leading up to the war are entered into with some detail. However, the General's view of the justice of the war differs materially from those held by Mr. Lincoln and by some northern writers on the subject. The result of the party struggle turning in 1844 on the question of Texas annexation. these contend, was a card forced by our South. Colonel O. Haller, an officer of Mexican War reputation has in a late paper pointed out some of the schemes used to force the conservative Northern element into the acceptance of at least two more southern senators into Congress. The prominent and most threatening one was public meetings held in many places, resolving in case of non-annexation, to separate the free states and form a new republic.

Hence it was natural that the election carried in the interests of home unity should leave much discontent in the north. It is not believed that justice to wronged individual citizens on the one hand, nor injustice to a weak sister republic on the other had much to do with the action of either political party. If United States citizens had suffered much from the Mexican Government, they had had a long time in which to correct it before the recognition of Texan independence.

It is certainly true that Mexico did not keep in good faith its contracts and promises made to the Texan colonists; probably at that time it was impossible to do so. The national church was then in great power and had no tolerance for a protestantism of any strength, and the dominant race, the sons of the Conquistadores, then (as now the chilenos view their German colony) could only look on these immigrants of another race as mere subjects to be governed.

Still our government never felt called upon to exact justice from Mexico for wrongs to these colonists; and these wrongs, real or assumed, cannot be pleaded as justifying our aegis being cast over Texas to protect it from the natural effort of Mexico to subdue its revolt so soon as her political quiet and military strength should justify the attempt. Mexico's internal dissensions kept this effort simply in abeyance. Our annexation, however, cemented these party differences, and some true Mexican patriots thought that Santa Ana, then in exile in Havana, if called back could unite the people, suppress personal feuds, and enable them to make a successful resistance to the United States in this unholy war. Probably in no part of the world at that time was ecclesiasticism so powerful, so unquestioned as in Mexico, and to all but the most enlightened, the feeling was that their religion was at stake.

The author's position that the war did both parties good would be hard to combat. It certainly gave the Mexican a different estimate of the "Gringo" and the Yankee of the "Greaser." It is not probable that we impressed the Mexican with our superior polish for that was not what conquered the war, nor were we impressed with their enterprise for such can never be postulated of unstable governments, but it taught all that war was a very serious business, and that much should be borne before engaging in such a costly luxury; and that as far as racial or individual courage is concerned, enough is always to be found among all people to maintain honor or resent wrong.

All efforts of President Polk "to avoid aggressive war" seem childish in presence of Almontes, the chargé d'affaires, making the act of annexation the basis of his protest in demanding his credentials. The feeling of the Mexican people was also well known. No man could have held power in Mexico for a moment who should consent to the loss of Texas. Texas claimed for her western boundary a large portion of territory that never sympathized with the American revolt, and over which she had never exercised any jurisdiction; so that even admitting the right of that race to revolt, they began the annexation of another people before their own autonomy was completed.

Slidell's diplomacy in bringing up the old claims question was a trick, for the United States had never thought of bringing these up as a cause of war, while the annexation, pure and simple, was understood by the diplomatic world to be the *casus belli*. When Slidell declared the interests of the two countries tó be identical to Peña y Peña, it must have struck him as insultingly ironical. It meant that it was best for Mexico to give up her north east province with its rich pasturages to strengthen the proslavery interests of the sister republic. What a sister! What identity of interests! But Slidell's *congé* was quite as irritating and was no doubt so intended. Mexico was never wanting in the ability of her diplomats.

Peña y Peña also Castillo y Lanzas, all through struck manfully and justly to the clear and simple diplomatic questions involved, while it appeared to be Slidell's policy to mix things as much as possible. We are introduced on page 28 to Slidell's instructions, which absolutely stopped all negotiation on the question of Texan annexation. We were to carry the boundary of Texas as far west of the Nueces as possible, *and to acquire further territory from Mexico as in payment of our citizens' claims against that government* (amounting to some eight million dollars). Here was the main animus of the war—acquisition of slave territory.

The inhuman treatment of prisoners by the Mexicans during their efforts to suppress the Texan rebellion is quoted, and the decimation of the Mier prisoners is possibly true, but those of them who were carried into Mexico were well treated, as were also our prisoners that fell into their hands during the after war. At that time the Mexican character would appear to have been very barbarous and cruel in war, while in peace it always has been hearty, cordial, kind and affectionate.

General Taylor's successes are very interestingly told, and even the old romance of it enjoyed at the time by the cotemporaries, it is found, loses none of its interest under the author's treatment. It is stirring reading, or should be to young America, now.

General Wilcox's admiration for his heroes does not permit him to criticise their acts crowned by success. To an unprejudiced reader of a critical turn of mind, Taylor's campaigns would scarcely be taken as models. His generalship in leaving Point Isabel unfortified and unprotected was criticised at the time severely. The brilliant victories of Palo Alto and Resaca de la Palma smothered comment. It cannot be said that these actions were foreseen or desired by Taylor. On arriving at Fort Brown and fortifying he learned that his supplies were to be intercepted, and fearing for his base he marched his whole force back, with the exception of a ridiculously small force to hold Fort Brown against an unknown amount of opposing ordnance. After strengthening his base he returns, but in that time any enterprising enemy would have fortified, and would reasonably have given a very different result to these actions. The success of Taylor does in no way commend such oscillations from base to objective, objective to base and back again. These movements confess that the impulse to gain the highest point in advance was an error.

The fact that many counselled Taylor to intrench after the battle of the first day, May 8, and await reinforcements before joining issue at Resaca, shows the strait the army was in, since this would have been most surely to the sacrificing of Fort Brown.

We are informed that this battle of the 9th should be called *Resaca de Guerrero* instead of *Resaca de la Palma*. These *resacas* appear to be ravines with water in the season but drying up, and where the country is covered with them, it would be easy to confound the names Similarly in our Revolution, Breed's Hill was called and remains Bunker Hill.

The battle of Resaca is as well described as possible, for from the nature of the ground and the chaparral (meaning a scrubby evergreen—oak thicket, and by extension any thicket), no grand movements could obtain; it was rather a series of detached but sore scrimmages. The previous battle of Palo Alto is well described and with the accompanying map will enable the student to follow the moving panorama of battle. Here fell that noted artillerist Ringgold, who may be called the father of our field artillery; so far at least as horsing our cannoneers. Had it not been for his enterprise, address, birth, social position, and previous high service, which alone could have induced Congress to give this a tangible organization, we would have waited with it on paper alone until 1861.

The old story of poor supplies from home appears here to be even worse repeated on Scott's line. It is not sure that all this was the inexcusable fault of government. The war could not be called a popular one and government was at great pains to be economical. We all remember the old joke reported of General Twiggs, who, en route to the front, stopped to inspect the supply departments at New Orleans and reported of them that "they were sparing no expense to be economical." But of some of the nation's servants at home it is fair to presume dotage. The excess of useless temporary militia forwarded to the Rio Grande by General Gaines without supplies or transportation showed criminal fatuity. These short term men gave rise to the old saying, now worn out; no supplies being sent they were principally fed on the dark bean of the country, the *frijol.* When asked to reënlist, which not one in twenty did, one gave his negative thus: "N'ary another —— blue bean, Capting."

The forward movement on Monterey gives some idea of the difficulties of campaigning in Mexico, only to be much more heavily accentuated in Santa Ana's movements before and after Buena Vista. An arid, grassless country, with no facilities for transportation, movement has to be paid for by the sacrifice of men.

The author hints but remotely at the cause of General Taylor's liberal terms of capitulation at Monterey. It was supposed that our country was at an understanding with Santa Ana (as fully set forth further on in the book) that he should be permitted to enter Mexico and bring about a peace as nearly as practicable on our terms. He passed through our blockade, and such was the disorganization of Mexico that his partisans found no difficulty in due time in placing him in power. But this could only be done by falling in with public opinion, which was for a vigorous defense of national rights. But at the fall of Monterey, and with the acute diplomacy of Ampudia, our hopes of a basis of reconciliation being reached without further bloodshed were good. The author we think, unfortunately for completeness of history, suppresses on page 171 the non-military reasons for the armistice of September 23rd.

General Wilcox gives a slight review of his contemporaries at this time and the eulogy on U. S. Grant does immense credit to the magnanimity of the author's character. From no view does he depreciate that great leader's qualities, while he gives ample credit for all he attained. To revert again to our claims it is hard to agree with the author in assuming that our government had determined to take California from Mexico, war or no war, upon the Texas question. However that may have been, it appears certain that our people would not have tolerated it. We slid into the Texan imbroglio with scarce toleration, but a whole-cloth steal of California would not have carried.

When we come to General Kearney's affair at San Pascual, the author's patriotism makes it easy for us. This reviewer can give a bit of the story from the Mexican side, from the views of a brother of Lieutenant Hammond killed, and from that of Don Juan Largo (or Long John) Warner, whose ranch is named on page 142, and which I think included Aguas Calientes. Mr. Warner had been an old Rocky Mountain trapper of the Kit Carson class. He had fetched up many years before the war in California, and had married a ward of Pio Pico and with her had got the ranch as a dot; the title to which, by the way, was not afterward confirmed to him by our Land Commission: he died very, very poor about 1855. I have campaigned with him and found him a man of most agreeable manners, philosophic mind, able in the field and in the forum. He was thoroughly mexicanized and loyal to the land of his adoption; he had no sympathy with our war of conquest. Upon Kearney's command reaching his ranch its officers were highly incensed at his hostility to the American invasion and treated him as a traitor. He was imprisoned a long time. It was a notable example of how different a thing it is to be an Irishman claiming American citizenship and an American claiming Mexican citizenship. Warner claimed that the Americans were whipped at San Pascual because Davidson's mules and the dragoons' horses had been stolen from him, and the animals being unused to the soft American bit refused submission to it, went where their wills or fears carried them, many into their old pastures, and some into the ranks of the Mexican cavalry. Andres Pico treats the whole affair as a joke, says they never had an idea of more than annoying the "Gringos" as a kind of boastful lark of the young men. It was only when they saw the poverty of the defense that they contemplated anything serious; they had neither infantry nor artillery, merely a lot of gay cavaliers with only the discipline of the ranch and *toreo*. Our surviving officers of the affair resent the charge of defeat but certainly they were penned, famishing for food and water, on San Bernardo hill for two days until relief came out to them from San Diego. The relatives of the dead hold to a defeat. Warner held grievance all his life for imprisonment and the indignities suffered from Kearney's command, for his loyalty to his adopted country — a principle of which every American is so jealous.

It is thought that a reading of this book will show that the ethics of war have improved of late years.

The advice the President vouchsafed to General Taylor as to the means of raising supplies in the enemy's country apart from its impertinence as advice, would be amusing if it did not partake of the gruesome. The author delicately points out its impertinence and plows around what would have been its barbarity in such a lean country as the states of Texas and Nueva Leon at that time. The orders freely but fairly translated were: rob if you can, pay if you must.

The author's rules which should govern the powers at home and the chief in the field are most delicately drawn on page 170 and could not be improved by a Wellington. He skilfully places the *Service* between the country and the President.

Marcy's correspondence with both Scott and Taylor is disrespectful — shows fear and jealousy of their future — tries to belittle their places and "keep them in their place" by curt snubs, and foists on them by well-chosen language the position of fault-finders. First by acts he insults them through ignoring their high rights under their high offices, and then calls their manly protests, thus forced from them, "animadversions"!!! Howsoever great a statesman he was the old "37½ cents" patch on his breeches was a true index of his littleness when occasion should make it appear profitable.

In the delicate matter of Scott's new line of operations calling off Taylor's force, the author is very judicious on the questions then rising between these two chiefs. At the time many thought they saw in Scott's orders a jealousy of Taylor; but one will not find it here and probably none existed. The passages between Secretary Marcy and General Scott on the subject of transportation and supplies before Vera Cruz were then very bitter, however screened by diplomatic gymnastics of language.

On reaching the subject of the battle of Buena Vista, which we are informed by the author is called the battle of La Angostura, he does not criticise it from a military point of view. He contents himself with giving a very fair and detailed account of what happened, and puts in no ifs. His unqualified admiration, however, for "Old Rough and Ready" challenges criticism. Taylor's reasons for being at Aqua Nueva are by no means convincing of judiciousness. It is certain that when the Washington authorities allowed his command to be reduced by Scott, they expected him to place himself on the defensive at Monterey. Had he done so it is not presumable that Santa Ana would have made any advance upon him, but would have flown to the defense of Vera Cruz. Yet we do not find that either Taylor's policy, nor Scott's orders, or our Government's plans were to divert Santa Ana. Taylor's object appeared to be to get as far into Mexico as he dared, but when he found he had to face twenty thousand men from San Luis Potosi, he was far from being prepared for it. To make this preparation instead of meeting the enemy at Agua Nueva where he would have been exhausted by a thirty miles march over a dry *jornada*, he rejected the battle ground through fear of his flanks, retreated to Buena Vista (where he was outflanked) and then left General Wool to hold the enemy, till he (Taylor) with the flower of his troops returned to Saltillo to place it in a state of defense; which one would think should have been done before the forward movement was made. It was the Santa Isabel story repeated. Under this view it can scarcely be called fair on Taylor's part to have made the answer to Wool reported by "Bob" Garnett. General Wool remarked to General Taylor on his arrival back from Saltillo: "General, we are whipped." General Taylor replied, "that is for me to judge." That was not so, they *were* whipped, clearly enough. It was simply Taylor's task to regain the losses by throwing in the overworked and much exhausted troops that he had just brought back from Saltillo with him. As they were choice troops, by five o'clock, p. m., they succeeded in making a drawn battle. Of course it was a victory for us, because Santa Ana retreated that night to Agua Nueva and General Taylor next day to Monterey.

The author's deductions from the battle have not gained universal acceptance. Many *do* consider that Santa Ana's movement showed more generalship than Scott's and Taylor's. Taylor certainly exhausted himself very much in seeking knowledge of the Mexican movements in the direction of Potosi. Taylor had *not* prepared Saltillo against the contingency of a Mexican advance. He was not ready to meet Santa Ana, and Scott had shown no prevision of Santa Ana's movement; assuming that Vera Cruz being threatened would call Santa Ana off. Scott's intercepted dispatches induced Santa Ana to try the scheme of beating his enemy in detail. This he but just failed in in Taylor's case.

There is much false deduction made from this battle of Buena Vista. It is assumed that the Mexicans were four to one. This is founded on Santa Ana's boastful statement intended to appal Taylor. That general marched with 18,000 men probably from San Luis Potosi, but the terrible march to Agua Nueva clearly placed 4000 *hors de combat.* Then Santa Ana made the mistake of attacking before recruiting his wasted muscle and spirit; possibly he feared his enemy's intrenching. Then he reduced those actually engaged by detaching Miñon's cavalry—1500, and a considerable force under Generals Blanco and Arguello. Then it must be remembered that a Mexican force always has a superabnndance of cavalry, which the nature of the ground prevented being of any great weight in determining the action. Taking the two arms, artillery and infantry, which did the fighting and the disparity was not great; certainly not more than two to one. Again, Taylor had the choice of ground, such as it was. Another point we must not forget, that our arms and ammunition were far superior to those of the Mexicans. Their escopete throwing nearly a two ounce copper ball had a greater range, but was not half so easily manipulated as our musket. Their field-guns were of heavier metal, but did not compare in mobility or ammunition with ours. If we take all this into account we will see that Mexico has nothing to be ashamed of in the battle of Buena Vista-Angostura, so far as manhood was concerned.

It is not clear how Scott and Taylor "would still have considered Santa Ana's attack at Buena Vista ill-advised had he even been victorious." Marcy says "the consequences (would be) fatal." The armament of Vera Cruz and San Juan de Ulúa was simply miserable. With a victorious army returning from Buena Vista, it was reasonable for Santa Ana to calculate that he could hold the passes along the Camino Real and pen the Americans in the yellow fever district. Leaving Taylor free to move and holding Scott in check at Vera Cruz would have subjected his own army to the vomito, and permitted Taylor to advance on Mexico as far as he could have supported and fed his army.

The following words may sound a bit odd as written by an active participant in our late rebellion. Speaking of the enthusiasm of the troops at Vera Cruz landing, the author says, comparing it to that roused by Napoleon's appeal to the "forty centuries,"—"but could some master hand have raised not the curtain shrouding dead centuries, *but the veil concealing futurity, and revealed the onward and upward course of the American Union through the nineteenth century, with the states added by their prowess to its field of blue, and its starry banner representing a power and commanding a respect that the mighty arms of Cæsar ana Augustus never won for the Imperial Eagles, what an impetus to heroism would the vision have given!*"

Verily, Wilcox was reconstructed!

An incident is mentioned at the Siege of Vera Cruz which should raise a question of national comity. The author says that on our flag being raised after the landing, it was saluted by the foreign fleets.

As the author was with the first landing party and names his regiment, it shows a little human nature not to designate the "battalion of artillery" with him; not being of his arm they were entitled to but a distant reference. As again, on page 288 at Cerro Gordo he is specific as to Penrose and Davis, Second Infantry, but they were joined by two "companies of the Fourth Artillery."

In the Scott–Trist dispute we find Scott brought out triumphant, while Marcy's special pleadings are contemptible.

Some topographical mistakes are made. It is said that Puebla is the only city from which the four snow peaks of Orizaba, Popocatepetl, Ixtaccihuatl and Malinche may be seen. These four with the Cofre de Perote may all be seen of a moonlight night from a bastion of the Castillo de San Carlos de Perote. Again, he says on page 339 that the troops had in front of them (marching from Puebla) Popocatepetl "seen daily for five months since the army came sailing down the coast, &c." Orizaba can be seen, sailing down the coast as soon as it is uncovered by the high plateau of Perote, but Popocatepetl can not be seen till the plain of Perote is reached.

A fine delicacy prevents the author from calling the San Patricio regiment of deserters "Irishmen," supposedly out of deference to the many Irishmen loyal to our colors. But we do not see anything to be gained by this suppression. When seeking for their motive we have to discard that of avoidance of fighting, for they fought their best at Buena Vista, Cerro Gordo and Churubusco. We must discard their hope of ultimate success against the American arms, hence, their desertion must have been due to a desire to change their nationality and make themselves appreciated by their newly adopted country. The religious question may have affected a few fanatics.

Space will not permit us to follow the author farther. He leads us well and minutely through as stirring, romantic and chivalrous events as ever graced history. To review it, could only be done favorably, but it would be rewriting the book, which can honestly be commended to the reader wishing to learn what the American of 1846–7 was. The politics and diplomacy involved, and General Scott's position are very fully discussed.

More care might have been shown in the "get-up" of the book. It is fully illustrated with the portraits of the noted offibers. All of the brigadiers have major general's grouping of buttons, showing that they were taken in after life. There is great looseness in the orthography of Mexican names. Why is is it that we would all be ashamed to misspell a French word, while we halt not at a Spanish one; chapparal is always written for *chaparral*; Santa Anna for *Santa Ana;* pupagullo for *papagayo;* burita for *burrita;* rincoñada for *rinconada;* Goatzacoalcos for *Coatzacoalcos;* Ioachim for *Ioaquin* and Cuanhtitlan for *Cuahutitlan*. Some of these no doubt would have been corrected had the author lived to publish the book, such as ventoro for *ventose*.

For an educated military man he is very fond of "*grape*." Light batteries are always firing "grape." The enemy is within "grape range" and whole platoons go down under their grape and canister. "Thomas and French at close range used grape;" "O'Brien's and Thomas' guns opened upon it with grape, etc." The "A little more grape Captain Bragg" from an old infantry colonel becomes very probable under this evidence, since it is used by a man then fresh from his West Point studies, and now writing after a generalship in the late Confederacy.

A very useful roster of the officers engaged in the Mexican War is given at the end of the book in which are some errors; some probably unavoidable. General Canby is reported as "killed in action with Modoc Indians," instead of having been treacherously assassinated under a flag or truce in an unarmed conference. Norvin H. Goff of the First Pennsylvania is reported as "assassinated at Perote, Mexico." The inference that he was assassinated by Mexicans should be prevented by the truth, that he was assassinated by a friend in cold blood, Captain Hervey of the Georgia Battalion, who it is believed escaped all punishment. The author gives eight members of the class of 1847 as in Mexico; Cullum gives thirty-six. He credits Lieutenant Braden, Secretary Association West Point Graduates for his information.

The maps though evidently prepared by the author with care are miserably executed in print, very irritating by their indistinctness and coarseness of execution. The typography is excellent and the style very readable; no complicated sentences are aimed at to leave the reader in confusion. His fairness to all concerned leaves an excellent impression of the author's character, and upon the whole it is a book that was needed in the History of the Mexican War.

JOHN HAMILTON,
Colonel, U. S. Army.

Professional Papers of the Corps of Royal Engineers. Edited by Captain W. A. Gale, R. E. Royal Engineers Institute Occasional Papers. Vol. XVI. 1890. Chatham, 1891. Pages, 260; plates, 46. — Vol. XVII, 1891, Chatham, 1892. Pages, xvi and 238; plates, 54; figures, 171.

The duties of the Royal Engineer officers are even more various than those of the Corps of Engineers of our army. The civil engineer as a rule applies himself to one branch of the profession; he is a hydraulic, a railway, a sanitary engineer, &c. But the royal engineer besides his military duties, the actual command and superintendence of men, may have to turn his attention to any branch of engineering, to superintend works of the most diverse description, such as the construction and repair of fortifications and barracks, the survey of the Kingdom, the management of a number of scientific and experimental establishments, the development of all the scientific appliances of war and the construction of civil works.

The value of these professional papers is well set forth in the preface to volume I of the Professional papers of the Corps of Royal Engineers published in 1837. "The duties both civil and military which are imposed upon officers of engineers, are so various in their character, and require so extensive an acquaintance with both practice and theory, that any individual officer can hardly be expected during the course of his services, to make himself completely master of all the details of the subjects which may be brought under his notice. He must, of necessity, refer to the experience of others, and it is one of the advantages of the Corps of Royal Engineers and of other bodies similarly circumstanced, that no jarring interests, or professional jealousies, can interfere to prevent one officer giving to another, when required, any advice and assistance in his power. It may, and indeed does, however, often happen that an officer when called upon for his opinion and advice, or ordered to execute some new work, may not have it in his power to refer to the experience of others for assistance; occasions of this kind have frequently given rise to suggestions for the publication of a professional work, in which should be embodied the experience of individuals; and which, being circulated among the officers of the Corps at large, would serve in some measure to remedy the inconveniencies which arise from the mode in which they are scattered over the world, and which puts a stop to that freedom of intercourse and interchange of information which would otherwise take place amongst them. At the same time, however, that this effect is produced, some advantage is gained by the difference in character and amount of the practical information found in different parts of the world, and which advantage will appear in a more prominent point of view, should means be taken to make the information generally known.

Conscious of this, a meeting of several officers was held at the Royal Engineer office, for the purpose of considering the details of a plan proposed for the above objects &c., &c.,"

In the preface to volume VII of the same series itis stated that "professional information should be looked upon as a species of common property held by the individual for the benefit of the Corps at large, and as no opportunity should be lost of increasing the amount of this common property, so the readiest means should be taken of communicating to others their share therein and I trust that officers will avail themselves of the 'Professional Papers' for this purpose."

It is unfortunate that our Corps of Engineers is so small and its duties so numerous as to preclude the publication of professional papers concerning their work. They would be of vast benefit to the young engineer officer whose instruction both at West Point and Willets Point is almost purely theoretical and who, as a consequence, gets no conception of how to carry on a work.

Volume XVI contains numerous papers of interest to the engineer and artillerist as well as to the service at large.

Colonels Saville and Hulton treat of the question of mobile infantry, the former of cyclist infantry and the latter of mounted infantry. Colonel Savile speaks of the difficulties usually met in introducing innovations into the military service and tells of the introduction of cyclist soldiers into the English service, not as couriers alone, but as fighting troops, formed as sections of volunteer battalions, and as separate corps. Types of cycles for military use are discussed and the service of the cyclist troops during English manœuvres in all conditions of weather and roads is recorded.

From these experiences he maintains the value of cyclist sections as mobile troops and their ability to accompany cavalry or artillery over such roads and at such speed as are practicable to these troops. Their availability for cross-country work together with other advantages and disadvantages for all services are also set forth.

Colonel Hulton begins by defining mounted infantry as infantry *pur et simple* so trained and organized as to be capable of receiving increased means of locomotion whereby they may act as infantry when great mobility and rapidity of motion are necessary, in contradistinction to Mounted Rifles, who are horsemen trained to fight on foot and who are intended to perform all the duties of cavalry except that which may be described as the shock.

The use of mounted infantry from ancient times, the unserviceability of cavalry for dismounted fighting, their inability to maintain a mounted contest against the superior fire power of infantry and the necessity of mounted infantry able to act freely under all circumstances without the support of slow moving infantry are all set forth. The value of masses of mounted troops able to act independently of the other arms is shown by citing various examples, including the numerous raids during the rebellion. The attempts made in different armies to combine the fire power of infantry with the rapidity of motion of cavalry are described and the results given.

Captain C. Orde Browne has a paper on guns and armor, devoted to the armor plate trials at Annapolis and Ochta, and a programme of experiments carried out near Magdeburg by Gruson with (1) mountain and quick-fire guns: (2) fortress guns on casemate carriages; (3) fortress guns on shielded mountings; (4) naval guns; (5) turrets. After mentioning the limitations of rapid-fire guns for field use, owing to inability to control the recoil, Captain Browne says that at the supreme moment however, as in the case of a rush at the battery when accuracy is not necessary, a small recoil may be disregarded. A fair instance of this occurred during the programme noted when a 5.7 cm. (2.24") gun fired case at cavalry targets 1800 m., discharging eleven rounds in fifty-one seconds. At the end of eleven rounds the piece had moved back six and one-half metres; but the gunner had been able to keep close to the trail and to see that the gun pointed fairly enough in the desired direction so that the cavalry targets were well riddled. This rapid discharge at a critical period is a function of sufficient importance to secure the adoption of quick-fire guns and, with this in view, there is a value in a maximum rate of speed such as may otherwise appear unnecessary and impractical.

In the case of shielded mountings and turrets, whether with quick-firing or ordinary guns, the main consideration is protection against heavy fire. In fortresses there exist points where, in a limited space, it is very desirable to place a piece which plays on an important part and on which the besieger's fire will be concentrated. In such a case a gun in a disappearing shielded mounting or turret may be of great value. There are places where, as an alternative, a gun might be fairly concealed, especially with smokeless powder; but in a regular siege concealment soon comes to an end and protection is then better than concealment. Descriptions are given of various shields; including turrets, shielded mountings, disappearing shielded mountings, shielded emplacements and movable shielded mountings: which last were largely the subject of the Gruson trials referred to. It is to be noted that smokeless powder was used in these trials.

Other papers in this volume are those on the treatment of sewage, road-making, hydrographic surveying, mobilization of forces, military posts in Burmah, electromotors, petroleum as a producer of energy and bridges in the Bengal Presidency.

The papers are all freely illustrated and the volume closes with a series of thirty plates of service ordnance and carriages — field, siege and garrison — both recent and otherwise. These plates must prove of much value to the English engineer and artillerist, if we may draw any conclusion from the need felt for a similar publication in our own service. From them we may at least see what others have done and are doing, if still in the dark as to our own weapons.

Volume XVII. This volume contains but one paper, which treats the subject of sanitary engineering. The editor states that recent inquiries into the sanitary condition of some English barracks have shown that this branch of engineering merits a place second to none among the many duties that fall to the lot of a royal engineer.

The author has endeavored to present in a concise form, information on sanitary engineering. He could find no one book that treated of it as a whole, and thus quite a library was consulted before the general opinion of experts could be deduced.

The various chapters treat of sewage disposal, collection and removal, sewerage, construction and materials, ventilation, traps, apparatus, surface water collection, subsoil drainage and sanitary notes.

The object of sanitary engineering is to promote the healthiness of any locality by the proper removal of those conditions which are hostile to it, and in supplying those which are necessary to health, such as pure air and water; a pure subsoil must of course be secured. The ventilators, warming and lighting of inhabited buildings, although important branches oi sanitary engineering, are not touched on in these notes.

It is most essential to health that adequate means be provided for the efficient removal of all decomposing refuse, as well as the foul water from houses and factories. Care must be taken to select a system which adapts itself best to meet the particular circumstances of the case, both as regards efficiency and economy. Six methods are named, viz: 1. The dry earth. 2. Discharge into the sea or tidal estuary. 3. Irrigation. 4. Filtration. 5. Precipitation. 6. Destruction.

Many engineers of high standing maintain that where practicable, the sea or the tidal estuary of a river is the right place, as no costly works are then necessary. Careful observations must however be taken of the tides and currents in the vicinity before a good system can be devised.

Inasmuch as all towns are not situated near tide water, other systems must be employed.

It was formerly believed that sewage might be made to pay for itself by utilizing it on farms, but the method of disposing of it by irrigation cannot be made a profitable undertaking. If a small area of land is used in the method of filtration, it must be constantly aerated by digging and ploughing.

Precipitation is more properly called the chemical treatment of sewage and is now coming into great use. A vast number of processes have been tried of which desciiptions are given to the author. The lime process costs about eight cents per annum. Webster's process for the electrical purification of sewage gives very promising results, both as regards the purity of the effluent and the eventual cost of the process.

The disposal of sludge and dust is always a great difficulty. It may be treated by evaporation or mechanical treatment, and requires special apparatus.

After the method of disposal has been decided upon, a system for collection and removal must be selected. Water-carriage is undoubtedly the best method. There are four varieties—the combined, a modification of the combined excluding subsoil water, the absolutely separate system, the partially separate. The pneumatic process is a special one used on low sites to force the sewage up to a natural outfall. Where a dry method is in force for the collection of the excrementitious matter it is called interception, and there are a great variety of appliances for effecting it, such as pails, tubs, &c. Under this head are included cess pits, as they have to be periodically emptied.

The absolutely separate system is undoubtedly the most perfect when carried out in its entirety, the great advantage being that the number of traps required to prevent the escape of dangerous gases from the foul water drains is reduced to a minimum.

The Rivers Pollution Commissioners defined the term sewage, as being applicable to water mixed with any refuse that may affect public health; which may consist of a variety of matters, some held in suspension and some in solution.

Drains may be defined as conductors for carrying off liquids of any kind in any position, but understood to refer specially to underground pipes of metal, stoneware, brickwork or concrete. The main drains from one or more houses are termed sewers.

Having selected the system on which the drainage of any particular locality is to be carried out, the plans should be carefully prepared and the details of outlets, gradients, manholes, &c., worked out. The author explains the usual practice in these details. As a general rule the water consumption may be taken as affording a constant daily supply of sewage of equal amount. Neville's and D'Arcy's formulæ for discharge of pipes, &c., are given.

Under the head of construction and materials the author gives details of pipes, gradients, method of laying joints, &c., for small and large sewers.

One of the most important subjects to be considered is the sewer gas generated in the foul water drains. Sewage which has begun to decompose is more dangerous than when fresh. It should, therefore, never be more than twenty-four hours in finding its way to the outfall. A quick velocity of discharge and ample flushing arrangements are therefore desirable. The principal points to be observed in ventilation are simplicity of parts, admission of fresh air and cheapness. Traps are used to prevent the passage of sewer gas in a particular direction through a pipe or elsewhere and should of course be self cleansing. Descriptions and figures are given of the traps for W. C.s and sinks in common use. Descriptions are also given of apparatus for baths, W. C.s and Latrines, along with the essentials of a good W. C. apparatus.

Urinals inside buildings are very objectionable from a sanitary point of view, as it is difficult to prevent their becoming offensive.

The author dwells upon the importance of sub-soil drainage in the erection of barracks. These drains should not be less than four feet under ground. Their location and construction require careful treatment.

Buildings should always have a damp proof course, and a layer of Portland cement four inches to six inches thick should be laid on the ground under wooden floors to prevent damp from rising and the growth of fungus. Ample and thorough ventilation should be provided under all floors.

Disinfection is more a matter for the medical department, but the author gives the best methods for disinfecting rooms.

GEORGE A. ZINN,
1st Lieutenant of Engineers.

BOOKS RECEIVED.

Aide-Memoire de l'officier de Marine, by E. DURASSIER and C. VALENTINO. —*L. Baudoin, Paris,* 1892.

The Resistance of Guns to Tangential Rupture, translated from the Russian by 1st Lieutenant T. H. BLISS, 1st Artillery, A. D. C.—*Adjutant General's Office.*

Die Militaer-Feuerwehr, by Captain A. G. VON EICHENSIEG, Engineer Staff. —*Issued by the Royal and Imperial Technical and Administrative Committee. Vienna,* 1892.

SERVICE PERIODICALS.

Revue d'Artillerie.

March.—Preparation of a regimental battery for war service. Notes on the field-piece of the future (continued). Summary of the principal experiments carried out by the Austrian Artillery in 1889 and 1890.

April.—On the conditions of stability of oblong projectiles. Summary of the principal experiments, &c. (as above, continued). Note on the general method of battery-fire against troops. The 9-cent. pointing arc, model 1890, of the Austrian Artillery.

May.—On the conditions of stability of oblong projectiles (conclusion). Quadrant-aiming and the designation of objectives for direct fire in the field. Drill regulations for the instruction of the German Foot-Artillery. Notes on the field-piece of the future (continued).

June.—Fire regulations of the Russian Field-Artillery. A conchylioid level. Notes on the field-piece of the future (conclusion).

Revue Militaire de l'Etranger.

March.—The great manœuvres of 1891 in Austria-Hungary. The road to India through Canada. The field-piece of the future according to the theories of General Wille.

April.—The great manœuvres of 1891 in Austria-Hungary (conclusion). The recent campaign in Chili.

This campaign deserves special attention, as being the first to bring out the properties of small-caliber rifles. One-third of the Congressionalists were armed with the Mannlicher. Some facts attract attention. Even with 180–200 rounds per man, the Congressionalists fell short of ammunition after firing *an hour and a half*. But it must be recollected that the troops were undisciplined. Losses due to the Mannlicher were 56 per cent. of the whole instead of 33 per cent.

Volleys or skirmish fire at 1000–1600 metres completely swept the field and arrested the initative of the enemy. Fire directed at 600 m. against a line of skirmishers, caused disorder in reserves posted 1000–1600 in rear. Physiologically, the Mannlicher either killed outright or produced easily cured wounds.

New organization of the Roumanian Infantry and Cavalry.

MAY.—Exploration exercises of the Italian Cavalry in 1891. The German Navy and the budget of 1892–93 .

Revue du Genie Militaire.

JANUARY–FEBRUARY.—Military balloons at the great army manœuvres of 1891. Mechanical procedure for the rapid construction of railways. Note on the housing of troops.

MARCH–APRIL.—The fortifications of Dantzig during the French occupation. Memoir of Colonel Goulier.

Revue Maritime et Coloniale.

JANUARY.—Gyroscopic horizon. Method of re-heading ship boiler-tubes. Dynamical oceanography. The English Naval manœuvres, 1891.

FEBRUARY.—Gyroscopic horizon (conclusion). The ancient troops of the navy (1622–1792). Vocabulary of powders and explosives. Councils of administration in military ports.

MARCH.—Problems of the British Empire. The employment of the single or double log "moulinet." The recent great naval war.

"A Battle of Dorking" view of the next naval war, being a translation of the greater part of Nelson Seaforth's now well known work.

Councils of administration in military ports.

APRIL.—Dynamical oceanography. Considerations on the relations between the barometer and the distribution of winds. A study on the mechanical theory of heat. Vocabulary of powders and explosives (continued).

MAY.—A study of the mechanical theory of heat (continued). The German Navy. Aerial voyages of great duration: balloons and the explorations of the African Continent. English Naval budget, 1892–93.

Revue du Cercle Militaire.

MARCH, 6.—Notes on Austro-Hungarian Army (continued in March 13th, concluded in March 27). Antiseptic treatment in the service (continued in March 20th, 27th and April 3rd, concluded in April 10th).

MARCH 13.—Interior life in the English Army.

MARCH 20.—Fire from horseback in Russia.

APRIL 3.—Practical instruction at the General Military Academy of Toledo (concluded in April 10th). A study of infantry tactics (continued in April 10th and 17th, concluded in April 24th).

APRIL 17.—Use of railways in Turco-Russian War (continued in April 24th and May 1st, concluded May 8th).

APRIL 24.—Recent fire instruction in Italian Army (conclusion May 1st).

MAY 1.—The "Lava" of the Cossacks and their method of fighting (continued May 8th, 15th and 22nd, concluded May 29th.

By "Lava" is meant the peculiar formation and charge of Cossack troops.

MAY 8.—The labors of the Geographical Service in 1890–91 (concluded May 15th).

JUNE 19.—The *Royal Sovereign*.

Revue Militaire Suisse.

JANUARY.—Artillery in the *corps d'armée*. The Swiss in the service of France and the memoirs of General Marbot. Supplement: The war in Spain, being unpublished recollections of General Jomini.

FEBRUARY.—The Swiss in the service of France. Supplement (as above.)

MARCH.—The Swiss in the service of France, and the memoirs of General Marbot. Note on shelter tents. Supplement:—The war with Spain, from the unpublished recollections of General Jomini.

APRIL.—The Swiss in the service of France and the memoirs of General Marbot (continued). Supplement:—Map for the study of the Russian campaign of 1812.

Mittheilungen ueber Gegenstaende des Artillerie-und Genie-Wesens.

THIRD NUMBER.—The armored-turrets of the forts of the line of the Meuse. Beton constructions in the works of the Meuse. A study of pointing arcs.

FOURTH NUMBER.—On the determination of the percentages of expected hits. The fortifications of the French–German frontier. The means of protecting fortifications against sudden attack. Indirect fire over masks not permitting the plane of fire to be directly marked out. On explosions in air-free space, and vacuum drying-apparatus.

FIFTH NUMBER.—The strength of steel-bronze tubes. The 6.5 mm. repeating rifle. On aluminium.

Archiv fuer die Artillerie-und Ingenieur-Offiziere.

JANUARY.—The participation of the foot-artillery in the greater army exercises in target-practice. The combat of the English Fleet with the coast fortifications of Alexandria, on July 11th, 1882.

FEBRUARY.—Schliemann's Troy. The old and the new powder. A review of a work with this title by Dr. B. Lepsins.

MARCH.—The evolution of the German Field-Telegraph.

APRIL.—A contribution to the history of the Moncrieff system in England. Siacci: on the resistance of the atmosphere, and the problem of curved fire. The extension of ballistic tables.

MAY.—Iron ramrods and pointed bullets in the 15th century.

Internationale Revue ueber die Gesammten Armeen und Flotten.

APLIL.—The Grand Duke Louis IV of Hesse as a leader in 1870–71. The Krupp 30.5 cm. gun (L. 35) on a hydraulic naval carriage. The battle of Wörth. The strategic use of cavalry in modern times. Naval kriegsspiel. French manœuvres, 1891.

MAY.—The present condition af German sea-coast fortification. Essential points in military chorography (concluded in June). The strategic use of cavalry in modern times (continued). England's position of power and its defense (continued in June). March and combat tactics of a *corps d'armée*. The reorganization of Spain's military system.

JUNE.—The Imperial Diet and the Navy. The future of torpedo-boats.

A conservative paper sounding a note of caution in regard to the future of torpedo-boats. In the opinion of the author the great speed of battle-ships and cruisers, and the rapidity of their fire have neutralized the importance of torpedo-boats, especially as these working always at high pressure, have but a limited radius of action. It is as vedette-boats and coadjutors in the defense of sea-coast works that they will prove of greatest value.

The modern combat (conclusion). The strategic use of cavalry in modern times (conclusion). Russia's war resources in Asia. The present condition of the fortifications of Copenhagen.

Jahrbuecher fuer die deutsche Armee und Marine.

APRIL.—Statistical and tactical considerations on the three great battles around Metz, in August 1870–71. Use of railways in the war of 1877–78. On the tactics of the future: supply of ammunition in battle: losses. The moral influence of smokeless powder on combatants.

MAY.—Why are questions on the organization, training and use of cavalry answered only in theory? Smokeless powder and siege warfare. General Dragomiroff on the value of the *armes blanches*.

Memorial de Artilleria.

JANUARY.—Fuses. Applications of electricity to artillery. New projectiles for all classes of rifled fire-arms. Doubts on explosives.

FEBRUARY.—Sea-coast artillery. War-ships.

A series of papers on the characteristics &c., &c., of war-ships, from the point of view of a sea-coast artilleryman.

Electric light apparatus for artillery service. A single projectile for field-pieces. Fuses (continued).

MARCH.—Improvement of the Krupp-Rubin fuse. Sea-coast artillery. War-ships. Applications of electricity to artillery. Modern military small-arms and their ammunition. An opinion on the German Artillery. The progress of ærial navigation.

APRIL.—A single caliber for field-artillery. Notes on hydraulic recoil checks. Sea-coast artillery. War-ships.

MAY.—A study of a trace of hollow projectiles. Primers. Mixed schools of practice of artillery and engineers. Installation of 24 cm. guns in the new battery of San Francisco, Fort Santa Cruz, Teneriffe.

Boletin del Centro Naval.

FEBRUARY.—Trial of Canet 32-cm. guns, L. 40, mounted in barbette turrets. The coast of Patagonia.

Proceedings of the Royal Artillery Institution.

APRIL.—The operations in Virginia in 1861–65. Field-artillery fire, Chapters V and VI. Quick-fire guns in harbor defense.

MAY.—Notes of lectures on artillery in coast defense, Part I. A suggested improvement in mountain artillery transport. Field artillery fire, Chapters VII and VIII. Range indicator dial.

JUNE.—Some notes on applied field fortification. Experiences at Okehampton. Field-artillery fire, Chapters IX, X and XI. Notes of lectures on artillery in coast defense, Part II. Notes on Egyptian Artillery.

Journal of the Royal United Institution.

MARCH.—An attempt to estimate the probable influence of the introduction of quick fire guns on naval tactics and construction. Military ballooning. The training of our seamen.

APRIL.—The telephone at home and in the field. The reconnaissance of a railway. Naval prize essay, 1892. The employment of photography in reconnaissance. Modern rifle bullets and their effects.

MAY.—Pigeons for land and sea service. Military band organization. Field howitzers and mortars.

Army and Navy Gazette.

MARCH 12.—Imperial defence.

APRIL 2.—Lord Wolseley on compulsory service.

APRIL 9.—Coast fortress defence.

APRIL 23.—The training of field artillery.

MAY 7.—Waterloo letters. (Siborne's.)

MAY 14.—Torpedo-boat warfare.

JUNE 4.—National defence.

United Service Gazette.

MARCH 19.—Artillery fire discipline.

APRIL 2.—Lord Wolesley and compulsory military service.

APRIL 9.—The shooting of field artillery.

APRIL 16.—Field howitzers and mortars.

APRIL 23.—Quick-firing guns.

MAY 14.—Torpedo boats in war. Aërial machines in war.

MAY 21.—Improvement in mountain artillery transport. Organization of the railways for war.

MAY 28.—Imperial defence.

JUNE 11.—Magazine rifles.

Journal of the Military Service Institution.

MARCH.—Position finding service. Army transportation. Was Gettysburg decisive. Artillery service in the rebellion. Infantry fire. Shrapnel fire. Power of military courts to punish for contempt.

MAY.—The military geography of Canada. Artillery in the rebellion (continued.) A plea for the colors. Diseases which have been epidemic in armies. Post schools in the army.

Hamersly's United Service.

APRIL.—The building of the soldier. A lesson from history. Riots and means for their suppression. Company discipline. Marbot.

MAY.—Wagon and rail transportation. Civil employment of troops.

JUNE.—The attack on Pine Ridge agency. On our army.

Army and Navy Journal.

APRIL 2.—The pros and cons of lineal promotion.

APRIL 16.—Army legislation.

MAY 7.—American jingoism.

JUNE 11.—The value of torpedo boats.

Engineering.

March 25.—Modern United States artillery. (Continued April 1, 8, 15, 22 and 29. May 6, 13, 20 and 27. June 10.)

April 1.—Canet vs. Krupp guns.

May 20.—Canet vs. Krupp. (Continued June 3; concluded June 10.)

Official Gazette, U. S. Patent Office.

June 21.—No. 477,492. Projectile, by Laurence V. Benét, Hotchkiss Ordnance Company, limited.

Railroad and Engineering Journal.

April.—Wire-wound guns. Sea-coast batteries. Interior line along the Atlantic coast.

May.—Sea-coast batteries.

Iron Age.

April 14.—The firing speed of machine guns.

Tests of Maxim gun with various cartridges. Effects of rapid fire. Relative rates of different guns.

April 21.—Torpedoes.—Classified and described.

April 28.—Watervliet Arsenal.

May 5.—Manufacture of gun-cotton.

May 19—The Sellers turning and boring lathe for 16 inch B. L. R.

May 26.—Making projectiles for the government.

June 9.—Breech mechanism for heavy guns.

June 16 and 23.—The recent development and progress of gun manufacturing in the U. S.

Development within last nine years. Supersession of built-up gun not impossible. Erosion to be prevented by mechanical treatment. Reduction in number of parts. 16 inch guns advocated. Nickel steel for guns.

Engineering Magazine.

May.—War a hundred years hence.

June.—Testing guns at Sandy Hook.

Journal of the Franklin Institute.

April.—Manufacture and uses of aluminum. Philadelphia as a sea-port.

MAY AND JUNE.—The development of American armor plate.

A paper prepared from standpoint of the metallurgist and not from that of the military engineer. Historical sketch. Compound steel and alloyed steel armor. Recent competitive tests and deductions therefrom.

Scientific American.

MARCH 26.—British war-ship Ramillies.

APRIL 9.—Parker's rifle sight.

APRIL 16.— Plating the monitor "Monterey." Hamner's intrenching tool.

APRIL 23.—Engines of the "Montery." Military ballooning. Photographing bullets.

APRIL 30.—British cruiser Edgar. Ericsson's Destroyer and submarine gun. Range of war-ship guns.

MAY 7.—Naval gun foundry at Washington. New cruiser Raleigh. Turrets of the Monterey.

MAY 14.—Elswick disappearing gun mounting. Photographing bullets. Big armor plate saw. Controlled torpedoes.

MAY 21.—New gun-boat Castine. Fast ships in prospect.

JUNE 4.—Tests of new armor plate.

JUNE 11.— Magazine guns. Progress at the National gun foundry.

JUNE 25.—The chronograph for measuring velocity of projectiles.

JULY 2.—Union Iron Works, San Francisco.

Scientific American Supplement.

MARCH 26.—Open hearth steel castings. New Greek turret ship Spitzia, claimed to be the most powerful war ship of its size afloat.

APRIL 2.—Explosion of dry torpedoes.

APRIL 9.—H. M. S. Blenheim. The cruiser Fronde.

ARIL 16.—Military appliances of olden time. Method of transporting artillery, incendiary apparatus, pontoon bridges and other engineering appliances.

APRIL 23.—The French armor-clad Neptune.

MAY 7.—New practice cruiser George Bancroft.

MAY 21.—The torpedo detector. English apparatus which gives an alarm when a torpedo is approached, without requiring contact. Manufacture of powder and nitrated explosives.

MAY 28.—A 4,000 ton forging press. New French torpedo cruiser Wattignies.

JUNE 4.—The British war ship Blake.

JUNE 11.—A giant light-house lens ; an 800,000 candle power light designed for the Head of Kinsale: largest lens ever made. The German emperor and his navy ; with typical illustration of a fight between torpedo boats and iron-clads.

JUNE 18.—Engines of U. S. cruiser New York.

JUNE 25.—H. M. first-class cruiser Gibraltar.

American Journal of Mathematics. VOL. XIV, NOS. 1 and 2.

Journal of the American Chemical Society. MARCH.

Western Electrician.

Electrical Review.

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JOURNAL

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ELECTRICITY AND THE ART OF WAR.

BY FIRST LIEUTENANT C. D. PARKHURST, FOURTH ARTILLERY, U. S. A.

Advancing from the earliest dawn of history to the civilization of the 19th Century, every step in man's progress has been attended by an increase in the means and appliances available for war. Though the grand underlying principles of strategy may be immutable, their application varies from age to age. Tactics constantly change as each new invention and each new application of the arts and sciences of civilization gives wider and wider scope to the handling of men.

Without pausing to examine the means and methods of ages past, we come directly to the present, with our wide spread civilization and hordes of fighting men. To fully enumerate the various arts and sciences now available for the art of war, would be to recapitulate each and every art and science that makes our civilization possible. Among these however we may select those that have the greatest prominence; as such we have steam and electricity.

With steam the locomotive became a possibility and an accomplished fact. With electricity our vast network of railroads became practicable. These two sciences are inseparable in our modern railway, and our present civilization would be impossible without either. Annihilate the telegraph, and our modern railroad would sink at once to a lame and feeble service until some equally good and reliable system of signaling could be devised; our vast system for interchange of news and ideas would vanish, and we would be forced back a century in our means and methods for ordinary business or war.

The locomotive, whose movements are controlled by the click of the telegraph sounder, becomes thus as much an engine of war as the heaviest piece of modern ordnance. With steam and electricity we are able to effect concentration of men, supplies of food and munitions of war, and conduct operations upon a scale that may embrace a continent. By their aid Sherman's Atlanta campaign and his march to the sea became possibilities. With like aid Napoleon's Russian campaign might have been as brilliant a success.* Without them Sherman could hardly have been successful in his Atlanta campaign. With them Napoleon might have conquered a continent.

The importance of the electric telegraph in war cannot be overestimated. Grant while Commander-in-chief was in daily, yes, hourly communication with his subordinates. From his headquarters on the Rappahannock and at City Point, he controlled and directed the movements of 600,000 men, divided into eighteen armies, operating over 800,000 square miles of territory. The grand combinations outlined in his despatches to his subordinates in April 1864 and January 1865, would have been impossible without an instrument which kept him constantly advised of the progress of events. From Atlanta, Sherman communicated with Grant 1500 miles away, submitting his situation with his long line of communication threatened by an active enemy. By the telegraph the plan of the march to the sea was discussed and authorized, and by telegraph instructions were given looking to the accumulation of supplies to meet him upon the coast.

* See Improvements in the Art of War. Captain F. V. Greene, Journal Military Service Institution, Volume IV, No. 13.

Without the telegraph Sherman at Atlanta must have been left to his own resources. No provision could have been made for his reception at Savannah, and in fact his and all the other vast operations of our Civil War would have been impossible as combined operations.*

The telegraph is now recognized as an indispensable part of the equipment of every army in the field, and the instances of its use are absolutely innumerable. During the last part of the Civil War over 3000 miles of line were constructed, 2000 miles taken down or abandoned, and 6000 miles were in operation at the close of the war.† It is estimated that from the commencement of the Rebellion to the 30th of June, 1865, there had been constructed and operated about 15000 miles of U. S. Military Telegraph—land, submarine and field lines.‡

If the influence of the telegraph was not as seriously felt in the Franco-Prussian War, it was not because its importance was not recognized, but rather because of the comparatively small field. Without it however, the mobilization and concentration could not have been effected in the short time from July 16th to August 3d. Similarly in 1866 the telegraph enabled the mobilization and concentration to be effected between May 3rd to May 16th and May 16th and June 5th.

On the latter dates an army of 197,000 men 55,000 horses and 5300 wagons was concentrated upon the frontier of Bohemia. On August 3rd 1870, an army of 440,000 men, with trains and material complete was assembled upon the frontier of France, and the movement across the frontier began the following day.§

Throughout this war (Franco-Prussian) the telegraph was of inestimable value in many ways, besides keeping up the communications with the base and the home government, and contributed in a marked manner to the German success. At the siege of Paris the wires were carried up to the advanced line, and without them this decisive operation could hardly have succeeded; for

* See Greene's Improvement in Art of War.

† Greene's Improvement in Art of War.

‡ Annual report of the Secretary of War, 1865.

§ Greene's Improvement in Art of War.

the lines of investment were forty-six miles in length with about 4000 men per mile, and the besiegers less numerous than the besieged. At Strasburg the telegraph wires were pushed up to the third parallel, and were of great assistance in directing the Prussian artillery fire. During the three days battle on the Lisane, when Bourbaki attacked General Werder who was covering the siege of Belfort, it was owing to the excellent telegraphic communication which had been established throughout the German Army, that the timely arrival of the reserve from the extreme right wing was effected. As also their subsequent return to the right at a critical moment.*

At the end of the Franco-Prussian War the wires in the field telegraph service had reached a length of 10,380 kilometres (nearly 6730 miles) with 407 stations, while the state telegraph service operated 12,500 kilometres (about 7767 miles) of line and 118 stations.†

In the Turco-Russian War on the side of the Turks no special telegraph corps existed, though permanent lines were built for military purposes. No organization or outpost telegraph service existed and the telegraph was not used to transmit orders applying to movements during an engagement.

On the Russian side all was different however. Here not only field but outpost telegraph wires were in general use throughout the army, and were of priceless service.‡

An incident of this war gives a marked instance of the use of the telegraph upon the field of battle. At the battle of Aladja Dagh near Kars, the Russian plan was to assault the Turkish fortified position in front with a force of about 30,000 men, while a turning column of 15000 men was to make a complete detour of more than forty miles, passing beyond the Turkish right through a mountainous country, and strike the center of their rear. The telegraph gave the means of making the attack simultaneous, and in this case the turning column threw out a thread of wire behind it, by means of which it remained in full

* Electric Telegraph in Warfare. F. C. Grugan. Journal Military Service Institution, Volume III, No. 9.

† History of German-French War.

‡ Electric Telegraph in Warfare.

and constant communication with the main body. The attacks were made simultaneously and they absolutely destroyed the Turkish Army. Its defeat made possible the storming of Kars, and sealed the fate of the campaign in Asia Minor.*

Regarding the telegraph line itself, it is said to have been built rapidly, to have worked during the attack on Mount Oghur and during the subsequent battle. It was guarded by Cossacks, and was not in working order during only two hours, and upon it depended the success of the campaign in Arminia.†

Instances might be multiplied as showing the great importance of the telegraph, either because of the aid lent by its presence or because of the conspicuousness of its absence; but they are not needed. Each continental power has now its organized field-telegraph service. Japan has fitted herself as well, and experiments are being constantly made to bring these organizations to an efficient state and to keep in progress with the times. Experiments are also being made with the telephone, and the next war will probably see them in use as an important adjunct for camp use and outpost service, and possibly for extended use upon the field of battle. Already good promise of success is had, and experiences in field manœuvers indicate how valuable an aid it may become.

There is one point that is worthy of mention, that can just barely be touched upon in the use of steam and electricity in war, under the conditions that must necessarily obtain in this country. That point is that our vast net-work of roads and telegraph lines that become of such vital importance in the event of war, are private commercial enterprises operated by civilians, and generally free from all government control.

In the event of war, upon anything like the grand proportions of our Civil War, or the proportion due to the size and population of our country, this net-work of roads and telegraph lines becomes at once an absolute necessity for military use, in the handling of troops, in mobilization, and in concentration of food, stores and munitions of war.

* { Greene's Improvements in Art of War.
  { Grugan's Electric Telegraph in Warfare.

† Grugan's Electric Telegraph in Warfare.

These civilian commercial corporations then become as important and indispensable as any of our heads of military departments. Upon the integrity and loyalty, not only of the corporation but of every train and lineman the success of a movement may depend. Some of our railways extend into Canada and Mexico. Any war involving either of these countries would see a corporation exposed to the loss of road-bed and rolling stock that might be in the hostile country. Hence, want of sympathy or downright disloyalty upon the part of such a corporation or its employees, might cause delay if not disaster. Cipher dispatches would not alone prevent this; for delay in sending, transmitting or delivering such a message, its contents being only suspected, might work the mischief as much as though the actual contents were known. An engineer, train despatcher, flagman, switchman or any other supposed to be trusted trainman, could ditch, disable or stall a train moving troops or stores, and thus work delay or disaster.

Do not then the trainmen and telegraph operators of all our lines become of as much, if not more importance than any combatant under arms? And should they not be so recognized and be regularly enrolled in the event of war, as part of the army's working force?

Franklin in 1751 described a method for firing gunpowder by electricity. Priestly in 1767 independently discovered a method.* Torpedoes and submarine mines are as old as our Revolution, and we all know how important a branch torpedo service has become of the art of war.

Continual experiment from Franklin's and Priestley's time have advanced the art of exploding gunpowder or high explosives, from the high tension or static spark of Franklin to the low tension platinum fuse of the present day, and has developed the battery or the hand exploder for this work. To-day we can count upon the certainty and efficiency of electric torpedoes as beyond a doubt, making them a terrible weapon of defense against a hostile fleet. So to electricity again we are indebted for this possibility. Mechanical mines and torpedoes we have to

* Ordnance Note No. 357. Electricity applied to explosive purposes.

be sure, and much ingenuity has been exercised in their construction and development, so as to render them reliable. But so far the electric torpedo is the only one that can be made harmless or dangerous at will. Judgment firing is possible with this form alone, and it is also the only one that can be safely watched, and daily or hourly tested to see that it is continually in serviceable condition.

Much as there may be yet to be done to perfect all the details, so as to secure a maximum efficiency with a minimum of liability to leaky joints or deterioration from long immersion, to simplify the details of watching and firing apparatus, all this is believed to be mechanical. With the constant development of improvement in the insulation of cables, the stability of high explosives and the general simplification of details, it may safely be assumed that the torpedo will be brought to a high state of efficiency, so as to be absolutely reliable even after long periods of immersion.

The history of the torpedo and its use in our Civil War, when first it came into great prominence, its use in the Brazil–Paraguay struggle, its naval effect in the Franco–Prussian and Turco–Russian Wars, are all interesting and full of important information. But it is not necessary to go into details. We have a torpedo service; carefully laid plans of every harbor of importance are kept constantly ready for instant service in the location and planting of mines. This is all as it should be so far as it goes; but the question is who are to plant, who to care for and operate, and who to protect the mine fields that will be established?

Our heavy artillery is presumably intended for the defense of our sea-coast. We are or should be located at our sea-coast works, ready to man the guns, defend our harbors and work in connection with the torpedo service. We are, or should be, familiar with the channels and topography of the harbors we have to defend. We are familiar with the range and possible sections of fire of all our guns. We know the weights of our projectiles and their striking force. But we do *not* know anything except the theory about loading, connecting, watching, testing or firing a torpedo. We do not know except by theory, anything about the effects that are to be expected. In fact what we do *not* know would make a book bigger than that which contains all the theory; and it cannot be learned from books, but only in the practical school of experiment and use.

It is thought therefore that the torpedo service should belong to the artillery, who are its natural defenders and users. We should experiment and use them, be constantly at work with them, and be as familiar with all the details as we are with the range and power of our rifles. In time of war the engineer officer will probably have more important work to perform than that of superintending a mine-field. The Battalion of Engineers will be busy elsewhere and have no time to plant all our mines. The artillery soldier will be the one to plant them, the artillery officer to superintend and direct, and have charge of the field when planted; and *now* is the time to learn and not when other things are crowding upon us.

After the bombardment of Alexandria, "in the citadel were found eighty-seven large submarine mines, capable of holding two hundred and fifty pounds of gun-cotton each, large quantities of small shell, fuzed and loaded, and several hundred electro-contact torpedoes of peculiar construction. A great many of the latter had never been unpacked, and were found stored in barrels just as they had been received. It is now known that the Egyptians had no wires, and this can be the only reason assignable for not planting the mines in the shoals and passes at the mouth of the harbor."*

Do *we* wish to be caught in the same manner? Was there any reason but want of proper organization, that found the Egyptians without wire? Should not the artillery have full charge, so that the responsibility may rest with one department alone, to provide and care for all the material and to plant, watch and manipulate the mines as well as guard and protect them? Then we will be ready, it will be our business to be ready; and we alone will be responsible if we are not ready to put in, use and maintain the most important adjuncts to our sea-coast defence.

Passing the use of land torpedoes and their proper location and operation, and the use of high explosives electrically exploded,

* Ordnance Note No. 252. Naval Intelligence Series No. 3.

for the demolition of bridges, culverts, embankments, canals and railways, we come finally to the consideration of more advanced uses of electricity, bringing us to the dynamo and the necessary means for developing the current.

The discoveries of Davy and Faraday made the modern arc-light a possibility. So long as the light depended, as it did in Davy's time, and until a comparatively short time ago upon the galvanic cell for its generation, it was uncertain, costly and cumbersome. Yet, in spite of these disadvantages, the great advantages to be derived from its use were recognized as so great, that we find the French advocating its use as early as 1855. The French fleet in spite of all of the imperfections and cost of the battery, employed the arc-lamp with a parabolic reflector to throw a beam of light upon the point of attack, in the campaign of the Baltic. Austria and Italy also experimented to the same end, showing the early importance that was attached to this aid in the operations of war.*

It was not until the introduction of the dynamo, and that too in far from the present form, that much success was attained. About the first real success was during the Franco-Prussian War and under the walls of Paris. Here the French made use of it as a source of light and a means of telegraphic communication. They made use of an Alliance machine, long since antiquated and obsolete, and a Serin regulator, which, in spite of the defects of the reflector employed, allowed several movements of the enemy to be detected, and did good work in preventing several night surprises.

However unimportant these results may have been, they pointed out the way to the Germans who immediately studied the new question. In 1873, at the Vienna Exposition, side by side, were to be seen French apparatus with the Gramme machine and projector from Sautter and Lemonnier, and similar apparatus from the workshops of Siemens of Berlin.†

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* Science et Guerre. L'eclairge electrique á la Guerre. Electricity for military operations. Journal Military Service Institution, Volume XII, No. 54.

† Science et Guerre. Electricity for Military Operations. Journal Military Service Institution, Volume XII, No. 54.

From this time up to the present constant improvements have been made. The dynamo of ten years ago is antiquated to-day. Improvements in lenses, in carbons and in lamp regulators have kept pace with those of the dynamo, so that now it is possible to have lights far superior to those above mentioned.

Our home electricians have also given thought and study to the subject, not in its military aspect so much as in its commercial, for want of any demand or encouragment. Yet search lights have been developed for marine use, and it is now common for our merchant steamers as well as our naval vessels to be provided with powerful lights for night work.*

Among the naval vessels fitted with search lights of domestic manufacture are the *Yorktown*, *Baltimore*, *Charleston*, *Miantinomoh* and *Philadelphia*. Fitted with French lights are the *San Francisco*, *Petrel*, *Concord*, *Bennington* and *Atlanta*.† Each new ship is fitted with the search light as a matter of course as with any other vital part, the whole subject having advanced from the experimental stage to that of absolute certainty and necessity.

Besides this development for naval or maritime use, there has been a corresponding development for land purposes. The commercial arc-light of to day is not the flickering, hissing, sputtering variable light of ten years ago. The same lights that are available for the sea are also available for land use, and besides these, special portable outfits have been developed to accompany an army in the field.

"There is a demand at the present moment for more light; the demand comes to the front rank of military necessity for modern scientific warfare. Darkness, that bugbear of the tactician, that friend to night surprises, secret expeditions and the like must no longer remain so. We must have darkness under control; in other words, having the means of readily and promptly lighting

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* Huntington arc-light projector. Electrical World, December 7th, 1888.
Electricity on Long Island Sound Steamers. Electrical World, September 27th. 1890.
Electric head-light. Electrical World. September 27th, 1890.
Lighting of the Plymouth. Electrical World, November 29th, 1890.
Electric search-lights on the lakes. Western Electrician, March 9th, 1892.
Edison Projector. Western Electrician and Electrical Review, May 7th, 1892.

† Naval Intelligence Series.

vast tracts of land or water to a brilliancy, only second to day by means of the electric light, we can have darkness at will."*

The importance of such a possibility would seem to be self evident. It is not my purpose, however, to elaborate this branch of the subject as pertaining to the army in the field, or to give its full tactical value and employment. It will suffice to call attention to the vast field that is open to the electrician and the tactician in this direction, and the probable use, in fact the almost indispensable necessity for its use for the following purposes:

First.—The passage of rivers, including the building or repair of bridges for that purpose.

Second.—The embarkation and debarkation of troops, both by land and by sea.

Third.—The repair and construction of railroads in the field.

Fourth.—The prevention of night surprises both to the army in the field, or in permanent or semi-permanent works.

Fifth.—For the defense of field works or other inland fortifications undergoing a siege. To aid the directing of night fire, and to screen the works against the fire of the enemy.

Sixth.—For the attack of field works and fortifications; to aid in night work in the trenches and to direct the fire of the attack. Meeting search light with search light.†

Seventh.—To assist in finding and succoring the wounded‡ and in burying the dead after an engagement.

Eighth.—For night signaling;§ for day signaling in cloudy weather when the heliograph cannot be used.||

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* Ordnance Note No. 287.

† The tactical value of the electric light. Journal Military Service Institution, Volume XII, No. 57.

‡ Since the above was written, notice has appeared of experiments having been made in this direction. See Army and Navy Journal June 18th, 1892. From these experiments it appears that powerful search lights with reflectors were used, and were of great assistance in open country. For wooded and obstructed localities portable electric lanterns, fed by accumulators in knapsacks were used. The experiment is stated to have been fairly successful and is likely to be repeated.

§ Incandescent lamp for army signaling. Electrical World, March 9th, 1889.

|| Science et Guerre and electricity for military operations. Journal of Military Service Institution, Volume XII, No. 54.

That the portable electric light outfit has its drawbacks as well as its advantages goes without saying. But that its advantages far outweigh its faults would seem beyond a doubt. Constant improvement in design and efficiency have produced the modern dynamo of light weight, slow speed and high efficiency for the special types needed for marine use.* Corresponding improvement can reasonably be expected for the portable land outfit when any encouragement is given to our electricians, looking to their being a demand for his work. Already the weights have been reduced so that a complete machine, with engine and boiler weighs but from 4,500 pounds to about three tons, depending upon the size of the dynamos and engine; the lighter outfit will furnish a current of 24 amperes and 45 volts at a moderate speed, requiring but about three horse-power of energy. The same carriage carries the projector a bobbin of double cable, and the indispensable necessities of the outfit, such as injector, main pump, tool chest, water-tank, etc., etc.†

The heavier machine carries the dynamo, engine, boiler, coal and water upon one carriage, with projector, lamp, two drums of cable (double), each 100 metres long and other accessory apparatus, including a telephone for directing the light from a distance upon another carriage. These wagons weigh about three tons loaded. Each requires four horses. The projector can if necessary, be dismounted and carried by hand to places inaccessable to the wagon. Steam can be got up in twenty minutes.

Pack mule outfits have also been made, no piece when dismounted weighing more than 220 pounds. The fact of so much pains having been taken in bringing out the mountain equipment shows the supreme importance assigned on the continent to the possession of search lights on all occasions.‡

The portable search light outfit has been most successfully used in manœuvres,§ and in the Egyptian campaign‡ It was also

* Naval Intelligence Series.
† Science et Guerre.
‡ Electricity for military operations.
§ { Electric lights in night attacks. Electrical World, March 9th, 1889.
{ Tactical value of electric light. Journal Military Service Institution, Vol. XII, No. 57.

used in an African expedition in the gold fields. "All night long steam was kept up on the engine, and at intervals the powerful electric search light sent its mysterious white beams of light into the dark woods beyond."*

That the introduction of the dynamo and search light for field army use will meet with decided opposition is beyond a doubt. The catapult when first introduced was received with disfavor; gunpowder was looked upon as an abomination by the chivalry of the middle ages; the percussion lock was condemned as utterly unreliable by the flint-lock champions; the breech-loader had to demonstrate its superiority before it was fully adopted; the use of the torpedo was characterized as barbaric; small caliber rifles smokeless powders, high powered ordnance and each and every improvement in the armament or equipment of armies have been combatted by the conservatism of nations.

But it is suicidal for a nation to go to war without taking advantage of every modern improvement that may aid, even in a remote degree in the strife. Any new military invention that is neglected or ignored, places just that much less chance of success with the ignoring nation, and just that much greater chance with those which have more wisely adopted it. The Austrians fought side by side with the needle gun, and yet did not appreciate or adopt the same, much to their sorrow in 1866. In war with barbarous nations, which cannot obtain or adopt the modern appliances of civilized nations, the latter are bound in the end to win. This would in all probability be the case in a war between two European nations, in which one was armed with magazine rifles, field-mortars, smokeless powders, shells charged with new explosives, field watch-towers, balloons, etc., etc., while the other commenced the campaign under the conditions which would have been regarded as normal ten years ago.

But however destructive and terrible in its proposed effects any such modern improvement or invention may be, it loses much of its significance when it is at the disposal of both contending

* Scribner's Magazine, April 1892

parties. Consequently the best means of opposing, or more accurately speaking, of paralyzing the advantages which the possession of a new invention confers on one side, will be its adoption by the other.

It has always been recognized that one of the principal means of getting on even terms with an enemy, is to fight him with his own weapons. But contending with the enemy on even terms would not in itself be sufficient to confer the probability of victory on our side. It is further necessary to investigate thoroughly the best means of taking advantage of the improvements referred to, and thus anticipating or preventing the enemy from obtaining the same results.*

The above quotation applies most decidedly to the dynamo as an engine of war. Our enemy, whoever he may be, will be provided with the best that modern science can produce. In self defense if for no other reason we must be likewise provided, and be ready and able to use it, as well as have it in our possession.

Leaving therefore the development and use of the portable outfit for general field use to those better qualified to discuss the subject, let us turn at once to a subject of vital importance to the artillery, the proper defense of our sea-coasts, harbors and forts.

Here we must expect at once to come in contact with the electric light. Every nation with any war vessels at all, has them equipped with search lights as one of the vital and essential elements for successful attack, as well as for their own preservation and existence. Our navy have lights up to nearly 50,000 candle power upon its ships. It is not to be supposed that they are better off than all foreign navies.

Each sea-coast fort will have to overlook and protect a system of sub-marine mines and torpedoes. These may and probably will reach to at least beyond mid-range for our guns, a distance that will render all unaided night operations, even with patrol boats, a very uncertain operation.

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* Influence of new inventions. Journal Military Service Institution, Volume XII, No. 50

But with a powerful search light, ready to be turned on at any instant the mine-field may be swept in a few moments. Patrol boats may, in fact must be provided with search lights also.* The enemy may thus be prevented from any attempt at countermining, conducted under cover of darkness. Night may at any moment be turned into day, the enemy's search light met with search light, and as much as possible the advantage maintained for the defense.†

That these search lights should be the best that money can buy and electrical science produce goes without saying. They should be permanent installations with their towers and protective screens complete, and be so located about the work as to command all approaches thereto, and also at any time be able to give a cross fire of light, so to speak, to screen the work or to cover any land disposition that may be desirable. Portable lights may also be of use; but in the main more powerful lights than possible with a portable engine and dynamo will be needed. That the search light can be and has been made powerful enough for its purpose, the following will show:

In experiments upon the French coast a vessel was picked up at a range of more than 3000 metres, and from this moment could be followed in all of its movements, be abandoned, and be again picked up with ease. The buoys in the harbor could all be seen, the furthest being 2600 meters away. Tried for an extent of field, a space of more than 207 metres long at from 3000 to 3500 metres was sufficiently lit up for all operations of artillery.

Tried for a maximum range the observer, with good opera glasses and placed near the apparatus, could readily see the barracks 9500 metres distant, and at an altitude of 500 metres. The experiments were made during a dark night. *A light mist prevented the air from being absolutely clear.*

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* Steam launches have been provided with powerful lights. See light upon Shipman steam launch at Rochester, New York.

† Ships *versus* Forts. Journal Military Service Institution, Volume XII, No. 53.
The tactical value of electric light. Journal Service Institute, Volume XII, No. 57.

In another experiment the light was turned and kept upon an approaching steamer. The captain on arriving near the observers, expostulated with them; the light had prevented him from steering, and he had several times nearly collided with other craft.*

Sautter, Lemonnier & Co. make four sizes of projectors, viz: 0.30 m., 0.40 m., 0.60 m. and 0.90 m. diameter, with lights from 6 mm. to 15 mm. The largest projector will light a circle 175 metres diameter at a distance of 7000 metres. This data is nine years old.† The Eiffel tower carried a light far beyond any of the above. With a current of 100 amperes and a projector of nearly 36 inches diameter, it was possible with a good night glass to distinguish the details of objects lighted by the beam at a distance of from four to five miles.

In the exhibit of the Paris Exposition, Messrs Sautter, Lemonnier & Co. had a projector of 56 inches diameter. The amplifying power of this great projector is enormous, being 5625 for a lamp of 150 amperes and giving from 100,000 to 110,000 candle power; the intensity of the beam projected from this lamp would be therefore from 500,000 to 600,000 candles, or from eight to ten times the power of the two 36-inch projectors placed upon the tower.‡

Besides the light or lights for general observation and watching with which the fort must be provided, other lights are also imperative for the following reasons:

The employment of the electric light is perfectly simple as long as it is only a question of one fort and one gun or group of guns; but when it becomes several forts and several lights the action becomes more complicated.

To avoid confusion *each group of guns* should have its own light, to be under the control of the commander of that group. Nothing but confusion can result from the unconcerted employment of several lights by independent observers, who work neither in combination with each other or with the guns, and are not con-

* Paris Electrical Exhibition, 1881.

† Ordnance Note No. 240.

‡ Scientific American Supplement No. 708, July 27th, 1889. For other lights see electric search light at the World's Fair. Electric Review, April 9th, 1892.

nected with any part of the defense by any means quicker than an orderly. Just at the moment the light might be most needed by a group of guns, it might be turned off from its target and be swept to some part of the field not commanded by that group. We should therefore have a light for each group of guns as well as for each fort.

The light should be posted where it will be least likely to be hit, and in such a manner as not to interfere with the fire of its own or any other group of guns by dazzling the gunners. Schemes have been advanced for the protection of the light by placing it behind cover, and using its rays indirectly by a combination of mirrors.*

Wherever it may be it must be under the sole control of the group commander to which it belongs, and its movements directed by him alone.

There must be electrical communication between the group commander and his light, and he should be able to control the movement of the light from a distance. There is no real difficulty about this. It is known that one of our prominent electrical companies has already solved the question in part, giving absolute control of the light beam both horizontally and vertically. If the control could be made *automatic* as well, so that the beams would always point to the same object as the group commander's telescope, the problem would be solved completely.

To avoid confusion of lights, only that fort and group in action should show its light, except at intervals to sweep its mine-field and prevent any chance of attack being made under cover of a demonstration against some other work.†

Page on page might be written on this subject of the search light, but space does not permit. We will only pause to say that we need the light *now* in limited numbers, for the same reason that we need guns and torpedoes. Besides this a demand should be created to stimulate our home manufacturers in this direction, so that there may be the certainty of our being able to get what we want when we want it, and at comparatively short notice.

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* Ordnance Note No. 240.

† Tactics of Coast Defense. Journal Military Service Institution, Volume X, No. 40.

Gun steel was not to be had in the country, until we held out some hopes of a contract for its supply in quantities to make it pay. The same demand for the electric light would soon place us upon an independent footing, giving us at the same time what we now have not, the means with which to drill and practice and find out the capabilities and field of usefulness of the light.

The search light, indispensable as it is, is not the only light we need. Our forts need internal illumination certainly for war, and as certainly for peace. If we are to be prepared we must practice night as well as day firing. Gun platforms, casemates, galleries, magazines, shell-rooms and all the approaches thereto, should be capable of being sufficiently lit for night work, and with the incandescent lamp the success that it is, the oil lamp is a relic of the dark ages.

With the incandescent lamp we can have light at will, as much or as little as we please. The lamps can be placed singly or in groups, and of whatever candle power desired. They can be protected from the storm; they can be guarded by globes and wire screens so as to be reasonably safe from injury; furthermore they can be arranged to be removed at will, so that they need not be permanently installed any more than the oil lantern; the wires and fixtures can be put in place and the lamps be put in their sockets only when needed, thus greatly diminishing the liability to breakage when not in use.

For magazine illuminations and shell-room work nothing could be safer. The lamp proper can be put inside a heavy protective globe,* with outside wire guard if needed. Even the naked lamp globe would not be dangerous; for break a globe with the lamp in action, and the light is gone instantly without any falling ash or sparks. The loop is so fine that it is instantly dissipated into gas the instant the air strikes it and it consumes.

The installation of search lights presupposes the installation of the dynamo. It has been shown time and time again that the incandescent lamp is cheaper than gas.† It has also been shown that it is cheaper than kerosene.‡ It would be money in pocket

* Naval intelligence series. Steam and water proof electric lamps. Electrical Review, April 2nd, 1892.

† Ordnance Notes 219 and 287, and current electrical literature.

‡ Electrical World, July 31d, 1891 and June 20th, 1891.

if the government would put in incandescent light plants for the lighting of barracks and quarters for the entire army. In our sea-coast forts where they must be had for other purposes, where the engine and dynamo must be provided for war purposes, the saving in oil now used for garrison purposes would in the end pay for the plant. For the dynamo and engine should be provided for the search lights, and incandescent lamps needed for fortress warfare; it would be folly for it to be idle during peace when it could be usefully employed. It would be all the better for being run and thus kept in order for daily use, instead of being allowed to rust and deteriorate, as would be the case when out of use.

Our guns are provided at enormous cost without there being any return thought of, except the protection and immunity from war that their presence provides, and the active work they perform against an enemy in the event of war. The dynamo and electric light plant is needed as an essential adjunct to their proper use. Hence, they too should be provided as war material, with no thought of return except as with the guns. If however they can be put to use that does give a return, and that replaces other sources of expense, is it not so much clear gain? And would it not be a wise policy to get as much economic return as possible and have in peace what we greatly need, and at the same time be provided for efficient work in case of war?

Much has been done in the navy, both on board ship as well as on shore, towards the development of special types of dynamos for naval use. Such special types are necessary on board ship from the limited space available for the electric plant, as well as from the unstable platform of the rolling and tossing ship.*

Except in special forms of small turret forts the land has the advantage. We generally are not cramped for room; we need not stint in weight; we have a stable platform, and in every way our conditions more nearly approach those of commercial enterprise. We all know with what success the problem has been solved in civil

* Naval Intelligence Series. New Edison dynamo for marine works. Electrical World, April 6th, 1889. High speed ship lighting plant. Electrical World, November 23rd, 1889.

life, as is evidenced by the immense amount of capital successfully invested in central station plants, and there is no reason to suppose but that our conditions can be as successfully met.

Our navy has shown that it is possible to use arc lights and incandescent lamps from the same dynamo. In the land forts this may or may not be advisable, depending upon the character of site and size of fort. In the general case it might be more advisable to provide special dynamos for the search lights independently of those for the incandescent circuit. But whatever the condition of the problem it can be safely assumed that they would not be insuperable, and that electrical science could in time give us just what was wanted. The thing has got to start sometime; it might as well begin now as sometime in the future. We then would be benefitted and be fitting ourselves for proper service in time of war.

In our latest war ships the dynamo, having come to be considered a vital element, is placed below the protective deck to be as fully protected as possible from all injury from hostile attack. Our dynamos and engines should be similarly located in the most invulnerable part of the work, under a thoroughly bomb proof casemate.

The voltage to be used and the system of wiring necessary, would depend in great measure upon the extent of circuit to be covered by the installation. It is possible to wire in such a way that there would be but little danger of a total extinguishment of lights from any damage but shot or shell. Interlocking systems of wiring could be used, such that even if a branch or main were shot away, that branch or main could be made active by switching it on to some other live branch or main.

In general the length of circuit would be such that high voltage would not be needed for economical results. The navy runs on an eighty volt circuit, but their circuits are comparatively short. We probably could run on an hundred volt circuit, at the outside, on one of two hundred and twenty volts; from this it results that there would be no danger of shock even if wires should be cut, and the ends be exposed to contact with the human form. With due care there need be no fear of fire. With proper safety fuses the dynamo could be secured against danger from any short circuit, caused by shot or shell carrying away or bridging mains, branches or feeders, and the whole installation could be made efficient and reliable and fairly economical.

It goes without saying that the installation would not be complete without a complete switch-board with regulators, ammeters, voltmeters and ground detectors. These have come to be considered as fully needed as the steam and water gauge, and safety valve of the steam boiler.

Passing by the system of signaling, telegraphy and telephones necessary for the administration or the fighting of the modern fort as needing but simple mention to be conceeded, we come to another branch yet of the greatest importance to our fighting capacity. To serve our guns we must have ammunition in quantity and in quality according to the demands. That the quality may be the best we must have well ventilated magazines for general storage, where the best of care can be taken of our explosives. That the quantity may be at hand we must have some means of serving from the general to the service magazines and from the latter to the guns.

As Captain Chester pointed out in a recent article in the Journal of the Military Service Institution, this all means work and plenty of it. But this work must be done, and the question is how to do it.

The search and incandescent lights already mentioned means the installation of the best of dynamos, and the steam engine with which to drive them.

Here then is our power, and an electric railway and electric shot hoist are the means of applying this power. By this means with suitable trucks and motors, the work can be done better and cheaper than by mule or hand power. The dynamo plant we *must* have, the electric road follows as a natural corollary. It can be located so as to run from storage magazine throughout the entire fort to all the service magazines. At these magazines electric hoists could be provided to lift the heavy weight of our modern cartridges and projectiles, and the whole thing be run with a minimum of hand labor, more rapidly, more surely, and more cheaply than by any other method.* And even if the wire be shot away in battle we yet would have the track and trucks, and would simply have to apply hand power to get along as best we could until the wire could be replaced.

Passing on to another problem that effects our fighting capacity, we come to our ability for the prompt handling of our modern high powered and heavy ordnance. Can we handle and serve these guns thoroughly and efficiently by man power alone, or must we call in other power to our assistance? It would seem to me that the necessity of the case, the duty of getting all that is to be gotten from the service of our heavy and costly guns, that from their very cost may be few in number, demands that we should have other than man power to manipulate them. We need not fear that we shall ever be able to rattle away so fast as to throw away ammunition in careless work. Even with the best of aid there will be time for all due deliberation. Yet there should be no time lost from the use of man, when time can be saved by use of other power. We should be able to load and aim promptly, and then wait if necessary for the favorable moment for a shot, and not lose chances from our inability to reload in time to give another favorable shot.

If then we are to use outside power, what power is it going to be and where is it to be obtained? That is the problem that now invites our attention. It may be taken as a fact beyond dispute, that the location of our sea-coast forts is and will be such that no source of natural power will be available. We have not yet harnessed the tide, and until we do, we therefore must look to artificial power for the aid we need. We must use steam, compressed air, water under pressure, wire-ropes, shafting, carbonic acid, ammonia or electricity as the aid to hand labor. Some of these means of generating or transmitting power may be dismissed at once as either too cumbersome, expensive or inefficient.

In the consideration of the problem for military purposes inside of our forts, not only the efficiency of the generator and the

* Electrical shell hoist for men of war.—Electrical World, June 22nd, 1889.

means of transmission must be considered, but particular attention to and consideration of the means of reconversion of the power when delivered is of prime importance.

At the very beginning having no natural source of power available, and, if we had the necessity for having our fort self contained, so as to be independent of all outside aid that cannot be defended without an undue extension of the site and work, necessitates that our power be generated inside the fort by some prime mover; this will be the steam engine, the power developed being used to actuate some means of storing or transmitting the power developed.

Wire ropes though efficient and reliable for the transmission of power even to considerable distance or from building to building, when the source of power is cheap, may be dismissed as wholly unsuitable to the military situation. The ropes would be bulky and cumbersome, exposed to danger from hostile shot or shell, and, furthermore, the means of utilizing the power when delivered would not be compact or readily applicable to the particular use required.

Compressed air has been largely used for particular and peculiar conditions. Here our engine would have to drive compressors, and store up the energy in suitable reservoirs ready to be delivered as desired. At the very outset we would meet with loss due to the necessity for keeping the compressors as nearly as possible at a fixed temperature. The heat due to compression means just so much work stored up. If we could use the hot air at once, part of this heat would be reconverted into useful work. But we cannot do this, and the cooling spoken of becomes necessary to economically store the compressed air.

In the transmission piping would be used, there would be a certain percentage of loss due to friction and possible leakage. The pipes would be bulky, expensive, hard to lay, and hard to protect ; for they should be readily accessible for supervision and repair. A pipe shot away would disable everything that it supplied, and would be difficult of repair.

The motor to utilize the compressed air is again not readily applicable to the problem. It partakes too much of the general nature of all reciprocating engines to be applied direct. It would therefore have to be applied indirectly through belting, gearing, or shafting and, hence, does not meet the case. Though successfully used in mining and tunneling, here the expense is but a secondary consideration. This expense is shown in one of our most extensive plants of this character in this country, in which the efficiency does not exceed from thirty to thirty-five per cent, and the actual cost of a horse-power delivered is not less than $800.00 per horse-power per year.*

Transmission by compressed air has also been tried industrially, and with fair prospects of success. Pneumatic clocks to the number of 8,000 are run in Paris; the transmission of power has also been in operation on a somewhat large scale, with great mechanical success, for some years past.† At Birmingham over 300 horse-power is distributed to customers, and the plant has a capacity to ultimately supply 15,000 horse-power.‡ But these instances are peculiar in their nature, and the system does not lend itself readily to the military problem, for the reason stated above that the motors are not applied direct.

The same may be said regarding transmission by steam. Here we have losses from friction and condensation; the pipes are as cumbersome, costly and hard to protect as those for air, with the additional drawbacks that they must be covered in some manner as a protection against cold and losses therefrom, from freezing and condensed water, or the draining out of same when not in use. Besides this a ruptured steam pipe would not be a very healthy neighbor, to say nothing of the difficulty of repair and the breaking down of the motors due to the rupture. Transmission by steam is but the shifting of the locus of the steam engine, so that one boiler may supply several small engines in place of one large one. Commercially, for certain work, this may be economical; but for the military problem wholly unsuitable. The small steam engine right at the gun cannot apply its power except indirectly, hence its application is cumbersome and awkward, and anything but what is required.

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* Scientific American Supplement. No. 707, July 20th, 1889.

† Scientific American Supplement. No. 721, October 26th, 1889.

‡ Scientific American Supplement. No. 726, November 30th, 1889.

Water under pressure is a favorite method for the transmission of power in many cases. In fact in some cases, such as heavy hydraulic rams, compressors, and other hydraulic machinery, it is the only method.

In certain special cases this may be the power required for the military problem. These special cases are the floating pivots for disappearing turret mounts, variation of elevation given by raising the entire gun-carriage when the gun is strapped in a saddle and does not permit of independent movement, and in certain forms of disappearing gun-carriages. But these are special cases requiring special treatment and do not come within the general question of other forms of mounts, that must needs be trained, elevated and loaded by hand, if other power is not applied.

For these cases hydraulic power would appear unsuited. A steam engine and accumulator, with lines of pipe and hydraulic motors would be necessary. To work economically they must work slowly; slowness of action is not permissable; and we have again the line of pipe to be protected and to be secured against frost.

Shafting, though commercially used in many cases with fair success, is used under conditions wholly different from the military problem. Though large areas may be covered and power conveyed thereto by shafting, possibly, where power is cheap, in a fairly economical manner, the means of conversion at point of delivery, to say nothing of the cumbersomeness of the plant, precludes the idea of its being the ideal system for our purposes. Though a gun may be trained in this manner, it must be at a speed depending upon the speed of the shaft and the gearing that may be interposed between it and the gun-carriage. To have interchangeable gears, or gears arranged so as to permit of variable speed of traverse as occasion may require would be a complication not to be allowed. The shaft also must always be working with a power sufficient to handle *all* the guns with which it is connected; that is, its speed must be constant, with no load or full load. This would require the best of engine regulation, and even at best, the loss of power in driving the shaft alone would be a very large percentage of the power developed by the engine.

Compressed carbonic acid or ammonia may be dismissed from consideration as impracticable. They would require the manufacture, as well as the compression of the gases, entailing a plant wholly unsuited to a fort. The motors to make them applicable after compression are again not readily directly applicable.

The steam engine with its boiler for direct use remains to be considered. Such an outfit to be effective at all times must first of all be thoroughly protected against injury, and this involves a casemate for every engine and boiler used: these casemates cannot but occupy room that can hardly be spared, and from the casemate the power must be applied.

We then come down at once to the means of application, and we see that we have the same problem in a minor form for each engine and each casemate that we had before for the central engine. We have only gained in shortness of line of application, and have lost in efficiency in another direction, by splitting up our power into several units of less possible efficiency per horse-power as compared to the efficiency of our large central unit of equivalent power to all of our engines. We have several casemates in lieu of one; we have several boilers, several crews of skilled engineers, stokers and machinists, several coal bunkers to keep full, and a general increase in expense for the same power, with the but doubtful advantage of an engine and boiler to every gun or group of guns, and we have *not yet* solved the economical application of the power to the guns to be controlled.

In the navy a steam engine was applied to one of the 8 inch gun-carriages as a training device. As an example of the cumbersome mechanical devices necessary to apply this power it may be stated that the engine took up so much room that it could not be put upon the gun-carriage itself. It was therefore put in a room by itself, and connections made with the carriage by a vertical shaft running up through two decks. The amount of power lost through friction and change of direction is great.* It must be remembered that this engine was supplied with steam

* Electricity on board war ships. Proceedings Naval Institute. Volume 15, No. 3, page 481.

from the main boiler, hence an extra boiler was not needed. When we have, as I am supposing, a boiler as well, the space needed may be imagined. Then again the gun captain controlling his gun, must have some means of stopping and starting an engine located at a distance, or a means of signaling for some one else to do it. Engines generally have "dead centers;" hence they cannot be stopped and started from any position, but must be stopped "off center" or be turned by hand to that position, so as to be ready to start again. To avoid "dead centers" the double engine must be used. All this makes a beautiful method of just "*how not to do it*," in order to have the control of one's gun under absolute command. The only remedy which we have is the shaft driven at constant speed by the engine all the time, its motion to be communicated to gun-carriage at will by means of a train of gears and suitable clutches; and even this is not reliable or what we need. The shaft moving at a constant speed would tend to start the gun with an unavoidable jerk and jar. Unless the best of friction clutches were used it would be wholly impossible to *start the load slowly* and easily without undue strain upon the gears and, after starting, keep it moving at a constant speed. Stopping again where we want it would be just as difficult.

So it would appear to me that steam as directly as well as indirectly applied through the steam engine as the final motor is in no way applicable to the solution of our problem. We therefore come to our last resource, electricity.

Prior to the year 1873 the transmission of power by electricity may have been the dream of some electrical expert or student, but it was not an accomplished fact. The dynamo as a generator had been well developed, and at the Vienna Exhibition large installations were exhibited. *By accident* the mutual interchangeability of the generator and motor was discovered in some of the preparations for the exhibition,* and from this time on experiment and research were bent to the solution of this most important subject. At the Munich Exhibition in 1882, it did not fail to receive a share of attention.† The experiments of M. Deprez

* The electrical motor and its application. Page 29.
† The electrical motor and its application. Page 31.

are well known to electrical science.

From this time on the progress of this branch of electrical science has been most rapid, each successive year seeing more efficient generators to supply the current, more efficient motors to use it; better appliances, mechanical constructions, and understanding of the best voltage to be used, until now it has passed beyond the experimental stage, and is upon a broad and solid foundation of commercial approval and success.

The efficiency of the system depends upon three things, each evidently less than unity.

First.—The efficiency of the generator, which now ranges as high as ninety-five per cent.

Second.—The efficiency of the motor also ranging from sixty-five per cent. for small motors up to ninety per cent. for those of large size.

Third.—A third factor enters the problem depending upon the rate of rotation of the motor armature, and the resistance of the circuit.*

It is evident then that we can have a high rate of efficiency by keeping down the loss due to this third factor, and due attention has been given to the matter in all the applications that have been made. These applications have been simply enormous. But a few years ago there was hardly a motor (electric) in use in the United States. To-day one single company numbers them by the thousand,† with an aggregate horse-power that is simply bewildering to contemplate. Motors of all powers from one-sixteenth horse-power to two hundred horse-power, with commercial efficiencies varying from seventy per cent. to ninety-two per cent. are guaranteed by the manufacturer.‡ Electric car lines running up into the hundreds have been built and are building, for distances from two miles up into the hundreds; § more than 450 roads operated by electric power with a total mileage of more than 3,600 miles, employing nearly 5,800 motor cars are reported; ||

* Ordnance Note No. 306. Transmitting power at a distance. Electrical transmission.
† Electricity on board ship.
‡ Catalogue Edison General Electric Company and others.
§ Engineering Magazine—March and April, 1892.
|| Engineering Magazine—May, 1892.

in one year nearly 30,000 horses were replaced by electric cars;* all this would look as though the motor was an accomplished success, and that electric power has come *to stay*.

For our military problem therefore we have a means of transmission of power that has been tried in nearly every conceivable way and has not been found wanting.† The engine and boiler that we must have to generate power, can be applied safely and economically to the generation of electricity in as large amounts as we may need or desire. This generating plant can be centrally located, protected, efficiently run by a small crew of skilled employees, and therefore compares most favorably with any of the other means of power generation heretofore considered.

With this much in its favor as a beginning the great superiority begins to be more pronounced when we consider the means of transmission, and of reconversion into power after transmission. Instead of bulky, costly and cumbersome ropes, pipes, or shafts, we have a few copper mains, that need not be large as compared to a five or six inch pipe.‡ These mains can be carried in any manner. Frost does not effect them, therefore they need not be protected from freezing, and can be anywhere, even upon poles in many cases. If a wire should be shot away, the most ignorant man in the command could splice it temporarily, even with a current on; for with voltages up to 220 no danger would result from contact with live wires.

As stated in the wiring for the lamps in previous pages, whatever system of wiring was introduced, it should be with interlocking mains, branches and feeders. Then if any wire was shot away and could not be spliced at once, the closing of a switch would throw that branch or main upon some other circuit from which it could receive its power until repairs could be made. The wiring too should be such as to allow but small loss in transmission. This is but a detail of first cost; the relative gain in efficiency

* Scientific American.

† As prominent examples see Electrical power transmission at Virginia City, Nevada, Electrical World, May 25th, 1889; electric motor in model mining operations, Electrical World, January 12th, 1889; electrical mining installation, Ouray, Colorado, Western Electrician, March 12th, 1892; a model mine equipment, Electrical Review, March 12th, 1892.

‡ Calculations for long distance electric power transmission, Electrical World, May 25th, 1889.

by a less drop in the leads being balanced against the greater first cost, to determine the expediency of the limit to permissible loss. We now have this second advantage in its favor, and let us look to ultimate application for our final result.

Of all machines made for the application or conversion of power the electric motor may be ranked as the best. With but one moving part, the armature, it has but one part to give trouble, the commutator, and that has long ceased to be troublesome for voltage such as we would probably use. Even up to 1,000 volts the commutator can be relied upon, and it is only when we run up into the thousands that much trouble is experienced.*

For equal horse-powers the electric motor occupies less than half the space of a steam engine and weighs less.† Special forms of motors are being and have been developed for special work. We tuck away a fifteen to twenty-five horse-power motor under a street car without much trouble, and we certainly can find room between the chassis rails of our gun carriages to put our motor. The motion of the armature being rotary to begin with needs no conversion, but is applicable directly through a proper train of gears to slow down the speed and apply the power to the best advantage. The motor can be *started slowly* thus beginning to move its load without undue shock or strain, after starting it can move the load rapidly or slowly at will. When we wish to stop, the motor can be slowed down, and the gun stopped just as we wish it to be stopped at its proper place, with its proper azimuth, without any necessity for "backing and filling" to get the gun properly directed. The motor that is worth the name has no dead centers; it can be made with a powerful torque so as to be able to start a heavy load, and no attention need be given to anything but the proper control of the gun, no thought being given to the motor, the position of its armature in stopping or starting. Anyone, even the most ignorant cannoneer, can operate it by opening or closing a switch; beyond an occasional oiling, by filling self-oiling bearings, and cleaning the commutator the motor runs itself.‡ When the bearings become worn, and that will not be for

* Engineering Journal—Electrical transmission of power. May, 1892, page 219.
† Electricity on board war ships.
‡ Electricity on board ship.

years with anything but the most criminal carelessness and neglect in the way of oil, new bearings can be slipped in by anyone who knows how to use a monkey wrench, and the motor is as good as new.

As for reliability and freedom from any break-down it may be stated that the motor of to day is unique in its record. In the commercial world hundreds of motors, of all sizes and types, are in daily use for eight, ten and twelve hours a day, every day in the year, with the repair account next to nothing. Nowadays "crossed" and "burnt out" armatures, cut and scarred commutators from sparking and improper construction, trouble with field coils are the rare exception. To day a mishap is extremely rare. Motors are not put under glass cases and labelled "handle with care." They are tucked away under street cars, but six inches above the street, and run the car through slush, snow, mud or rain from sixteen to eighteen hours out of the twenty-four, averaging from ninety to one hundred and twenty miles per day,* No service that we could possibly put them to in handling our guns could compare with this, either in variation of speed or load, length of continuous duty, suddennes of shocks or strains, unfavorable conditions of weather or streets, inaccessibility and narrowness of space allowed, and lack of even a small amount of attention. These motors run, not by reason of any fostering care on the part of the motor-man, *but in spite of him.*†

Our motors must necessarily be exposed to the elements, uncovered and unprotected except when in casemates. To meet this the motor of to day can have a stream of water played upon it from a hose, to wash it off and clean it, without injury. Armatures have been tested for insulation and found all right, have been soaked for twenty-four hours in hydrant water, taken out and tested again and found to be sound in every respect. An armature was then put in salt water for twenty-four hours, taken out and put at once into a motor, without drying of any kind, and the motor ran for two hours at an overload of from twenty-five per cent. to fifty per cent. without trouble or break-down.

* Electricity on board war ships.

† Electricity on board war ships.

No more conclusive test could have been devised.*

Field coils and armatures can be made *absolutely* water proof, hence no fear need be felt that there will be a break-down from exposure to the weather.†

Though from its position pretty well secured against injury from hostile shot, the motor may be encased if need be so as to be proof against pretty heavy fire, so that stray bullets from Gatling or rapid-fire guns need not affect it. It can be much better protected than any other form of motor from its compact form, and there being but the one moving part. When fire gets heavy enough to disable the motor the position of the gun would be untenable anyway, and the gun itself, or its carriage, probably be disabled.

We then have an efficient, thoroughly reliable, and easily applied mechanism to convert our power into mechanical energy at the gun, and the advantage of this system may now be summed up.

First.—Efficient and reliable means of power generation.

Second.—Efficient and reliable means of transmission.

Third.—Efficient and reliable means of conversion and application.

Fourth.—Efficient and reliable means of gun control.

What more anyone can ask for is hard to see.

It may be objected that this is all very well for short distances, but that it would fail in the length of circuit necessary for our modern forts. To meet this it may be said at once that the distance to which power may thus be transmitted economically is a direct function of the voltage used. As stated under the head of lighting, we should not introduce a dangerous voltage, and thus add a means of killing in addition to the hostile shot or shell. Nor is there any necessity therefor; even with the limiting voltage of safety, five hundred volts, power has been and can be economically transmitted for at least three miles, as we see every day with the Old Point and Hampton electric road. That we will ever have a fort six miles in diameter is hardly to be expected. Yet we could have, so far as safe power transmission is concerned;

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* Electricity on board war ships.

† Giving a motor a bath—Electrical World, May 11th, 1889. An amphibious motor—Electrical World, April 13th, 1889. Dragging motor through the mud—Electrical World, June 29th, 1889. Water-proof and fire-proof motors—Electrical World, June 15th, 1889.

we could have our dynamo plant centrally located, strongly protected, and supply power to outlying detached forts too small to generate their own power for want of room, and all within safe limits.*

In the application of the power the question naturally arises what must be the powers of the motors to be supplied?

The *Chicago* has a five horse-power motor applied to train an eight inch gun-carriage, and a one-half horse-power motor to be used for elevating.† The training motor takes a current of forty amperes as a maximum, with a heavy load. The one-half horse-power motor runs at one hundred and six volts, the voltage on the five horse power motor being the same.

It must be remembered that the land and sea conditions are not the same, and that they are all in the land's favor. We have a steady platform instead of a rolling and pitching ship. In training our guns, therefore, we have not to run up hill at any time. We have approximately a fixed load to handle at the start, slow in the beginning and requiring a maximum of power; but when once started, comparatively easy to move if our traverse circles are anything like what they should be. If, therefore, a five horse-power motor will handle an eight inch gun on a rolling platform it certainly should be able to control it upon one that is stable. We need not fear for want of power therefore; for if need be we can put on ten or fifteen horse-power motors; if such motors can be tucked away in a limited space under a street car there need be no fear but that they can also be found room for on our modern gun-carriage.

The class of motors to be used is also a question of interest. We can have almost anything we want. We can have them for constant current, for constant potential, for varying speed, varying load, constant speed, or constant load. We have but to pay our money and take our choice of what is best suited to the conditions of the problem.

For gun training we have after starting a varying load, and the necessity for a strong torque at the start to move the heavy load.

* Space too limited to quote authorities for long distance transmission.
† Electrical World, February 7th, 1891.

As we have to shift our gun, now to right, now to left, in following a moving target, the motor must be able to control the movements of the gun with absolute certainty. The series wound motor is here probably the most suitable, it has a strong torque at the start and hence will take hold with a powerful turning movement when first applied to move the heavy gun from rest, or when reversed to change its motion from right to left or *vice versa*. When once in motion its speed may be varied if desired by having it so arranged as to be able to throw on more and more current by cutting out resistance, or less and less current by cutting in resistance as we may desire it to move faster or slower. This may all be accomplished without the cumbrous detail of mechanism necessary for the variation of speed from a steam engine.

Where constant load and approximately constant speed are required, the plain shunt wound or compound wound motor may be applied. For elevating we have approximately a constant load; there is no necessity for change of speed and the plain shunt wound motor could control the gun, within certain limits at a constant speed of elevation or depression.

Besides the ability to handle our guns rapidly in azimuth or elevation, we need the ability to load rapidly, so as to take full advantage of all chances for favorable shots.

To load a modern high power rifle is no child's play; projectiles ranging in weight from two hundred pounds to half a ton, and powder charges from over one hundred to eight hundred pounds, are not to be picked up and thrown around like foot balls; something better than a hand power crane is needed, what that is to be is the question.

It is readily conceivable that the loading of a breech loader is more easily effected than that of the muzzle loader; but, unless we adopt some form of loading arrangement such as have been adopted on ship-board, where the breech of the gun is depressed and projectile and cartridge are inserted from below decks by a loading device, we will have to lift our weights to the breech of the gun from the gun platform, in a somewhat similar manner to that now in use for our old muzzle loaders.

There would seem to be no insuperable objection to the adoption of the method above mentioned as in use on ship-board. The shell-room and service magazine could be located below and in rear of the gun, in a suitably protected casemate. From this lower position the projectile and charge could readily be raised to the gun breech and as easily inserted. True enough, we would have to have a site sufficiently well located above the water line to allow the shell-room and magazine to be above sea level, in order to avoid the complication of a water proof casemate below the water level. But generally our site will be sufficiently elevated, or can be made so, and even if not, water proof casemates are not impossible. But, whatever the method, power should be applied. Again electricity comes to our aid as most fully reliable.

Mention has been made of shot hoists in connection with the tracks and trucks to supply our service magazine. Such a shot hoist has been put on board the Atlanta.* It is most ingeniously contrived so as to give perfect control to the speed of hoist, and so that the projectile can be stopped instantly when at the right elevation; it can be controlled by one man. If this man should be shot or become demoralized and abandon the hoist while in operation, it would come to rest at once and therefore cause no danger from a "run away."†

Such a hoist is one that could be used for all of our guns, not provided with lower shell room and magazine and some other form of loading device. It also could be used for the heavy charges and projectiles in loading and unloading trucks that bring up the ammunition.

Where lower shell rooms and magazines are provided, it could also be used where other forms of loading devices were not employed. Each gun being equipped with its shell room, magazine and hoist, the ammunition for the next round could be made ready and loaded upon the hoist as soon as it was emptied of the previous round. The shell room crew could do this and have everything ready for the next round to be hoisted when needed. Heavy projectiles and charges of powder would not then have to

* Naval Intelligence Series—electricity on board war ships.

† Electricity on board war ships.

be transported by hand power from a general shell room and magazine pertaining to a group of guns, but would be on hand at once ready to be loaded; for it is reasonable to suppose that all this can be done in the lower shell room in the time taken to train, elevate and fire the gun, where anything like deliberation and accurate range work are being followed. Certainly the work would be done quicker by a crew who have nothing else to do, and who have power at their disposal, than would be the case with a part of the gun crew who must walk an unknown distance to a general room, and from there transport back in some unknown way the heavy projectile and charge, load it on to some form of hoist, then hoist it by hand, and finally by "brute strength and awkwardness" get it into the breech of a gun.

Where anything like the inclined railway and telescopic rammer are used, it is simply a matter of detail to substitute electric for other powder. With an electric training motor the gun breech can be thrown around to the loading position with ease and rapidity, the breech lowered, and the gun thus put rapidly in the position for loading. In the mean time the shell room crew have the ammunition for the next round all ready in place upon the railway in front of the rammer. As soon as the breech is in position the railway is raised to its position, lifting away the cover over it automatically, and the rammer slides the projectile and cartridge to its proper seat in the breech. The railway then lowers, automatically closing the cover; the breech block is closed and there you are with the gun loaded, ready to train to its proper azimuth and elevation as given from the range-finder.

It may be objected that we are developing a very complicated and costly outfit to reap but a doubtful advantage, and that we will need a crew of trained electricians, mechanics and the like in place of cannoneers.

As to the first objection it can be said that the outfit may be costly but it need not become complicated. Guns are costly, war is costly, but that we can have nothing whatever to do with. We must have the best of modern high power guns for our national defense, or sink to a low rank among nations. To handle these guns we must have the best power that modern science can give us, no matter what it costs; but when it so happens that the best power is also the cheapest, it would look as though there was but one thing to do and that is adopt the best because it is the cheapest, not only in the long run, but in actual cost of operation and maintainance.

As to complication there need be none. Doubtless the first installation would have many faults. Every art and science has had to "creep before it could walk." Minerva may have sprung in perfect form and fully equipped from the head of Jupiter, but that is the only case I know of either in ancient or modern times. We don't have that kind of headaches now, though many a head has ached from problems, thought and study in the perfection of details of inventions. Practice and the details of execution or construction alter and amend, simplify and improve, and no piece of mechanism, no matter how simple, can yet be said to be fully perfect. Actual construction and trial are necessary to fully determine the practicability of many things. We never will know what is best for our guns until trial has proved or disproved theory.

As to the qualifications required of our men, let it be granted that they must know more and do more than in days gone by. Time was when Jack Tar was required to "hand, reef and steer" as his main qualifications, with a little ability to handle a cutlass, boarding pike or sponge and rammer thrown in. If to-day he knows more about gunnery and less about reefing, more about engines and less about seamanship, he is but adapting himself to changed conditions. If he can change and adapt himself, and be just as ready and efficient for war service as ever, so can we.

But of all the powers that may be used to give us the aid that we must have, electrical power requires the least technical knowledge upon the part of the operative. Motors have no boilers to blow up and create havoc. They require no fuel except that supplied by a simple wire that, if properly put in, will not burn ones fingers, shock ones nerves or set fire to the surroundings. Water does not run low and need constant attention. All the operator has to do is to turn a switch and he has his power under full control.

In all future warfare, whether we use our present black powder or any of the recently proposed smokeless powders, complete and thorough ventilation must be provided for all our casemates, turrets or other covered works, and for galleries, passages, connections, bomb proofs, or magazine and shell rooms connected to the work that may fill with smoke, or with the noxious gases developed by the combustion of smokeless powder. In the one case the ability to see will be the controlling reason; in the other the ability to breathe and not be poisoned or overcome by noxious gases, will compel the same appliance to free the locality as rapidly as possible from the gases.

All underground galleries, magazines, shell rooms or other appurtenances to the work will also need artificial ventilation to make them habitable and endurable in the heat of an engagement, or for prolonged occupation at any time. These requirements again call for the application of power, and again in the electric motor and blower combination we have the power and its application for the solution of our problems.

These combinations were first invented for the ventilation of engine and boiler rooms and stoke-holds on board ship. By their use *no further heat is developed*, as would be with any form of steam engine, but all the energy would be devoted *to cooling the space* by the rapid removal of the already heated air and its renewal by a supply of cool fresh air from some outside source. Such blowers have been and are in use upon the cruisers *Baltimore*, *Charlestown*, *San Francisco*, *Philadelphia* and *Petrel*, and doubtless now upon all of our naval vessels. They have been most favorably reported upon, not only as to their effective work, but also because of the little trouble they give in their use or in keeping them in order.

We therefore have a combination that is simple, durable and effective, that occupies but little space, and that has the power to move large quantities of air per minute. They have been constructed to move as high as about 5000 cubic feet of air per minute, with a diameter of inlet of sixteen inches, diameter of outlet the same, the fan or blower moving at a rate of 875 revolutions per minute. Smaller outfits (and doubtless larger ones) are to be had, so we can have no excuse for not having all covered works or other appurtances to our works, not open to the free winds of heaven, perfectly ventilated and rapidly freed from smoke or noxious gases.

It is needless to dwell upon the great advantages to be derived from such a condition. Smoke has become one of our greatest bugbears; noxious gases will be just as bad, though for a very different reason, and by proper application of the above power we can be free from both.

Space will not permit of more than mention of the range finding problem. The details of this most important question have been well worked out by many independent workers, both at home and abroad. In every scheme of practical utility, electricity enters as the working force. Our forts will not be fully equipped or fully efficient until all are supplied with the best range-finder that is to be had, so that we can at any time, by day or night, locate and track an enemy's vessel, and by signals if we must, automatically if we can, indicate to the guns the proper azimuth and range to reach the target.

When this becomes possible, and that it is impossible who will say, the gun captain may then direct his piece as absolutely and accurately without seeing the target as if it were in full view. Indirect fire thus becomes a possibility; it is now simply a great desideratum.

The conjoint defense of one of our harbors by land and sea necessitates some reliable and prompt means of communication between forts and ships.

The flag and torch, reliable as they may be for want of better, sink into insignificance before the possibilities held forth by electricity. One squadron of our fleet now has an installation that we at the Artillery School have all seen. What is to prevent the same system from being installed as a permanent feature of each of our sea-coast forts? For long range night signaling the search light used by flashes or in any other preconcerted method, can be seen for miles; it is also thought that it could be used by day the same as any heliostat.

Let us now pause for a moment and see what we need for a sea-coast fort:

First.—The search light.

Second.—Inside illumination for night work as well as general illumination for every day affairs.

Third.—The generation and transmission of power.

Fourth.—Signaling installations.

All these require the dynamo; the range-finder, and ordinary telegraphic or telephonic communications can be by the galvanic cell.

We then require a central engine, or engines capable of generating the requisite horse-power to drive our dynamos. From the central station our mains must lead to the search light stations, carrying a powerful current for arc light use. From our station again other mains must lead out to cover the area of the incandescent lamp circuit; again mains must be placed for our electric road, and possibly for the motor service.

In the aggregate an enormous horse-power will be called for in anything like a large sized fort with many guns, and it might be interesting to work out the actual power required for a supposed site. But without going into this it may be said at once that the power actually installed need not be the gross aggregate of all the horse-power called for on all the circuits.

It has been proven by experience that the commercial central station can lease or sell more power in the aggregate, than it actually possesses. It can engage to light more lamps than the dynamo can possibly supply at its full load, and why? Because experience has shown that never will all the motors or all the lamps be in use together.

In our installation the incandescent installation for battle or night work would not be in use except occasionally in time of peace. Conversely the installation for barracks and quarters would not be in use in battle, hence these two circuits would not interfere with each other, and their aggregate need not be taken.

It is hardly to be supposed that all the gun-motors would be in use at the same instant. Still it might happen, and to be on the safe side, perhaps enough power should be calculated upon to provide for all.

As stated once before the navy has shown by their ship installation that arc lamps and incandescent lamps can be run from the same dynamo. It can also be shown that both kinds of lamps and motors as well can similarly be supplied. In commercial practice however, independent power circuits are now being installed as better meeting the economical conditions of the problem.

It is possible then to have what we want just as we want it to best fulfill the military condition, and that too in an economical manner.

We can have one dynamo or set of dynamos to run all three of our circuits, or we can have a set for each. As the motor service would be needed in battle, either by night or day we could have special dynamos for that service, while the search light and incandescent service could have their own dynamos. Study and investigation of the best conditions to meet the problem would soon tell us what best to do, while the experience and intelligence of our civilian electrical engineers and experts should be invited to our aid.

Mention was made some pages back of the necessity for trial to prove or disprove theory; the list of applications in which the use of electrical power has been most successfully demonstrated is altogether too long for me to repeat. Almost every day some new problem, some new application is successfully met and accomplished, until now the power user has but to make his demand to be reasonably sure that he will be efficiently supplied, thus most decidedly demonstrating the success of theory.*

As events have turned out we are perhaps to be congratulated that we have made no more advance than we have in solving the problem of proper mounts for our guns. Not being committed as yet to any system, we have the whole field before us from which to select, without having anything yet made and in place to hamper us in our selection.

The time has come however for us to do something. We are making our guns and they need mounts to be of service. Guns and platforms need forts in which to place them; and, as we now have nothing, or next to nothing, we can build from the foundation

* As samples of the use of heavy power machinery, see—
Sprague electrical mining hoist—Electrical World, October 19th, 1889.
Electric dock hoist—Electrical World, November 1st, 1889.
Electric cranes in Philadelphia—Electrical World, January 17th, 1891.
Electric cranes at the Grant locomotive works—Electrical World, March 19th, 1892.
Electric cranes ot the E. B. Ellis works—Electrical World, April 16th, 1892.

up, with such construction as will the most readily adapt itself to these questions of generation, transmission and application of power, as well as the proper protection and command for our guns.

And, because electric power has not as yet been used to any extent for such work, we need not wait for its success to be demonstrated by some one else before we adopt it. Its success in every other field is beyond all doubt. Its application to the various problems of gun control and fortress service and warfare, is but a matter of detail that can most certainly be met and successfully accomplished in spite of all the prognostications of failure that may be brought against it. We must remember that all advance and knowledge has been brought about by some one, at some time, at some place doing something that never had been done before; this too in the face of opposition, of ridicule, and sometimes of absolute persecution. It was mathematically demonstrated that a steam ship could not cross the ocean for want of room for her coal. Yet while this was being discussed, an American ship steamed into an English port. It was proven beyond a doubt that an iron ship could not float; yet while it was being proved iron hulls were being launched. Look at our "grayhounds of the sea" to-day, and then laugh at these doubts and predictions of failure if you will. Are they any more ridiculous than are the croakings, the doubts, the indifference, the inertia of military men the world over, when something new and as yet untried as a military adjunct is brought forward, as an improvement upon existing military methods?

When therefore the power has shown what it can do successfully in every other field; when its generation and application have been proved to be both certain and efficient, as well as economical and within control, should it not be recognized and welcomed, be tested, be experimented with in every way, and every facility be given both to those of the Army and Navy as well as our civilian engineers, to bring it to its full development for military use?

Let us hope therefore, that, as our guns are built, our platforms laid, our carriages erected, and our forts planned and constructed, and we finally find ourselves once more possessed of a sea-coast defense worthy of the name, we may find therein the dynamo as a vital part; we may have the search light, electric light and power for the use of our guns, and thereby have the aid of Electricity in the solution of our part of the problem of the Art of War.

[DISCUSSION.]

General *H. L. Abbot*, Corps of Engineers.—The paper by Lieutenant Parkhurst upon "Electricity and the Art of War" is not only a suggestive, but also a timely contribution to the ARTILLERY JOURNAL, for after long delays the work of reconstructing our coast fortifications has made a fair start with promise of continued progress. Many of the more important ideas in the paper have been introduced in the new plans, such for example as the hoists for transferring the ammunition to the vicinity of the gun without delay, or calling upon the men serving it to leave their posts. The importance of search lights was easily recognized as long ago indeed as 1872–77, when different lights and reflectors for the purpose were imported and experimented with at Willets Point, although at that date they were rarely seen in this country. Illumination by incandescent lights for magazines and interior passage ways will form a part of our new system; and motors for operating our guns are under consideration, and will be introduced as soon as the details of the carriages, upon which their definite application depends are determined. It is a good sign of the times that these matters are appreciated and are engaging the attention of artillery officers.

I cannot however but see with regret in so interesting a paper, the old claim that the service of submarine mines pertains to artillery troops again raised. This matter has already been determined by Congress and by the War Department, and I think its further discussion only tends to create feeling where the utmost cordiality should prevail. Silence upon such questions is golden. The line of argument adduced for the transfer would justify the infantry, confessedly the most important arm in campaigning, in claiming to serve the field-guns. It goes without saying that the commanding officer, whether in the field or in defending our harbors and fairways against a hostile fleet, must command all the arms of service combined in the common operations; but this by no means implies that special services should not be performed by specialists. The engineer troops, by reason of their duties as pontoniers, are familiar with the water and management of boats, and they are the only troops so instructed. Their duties as land miners train them in a more varied use of explosives than any other arm. It is perhaps for these reasons that the new branch of sea mining has been assigned to them in preference to the artillery, both in this country and in other services. The assignment is simply a division of labor calculated to meet the requirements of service in the most natural manner. I am sure when artillery officers better appreciate the varied and multifarious calls which will be made upon their arm in the modern system of coast defense, they will recognize the fact that no time will be left for undertaking new duties, and that they will welcome the aid of their natural allies in all branches of military mining. No distinction can be drawn between the status of artillery and engineer troops as special arms of service, and anything calculated to create jealousy between them should be deprecated by all who have the good of the army at heart.

Captain *E. L. Zalinski*, 5th Artillery.—Having had some experience with pneumatic, hydraulic and steam power, I fully concur with Lieut. Parkhurst in the superiority of electrical power for use in the manipulation of guns and artillery appliances. Electrical connections, if cut, can be repaired more quickly than can either steam, hydraulic or pneumatic pipes. Besides ease of repair, greater flexibility of the system is possible.

The German search light made by Schuckert, of Nuremburg, is used by the Germans, English and Italians, and presents many advantageous features.

Major G. S. Clarke, R. E., has suggested the use of horses in operating dynamos for search lights for field and siege operations in lieu of steam. A large number of horses are usually available and light portable horse power machines could be made.

There is no difficulty in causing a search light to follow automatically the movement of an observing telescope, as suggested by Lieutenant Parkhurst, but I cannot imagine any particular necessity for introducing such a complication. It will be easy enough to direct a telescope by hand upon areas illuminated by the search light.

There is a constant danger of introducing too much mechanism which is to be avoided as much as is the other extreme of not utilizing it where it can reduce the manual labor and increase facility of operation.

It should be considered an axiom in designing artillery machines that it should be possible to operate them manually if the power used fails or the mechanical parts operated by it are injured. Even the search light may be replaced by using the Wells Lucigen light This last has the advantage of requiring no dynamo or machine to operate it and is very portable. It is used by the English and Italians.

The time is not at all distant when tidal power will be harnessed to produce electrical power. I have had the privilege of seeing a scheme devised by Colonel Anson Mills, 3rd Cavalry, which appears thoroughly practicable. Others have been proposed which have the semblance of practicability. Some of these will surely realize the anticipations of utilizing the great tidal power of our sea coast.

Whilst it is true that our past state of defencelessness leaves us at liberty to start anew with the most advanced military appliances, I very much fear that in many ways we will have forced into our hands an armament which, when completed, will be behind the age. Many of the guns now making are likely to be of a power which was high five or eight years ago, but are not up to the possibilities of to-day. We, as artillerists, have very little to say in the matter.

Lieutenant Parkhurst presents excellent arguments for the immediate introduction of electric lighting at all artillery posts. As he rightly points out, it is not alone a question of artillery efficiency in case of action, but it presents both the features of immediate current economy and the appliances for providing practical instruction and experience in one of the most necessary elements of an artillery defence.

Mr. *W. H. Jaques*, Ordnance Engineer, South Bethlehem, Pa.—The development of electrical appliances in connection with the art of war is a subject that demands earnest and immediate attention. Something has been accomplished in the United States in this direction, but little more than enough to discover its vast importance.

Great as was the usefulness of electricity during the period of the Civil War campaigns of Grant and Sherman and in the Franco-Prussian war, it was only a means of communication; and there was probably no one at that era whose imagination was sufficiently elastic to dream of electricity ever acquiring the compass it possesses at the present time. To-day it is not only equally important as a means of communication and control, but to its usefulness in that direction is added its wonderful force as a motive power easily led, connected, interlocked, switched and repaired more rapidly and simply than any other agent.

Far reaching as its employment then seemed and priceless as a communicant, that importance will be insignificant when compared with the application that will surely be developed in any future war even as short and spirited as the Franco-Prussian. Telephonic communication is already a vast improvement over the slower telegraph and complicated cipher systems, although probably a cipher will have to be employed with the former to avoid the discovery of plans in case the enemy taps the lines.

Lieutenant Parkhurst's suggestion is a valuable one, that the employees of our vast network of railroad and telegraph lines should be regularly enrolled in the event of war. But I would not wait until the opening of hostilities or even until the declaration of war to organize and discipline this important body of men. The naval reserve and militia movement has been so eminently successful that an organization called by some such name as the "Military Reserve of Communication and Transportation" or the "Electrical Reserve" would perhaps be equally popular; the United States and state governments, as in the case of the naval reserve, making some provision for its expenses. The officers detailed to effect this organization should be taken from those who have made a special study of electricity and its various applications. From this reserve in time of war could be drawn the necessary forces for operating the electrical appliances of all military machines including torpedoes, mines, gun carriages, range finders, etc., etc.

In the same manner that torpedoes are operated at almost any distance from the generating plant so, indeed, will many other war engines be controlled and operated, the power being generated at points the nearest invulnerable and least subject to attack and led to war material of adaptable character as boldly as daring cavalry dashes of earlier warfare.

Mr. Parkhurst's reasoning for the substitution of electric lighting for the older methods is instructive. Even if it were not economical it should be substituted on account of its greater and simpler applicability and control and the opportunity it affords for better ventilation.

In the handling of guns and ammunition electricity bids fair to supplant all other powers but hydraulic, which is not only, as Mr. Parkhurst says, a favorite method but will probably prove to be in a great many cases the most efficient.

In his affection for electricity he has probably made it harder for steam and easier for electricity to accomplish what he desires than a comparative test would prove were the simplest and most efficient application of both systems employed. Mr. Parkhurst certainly presents enough in their favor however to justify a practical test of his suggestions.

These are very interesting but their value can only be proved by practical test. That opportunity should be given to do so there is no doubt and I trust our legislators may be induced to provide the means.

Dr. *Louis Bell*, Chief Engineer Power Transmission Department, General Electric Company.—It is decidedly interesting to meet with any new application of the arts of peace to the art of war and Lieutenant Parkhurst's discussion of the uses of the electric motor in the service contains much that is new to laymen and to those officers who from the pressure of their own private work have been unable to follow the quiet, but none the less rapid progress which has been made to facilitate military operations.

Perhaps the two applications which at once strike the electrician as the most promising, are the manner by which heavy guns may be moved by electric motors and the use of the search light as a weapon of defense.

With respect to the use of electricity for power purposes, Lieutenant Parkhurst falls into an error which is quite common and comparatively trivial; but should, nevertheless, be corrected. The electric motor was not in any sense of the word an accidental discovery. There is, unfortunately, a tendency to laud accidental discoveries, of which, however, the electric motor was not one. It had been plainly established by Pacinotti as early as 1864 that his dynamo electric motor was reversible and would run as a motor. The same principle had been laid down by several other investigators; had been noted by Gramme in his workshop and was shown at the Vienna Exposition, not accidentally, but deliberately.

But this aside. The salient advantages of the electric motor which recommend it in every case where power is desired for handling heavy artillery, are its compactness, perfect controlability and its comparative independence of source of power.

The first is an enormous advantage, both in placing the motor in the most effective position and enabling it to be shielded from accidental displacement, or hostile shot. The second is absolutely necessary to secure the proper and prompt training of the piece. While the third may perhaps be more prominent on the sea than on land, it is always an important feature. The steam pipe is an all too rigid method of conveying power. Suppose the pipe were to be struck by a shot, it cannot be readily mended; while were the same accident to happen to the leading wires of the motor, repairs could be executed or new lines even could be run under fire inside of five minutes. In new ships or forts, for motors, it would be a very simple and easy matter to run more than one set of wires, so as to minimize the danger of the wires being broken during action.

A totally different field is that occupied by the search light. For sea coast defense it certainly could take a very important position. It is hard to imagine anything more confusing than to attempt to bring a ship up a tortuous channel under fire, while the continuous glare of a dazzling search light is about her course. Even were this difficulty surmounted the constant blaze of light about an approaching ship makes her a magnificent target for the gunners, while her own men would find it no easy matter to lay a gun with any accuracy in the face of the search light. The recent civil war in Chili gave us at least one good example of how exceedingly unpleasant the search light can make it for hostile vessels.

In this connection it may be well to suggest the use of metallic reflectors intended for search light apparatus. Probably this point is more important on land where, from their stationary position, they offer a better target than would be the case were they constantly moving. A single shot from a rapid fire gun, or even a Gatling, would seriously damage the usefulness of our ordinary forms of search light. With metallic reflectors, a few hits by small projectiles would produce relatively trivial effects. The care required is greater to be sure, but whether this is not justified by the additional security is a question worthy of consideration.

In the field the search light has a somewhat less prominent position, but still one of decided usefulness, and in detecting the enemy's movements and similar work ought certainly to be valuable. Another excellent auxiliary to the search light in the field might be found by using a captive balloon, which would enable the country for a radius of perhaps five miles to be scrutinized very carefully.

Lieutenant Parkhurst has certainly done good service in bringing these and other prominent uses of electricity before the attention of those who are best fitted to judge of their importance and who are in a position to see that the improvements suggested are carried out.

Mr. *O. T. Crosby*, General Manager Railway and Power Transmission Departments, General Electric Company (late 1st Lieutenant, Corps of Engineers, U. S. A.)—Referring to the article on the use of electricity in warfare by Lieutenant Parkhurst, of which advance sheets have been very kindly sent me, I regret that I have time to give but a too hasty consideration to the subject, interesting to me by reason of my business connection and as a former officer of the army.

However, it is fortunate that little remains to be done for those who are asked to express opinions concerning this paper, save to endorse largely all that Lieutenant Parkhurst has said, and perhaps to emphasize some of the points made by him..

To begin, by what is really a digression from the general subject treated, permit me to refer to Lieutenant Parkhurst's suggestion concerning the transfer of torpedo service .from the engineer corps to the artillery. The close connection of the torpedo service with what may be termed the other elements of the fighting service in a fort, make it desirable, it seems to me, that officers of the same corps should direct both services.

Supposing an engineer officer to be in charge of the torpedo service of any fort, his relations will be so intimate with the commanding officer of that fort. and so remote with the general commanding his own corps, that the logical thing to do would be to temporarily relieve him from any practical obligation to his own corps commander, and place him wholly under the orders of the fort commander.

He would have toward the commanding officer of the fort, practically the same relations as those of the artillery officers, engaging in the regular duties of serving the guns of the fortification.

Why not have him once for all in the artillery service, so that official "lost motion" of relieving him from duty under one head and placing him under another may be done away with?

Further, constituted as it now is, the engineer corps seems to me by no means large enough to supply in time of war the proper number of officers for torpedo service without serious neglect of many other forms of duty, which are clearly those to be performed by the engineer corps.

The artillery officers, on the other hand, are now and have been for some years, really more numerous than would be required by reasonably hard work in a regular line of duty; and again, even if it were appropriate that at the beginning of the effort to develop a torpedo system, it should have been placed in the hands of the engineer corps, now that the system is quite well perfected, it seems that no such reason could be fairly alleged.

I trust that my former comrades in the engineer corps, service with whom is now and ever will be one of my dearest memories, will not consider this as in any way treasonable.

Going now to the main questions involved in Lieutenant Parkhurst's paper, I find that he has so carefully presented the case, that to anyone familiar with the electrical business, he seems to have been unnecessarily concerned as to the appreciation by his readers of the fact that the motors "do move." I know full well, however, that his care in this respect would be justified in many cases with those who have not been able to familiarize themselves with the enormously rapid march of electrical progress. As to the magnitude of the machines, and as to the number of uses to which they have been put, Lieutenant Parkhurst has not, indeed, said as much as the facts would justify.

700 horse-power dynamos are daily in operation in the city from which I

write. 2,000 horse-power dynamos are now in course of construction within a few miles from the same city.

Going to motors, these dynamos, of course, may at once if desired be used for the correlative work of motors, instead of that of generators, for which they were above mentioned. Moreover, electric locomotives, having a capacity of 1,600 horse-power, composed of six armature units, are now being built for use in the Baltimore tunnel of the Baltimore and Ohio Railway Company.

The hauling of heavy street cars, frequently in trains of two or three, is to-day too common a matter to be more than worthy of passing mention.

A hundred uses in mines and manufactories are now being made and their number daily increases. Rapid progress is being made towards the use of higher potentials than are commonly used, and in this way the distance over which the power can be economically transmitted will be within a short time, largely increased.

In special cases, where coal or other fuel at the point of use is abnormally high, it is to-day entirely commercial to transmit for manufacturing purposes, over a distance of ten or twelve miles, from any convenient water power.

As a matter of fact even to-day, so far as military uses are concerned, the additional cost of copper, caused by placing a station quite out of the reach of the enemy's guns (if it were difficult to thoroughly protect it in the fort), would be a matter of small concern.

I regret that very constant occupation prevents me from putting my shoulder to the wheel in the worthy work which Lieutenant Parkhurst's paper signalizes, but I can at least offer, as I now do, my best wishes for success to those whose duty and opportunity it is to urge our army toward the most modern methods in every activity which they may pursue.

[TO BE CONTINUED.]

RECOIL OF HEAVY GUNS AND ITS CONTROL.

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

When a charge of explosive is ignited in a close vessel with rigid sides, a pressure is produced but no motion. If, however, the sides of the vessel yield, either by expansion or rupture, motion of the parts involved follows. The direction and extent depend on individual circumstances, and when the containing vessel is a gun chamber, the motion of the gun is known as recoil.

In the early use of guns with mealed powder, the conditions as to charge approached those of the present with slow burning powder. The pressure was never very great, and recoil not at first excessive.

The recoil checks depended on, were those incidental to the system devised "to throw stone or iron balls from metal tubes closed at one end, the force being exploded gunpowder." These two checks were 1st, the great mass of piece as compared with shot and charge; and 2nd, the friction of carriage (used in its most general sense) on whatever supported it.

As the properties of gunpowder became better known, and experience taught modifications in gun construction to better utilize these characteristics, higher velocities for the projectiles became the rule. With increase in veolcity came greater recoil, but so long as cast iron was used as a gun metal and the powder was quick burning, the great relative weight of gun to shot and charge absorbed, as will be seen later, much of the recoil. Even this, with sliding friction of the carriage became inadequate, and other means were resorted to.

The first devices were merely to increase the resistance already existing, as the use of ropes and friction drums; friction clamps came later. Gravity was called into play by sloping upward the chassis rails, and so causing the carriage to rise as it ran to the rear. The pneumatic buffer followed and then the hydraulic; the last seems to have come to stay.

The pneumatic system is not now playing a very important part in the problem of controlling recoil, although there is a company pressing its claims, and it is understood that the buffer system of Lt. Gordon's new carriage is hydro-pneumatic. The hydraulic buffer is credited to Captain Fraser of the English Navy. The idea was soon taken up by Krupp and others.

In the last 25 years, since hap-hazard experiments in all matters pertaining to ordnance have largely yielded to those directed by science, considerable progress has been made. Still there is much to do in the matter of advantageously checking recoil, that is, bringing a piece to rest, without unduly straining the carriage and its attachments.

Causes of recoil.—As before stated, whenever the gas of explosion can expand by forcing one of the sides of the containing vessel, motion results. Motion of what? Obviously of the gas itself as it expands and also of the envelope as it yields. Pass at once to the gun.

From every day experience or observation, we know that the gas, the projectile, and the gun all move, and since there can be no motion without a force, and since the amount of motion depends on the intensity of the force, *that* is the basis of the problem and must be determined first.

At the instant of explosion, gases of high tension are formed and the pressure is relieved by expansion and cooling. If the gas expands, the space between the base of the shot and breech-block must increase. This may occur in one of three ways, the shot may move forward, the piece may move backward, or both motions may occur simultaneously. That the expansion should take place under either of the first two cases is contrary alike to the principles of mechanics and the results of experiment. The fact is, that motion practically exists in both gun and shot, at and from the same instant of time. We usually consider the motion of the piece as a *reaction*, we would just as well consider the motion of the shot as reaction. In strictness, neither the one nor the other is correct, both motions result from actions, and the reaction is on the particles of gas. We can thus remove the *bête noir* reaction. Thorough experiments have been made on this subject, and the simultaneity of the motions proved beyond question. The authentic record of these experiments not being available, the writer found it necessary recently, to prove by experiment the co-existence of these motions.

The apparatus described in Appendix I, although too crude to show that the two motions began at the same instant, proved conclusively that the barrel of a Springfield rifle suspended as a pendulum, had recoiled about one-half inch when the shot left the muzzle.

The total force of the powder is utilized in producing the following results:—

(*a*) Moving forward the shot, gas and air in front of the shot.

(*b*) Rotating shot and overcoming friction.

(*c*) Moving gun and gas to the rear, and

(*d*) Finally blowing out the gas after the projectile leaves, until a pressure of but one atmosphere is left.

What really takes place in a gun is unknown, so in order to even approximate the values and effects of these parts, we must have some hypothesis. Suppose the gas is all formed at once, and that it remains homogeneous, also that the chamber and bore are of same cross section. Although not susceptible of proof, it seems almost self-evident that a section of this gas will remain stationary in space while the shot is in the bore. That portion of the charge in front of this section moves forward with the shot, while that in rear moves backward with the piece. If this section is immovable in space, the forces acting on it in the direction of the axis of the piece (others are obviously disregarded) will be in equilibrium.

Of the force acting on the rear of this layer we have two parts, one moving the gas to the rear and the other pressing on the bottom of the bore. It is evident, then that any recoil produced is directly traceable to this second part. All of this, however, will not be effective, and to divide it into effective and non-effective, we must first divide into its components that pressure which is exerted on the front side of the invariable section. There are four parts to this pressure,

1. That which gives motion of translation to shot and air in front of it.

2. That which gives motion to the gas.

3. That which overcomes friction and rotates the shot.

Any part of these that gives a pull on the gun forward, will evidently counter-act a part of the force pressing on the breech-block, and make it non-effective, producing merely a stress on the gun tube. That which overcomes friction then, is such a part. Again, rotation is caused by the pressure of the lands against the rotating band, or *vice versa.* This pressure against the lands may be divided into two components, one in the direction of the axis of the piece, and the other in a plane perpendicular to it. This last component gives to the piece a rotation (if unresisted) opposite to that of the projectile; the first gives a pull on the piece forward, and neutralizes a part of the pressure on the breech-block. The force that moves the gas forward must also be divided into two parts, one part of this counterbalances that pressure which gives the backward motion to the gas in rear of the invariable section. This is very small, comparatively, and in subsequent considerations is neglected.

We have thus eliminated all the forces in front of the zero section except that which produces motion in gas, shot and air in front of shot. Hence, until the shot leaves the bore, the effective force for recoil is equal to the sum of these. When the shot leaves the muzzle the remaining powder pressure is exerted in blowing out the gas, and practically the whole of it is effective for recoil.

DETERMINATION OF VALUES.—We must now find some expression for the three forces which cause recoil:—

1. That which forces the shot and air forward.

2. That which moves the powder gas.

3. That which gives the after blast.

First.—For the first of these we take the pressure curve as computed in interior ballistics, or consider the amount of work done in giving the shot the muzzle velocity it has. The part referring to driving out the air is quite small comparatively, and is usually neglected. If it is desirable to consider it, take about two-thirds of the weight of the air in the gun tube and add it to that of the projectile. For a ten-inch modern gun, this increment to the weight of the shot is about five-sixths pounds; two-thirds is taken as that is about the average velocity of the shot, the muzzle velocity being unity.

Second.—The pressure taken up in giving motion to the gas itself is quite considerable and very little seems to be known regarding it.

There are three distinct methods of approximation. The first, following Piobert, is to consider the gas as homogeneously distributed, and to take the velocity of its center of gravity as a mean or writing $\Sigma\ m\ v = \frac{1}{2}\ M\ \gamma$, γ being the velocity of the front layer and equal to that of the projectile.

A second, is to find a relation between the pressure on the base of the shot, and that required to give the gas the velocity it has. The sum of these is evidentally the force, effective for recoil, while the shot remains in the bore. Lieutenant Berry, 4th Artillery, is the only one known to the writer who has gotten an expression for this relation, which, although not yet verified, is remarkably promising.

The third method is to get an expression for the amount of work done on the gas, and from this obtain the value desired. The expression for this work is given in text-books as follows:—

$Q = \frac{1}{2}\ \theta\ u\ \gamma^2$, $\theta = \frac{1}{3}$, $u =$ weight of charge, $\gamma =$ muzzle velocity of shot.*

If these two values could be accurately determined, the energy of recoil when the projectile leaves the bore would be known, and there would remain but one other element, viz:—the third component of the pressure, or that due to blowing out the gas.

This problem is entirely similar to that of determining the second value discussed above, and is equally complicated. Very little seems to have been done with it except experimentally, and the result is given in the form of an average velocity of issue of the gas from the muzzle. This is put down as about 900 metres, or approximately 3,000 f. s.

FORMULÆ.—What is desired in the solution of this problem is the energy of recoil and the space passed over in attaining this

* A deduction of this value of θ is given in Appendix II, as the writer has not found it elsewhere.

energy. If the velocity is known the energy results immediately; hence, if M = mass of gun and carriage (including brake) and U its velocity when a maximum, m = mass of shot and γ its muzzle velocity and u the mass of the charge, we have (Hugoniot) $M\ U = m\gamma + 30c\ u$.

Meigs & Ingersol, following Sladen, give the value of U as $\frac{m + c\,u}{M}\gamma$. In which "c" is a variable constant depending on the weight of the charge. The following values are given: If $u = \frac{1}{2}\,m$, take $c = 1$ and if $u = \frac{1}{4}\,m$, take $c = \frac{3}{4}$. (No deductions given.)

This formula does not seem on its face to be correct, as experiments, so far as known to the writer, make c or its equivalent constant or independent of the weight of the charge. It does not agree with the previous formula.

The 6″ naval rifle has a projectile weighing 100 lbs. and charge of 60 lbs, with $\gamma = 2{,}000$ f. s.

The first of the above formulæ gives $M\ U = 300{,}000$ and the second gives $M\ U = 350{,}000$. Reducing the charge to 25 lbs. and computing the muzzle velocity to be 1,542 f. s., we have from the same formulæ repectively, $M\ U = 216{,}412$ and $M\ U = 229{,}200$.

This example is given merely to show the variations in the formulæ. The one given first is more reliable, and better adapted to large charges of slow burning powders.

It is admitted that, on the proper control of recoil, depends the practicability of building heavy guns, and yet few experiments (relatively) are made. Many writers on this subject fall into the error of beginning the problem of recoil after the carriage has attained its maximum veloclty. They ignore altogether the fact that the brake has an important part to play during the preliminary period; others, although the subject is mentioned, pass on and consider the second period only.

Let us see what effect the brake has during the first period, or while the system is acquiring velocity. The writers above alluded to, consider in effect that the system is rigid until the end of the first period, and then immediately moves off with its maximum velocity. The fact is, as soon as the pressure on the breech-block equals the resistance of the brake, plus friction, motion takes place. If the resistance is zero at the origin, motion takes place at once as in the case of free recoil.

It is capable of demonstration (see Appendix III) that when a force, constant or variable, acts at and for the same time on two bodies the following relations exist:—*The velocities generated, the spaces passed over and the work done in the two cases are inversely as the masses of those bodies.*

Now it is self-evident that the length of recoil will be greater when recoil is free than when there is a brake. Then from the second proposition alone, the resistance may evidently be considered as mass added to the system. If this be so, we see, from the third proposition, that the work performed on the carriage system has been decreased exactly in proportion as the mass was increased.

Consider two carriages with brakes identical, except that one does not begin to act until the end of the first period, when the maximum velocity is attained, while the other begins to act with the first motion of the carriage. At the end of the first period the pressure on the breech (π) has ceased to act, and all the energy available has been stored up in the carriage system, shot and charge; the same amount in both cases but divided differently.

The ratio of weight of carriage system (M) to that of shot and charge, is greater in the carriage with a brake than in the other, and hence the ratios of the work and spaces passed over is less in the same proportion. The brake has had the effect of putting more energy in the shot and less in the carriage system, and has also shortened recoil for this period. During the second period the brakes are taken as identical, but in the one case as there is less enery of recoil to overcome, the remaining path will be less. This gives a double shortening for the system in which the brake acts from the beginning.

It should be observed that, although in the first stage, the brake has been considered as added mass, it must not be so considered in calculating the work stored up at the end of that period, as would be the case if it were an actually added mass.

To find what mass should replace a given resistance of brake, we proceed as follows:—

The acceleration due to any force is the ratio of the force to the mass $\left(\frac{F}{M}\right)$. Now the resistance (R) is directly opposed to π, and hence the acting force is really their difference, or $\pi - R$, and the resulting acceleration is $\frac{\pi - R}{M}$. Write for the acceleration an expression in which the force is π and the mass is $M + m$, (m corresponding to the resistance R.) Since the two expressions are for the same acceleration we place them equal, or, $\frac{\pi - R}{M} = \frac{\pi}{M+m}$ $\therefore m = \frac{R\ M}{\pi - R}$. From this if π is given and m is constant, we can determine the value of R equivalent to the mass m, and so shorten or lengthen the recoil during the first period.

If the length of free recoil $= S$ and we wish to reduce it by "s," we have $S : S{-}s :: M{+}m : M$ or $m = \frac{s\ M}{S-s}$ and equating this with the above value of m we have $R = \frac{s}{S}\pi$, $\left(\text{and } S' = S\ \frac{M}{M+m}\right)$. In an entirely similar manner we show that if $Q =$ the energy of free recoil, we may reduce it by q and have $R = \frac{q}{Q}\ \pi$.

In both of these cases we may write the above equation in the form of $\frac{\pi}{R} = \frac{M+m}{m}$, and if "$m$" is constant, $\frac{\pi}{R}$ is constant, and $R \propto \pi$. If this relation does not exist then both R and m may vary, and the law is $m \propto \frac{R}{\pi - R}$.

In the Navy buffer the orifice is constant during the first period and hence, as shown further on, $R = b\ U^2$.* Then $m = \frac{M\,b\,U^2}{\pi - b\,U^2}$. When π is not known we have, by a method described later, the ratio $\frac{\Delta s}{\Delta t}$ *for free recoil* and for such values of

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* $b = \frac{1}{2}\ \frac{k}{g} \cdot \frac{A^2}{a^2}$ (see page 376).

$\triangle t$, that, within the limit taken, the value of π may be considered as varying uniformly. Assuming then that π has a value equal to the mean of its values at the beginning and end of Δt, we have $U = 2\frac{\Delta s_1}{\Delta t}$. The acceleration equals $2\frac{\Delta s_1}{\Delta t^2} = \frac{\pi}{M}$. ($\triangle s_1$ is measured from the origin motion.)

Substituting these values of U and π in the expression for "m," we get an approximation for the mass added by R, *too great* since U was taken too great. The second approximation is made by taking $\frac{\pi}{M+m}$ for the acceleration, and getting a new and more nearly correct value of m. As the value of m taken at the beginning of this last approximation is too great, it follows that R and hence U is too small, and so the value of m deduced by this is *too small;* thus, the approximations vary on both sides of the true value. Continue until a sufficiently correct result is obtained.

For the second $\triangle t$ (free recoil), we have $\triangle S_2 - 2\triangle s_1 =$ the gain in s during $\triangle t_2$ due to π. Hence, $2\left(\frac{\triangle s_2 - 2\triangle s_1}{\triangle t^2}\right) =$ the acceleration for Δt_2, then multiply by the mass and as before find π for Δt_2. Substitute this in the value of "m" and find "m;" continue until the first period during which π acts is complete.

Next to compute the value of Δs for constrained recoil. We have already these spaces for free recoil, and π and m corresponding to them and using the expression previously deduced, we have $S' = S\frac{M}{M+m}$, or the spaces are inversely as the masses. Then $\Sigma S' =$ total constrained recoil, and similarly $Q' = Q\frac{M}{M+m}$, whence $\Sigma Q' =$ total energy stored. As a check for this, if we remember that no additional energy is in the system due to the mass "m," but the work corresponding to it has gone with the shot, we have $(\frac{1}{2} M U^2) = \Sigma Q'$, where U is the final velocity when constrained by the brake.

In the above the area of orifice is taken constant, and enters to the second power in the constant b. If it vary, the problem is more complicated, but the method remains the same. Proceed as before with a value corresponding to S for free recoil until S' is found, then take a new value corresponding to this, and so on. It should be noted that the whole of this method is rendered necessary because the value of π, the pressure on the breech-block at any time, is not known.

The pressure on the base of the shot which gives it translation is pretty well determined, and given in the pressure curves for various guns and powders, so there only remains to find the relation between this pressure and π, or in other words the amount of pressure expended on the gases.

CONSIDERATIONS AFFECTING R.—The acceleration during the first period often reaches 250 f. s., or nearly nine times the acceleration due to the force of gravity. Why the *velocity* of recoil is no greater, becomes evident when we consider the time element. $U = acc. \times$ time or in this case $U = 250 \times \frac{1}{70} = 3.57$ f. s. (the numbers are average for free recoil). This gives some idea of the shortness of the time.

It is a recognized principle in considering the strength of materials, that a stress suddenly applied is as dangerous to a structure as double the force gradually applied. As shown further on it is desirable that, during the second period at least, R should be constant. Assume then, that at the beginning of this time R is a given stress (R'), and as it is zero when the system is at rest it must pass from zero to this value. As the time is very short it is, at best, applied quite suddenly. What then, is the best law of increase of R from 0 to R'? Since it is deleterious to apply the stress suddenly, it is self-evident that R should increase uniformly when considered as a function of time.

It becomes necessary as before to know π for different intervals of time (Δt). In the absence of any expression for it, we must proceed as before, that is, by finding it for free recoil. From the values of π thus determined and R assumed as above ($= b\ U^2$) we readily calculate "m." Then the acceleration of constrained recoil becomes $\frac{\pi}{M+m}$; we pass to the mean velocity as before and hence to the space passed over.

To find "a," the area of orifice, we have from above $R = b\frac{U^2}{a^2}$

and this will be the value of "a" for that particular space. If these values of "a" be taken as corresponding to the middle points of the spaces, the curve of "a" can be drawn. It would be interesting to compute the values of "a" by this method, but the data obtained by experiments on free recoil are not at hand.

In determining the maximum value of $R = R'$ we must consider two things. 1st, what the carriage will stand, and 2nd, length of recoil. As already stated, the system generally adopted is that involving a constant value of R for the second period. This being true, we have the simplest of relations between R ($= R'$) and the length of recoil, or rather that part of it corresponding to the second period. For the total work stored in the system is $\frac{1}{2} M U^2$, and this must equal $R' l$ ($l =$ length of recoil for second period).

For ballistic reasons it is evident that R should be as great as possible, for as already shown, as it increases, "m" increases, and hence the greater the energy stored in the shot, and thus the nearer does this approach the total energy of the powder. If $R = \infty$ then there would be no work stored in the gun system, and the effective work on the shot and gas would equal the total work of powder, less the work of friction and rotation.

Suppose the gun system weighs 100 times as much as the shot and charge, we should have the work stored (approximately) in the two systems to each other as 1 to 100, that is inversely as the masses. Thus we see that the energy lost on the carriage recoiling freely, is approximately one per cent. and is less as R increases. The relative advantage then of making R great for ballistic reasons, is more than counterbalanced by the consideration of the greatly increased stress on the carriage system applied instantly.

Again in the general case, where the buffer is attached to the lower part of the slide, the moment for rotation increases directly with R and produces more jump, to the detriment of accurate firing. This last of course applies principally to the first period, or rather to that part of it during which the shot is in the bore. Since then, there is little relative gain ballistically in increasing R and considerable loss in doing so, both as to carriage construction and accuracy of fire; we should naturally take R as small as possible. On the other hand, we have "$R\,l$" equal to a constant ($=\frac{1}{2}\,M\,U_0^2$) = energy of system at end of first period, and it is evident that the minimum value of R will depend on l (= length of recoil for second period). The total recoil λ must be determined to accord with the particular case. The 5″ guns of the Navy and Army have respectively $\lambda_n = 12''$ and $\lambda_a = 36''$.

We shall not go into the question of determining the values of either l or R most suitable, but have simply shown on what considerations their selection will depend. If l has perforce a certain value, and this gives for the particular gun a value of R too great, we shall necessarily alter the carriage so as to accommodate R, or take a different gun, or change the elements of loading.

Hydraulic buffer.—For taking up recoil, we use the hydraulic buffer, an arrangement of cylinder and piston, so familiar that space will be given only to those details which modify the action. The action of a brake during the first period in modifying recoil has already been noticed, and as it is quite complicated, we shall only consider the second period in discussing the workings of the hydraulic buffer. Nothing is lost by this, as all the principles are brought out without the attendant complication of the first period.

The system of gun and carriage has, at the end of the first period, a velocity of translation U_0, and hence a stored energy of $\frac{1}{2}\,\frac{W}{g}\,U_0^2$ with a resistance opposing it equal to R. As no further energy is added, the problem is simply that of a given resistance overcoming a given energy, under the hypothesis that the energy is a given constant for any special case, and depends on elements of loading, &c.

To attain certain results certain weights of shot, charge, &c., are used, suited to the strength of the gun, and thus all the quantities entering the expression for energy of recoil are fixed, so far as the problem under consideration is concerned. The only two variables then are l and R: the relation between these is fixed by the equation $\int_{l}^{0} l\,d\,R = \frac{1}{2}\,\frac{W}{g}\,U_0^2$ and the limitations already spoken of.

The action of the brake is to convert energy of the gun system into energy of the fluid of the buffer. As the total weight of fluid is small relatively, its velocity is correspondingly great, or more strictly, its acceleration is great. Two cases arise, 1st, the value of R may be variable, and 2nd, it may be constant as heretofore considered. The total resistance is divided into two parts, a constant depending on the inclination of the chassis rail and co-efficient of friction, and the resistance of the brake itself. Call the first "r" and the second "ρ" and we have at any time $r+\rho=R$. There is nothing special to consider in regard to "r" so we pass at once to "ρ." Since $\frac{1}{2}\frac{W}{g}U_0{}^2-r\,l=\int_1^0 l\,d\,\rho$, we may write $\int_1^0 d\,\rho\,l=\frac{1}{2}\frac{W}{g}U_0{}'^2$.

Now let A = cross section of cylinder, "k" the weight of a unit volume of the fluid, "a" = the area of orifice, "z" the velocity of issue through the orifice. It is evident that $z\,a\,dt=U'\,A\,dt$, for the first member is the fluid which escapes, and the second is the fluid displaced in the time dt, hence $a\,z=A\,U'$. Suppose ρ constant for the space dx corresponding to dt, the work of resistance will be $\rho\ dx$ and the work on the fluid is $\frac{1}{2}\left(\frac{k}{g}A\ dx\right)z^2$. The quantity $\left(\frac{k}{g}A\ dx\right)$ is the mass of fluid that escaped, and z its velocity, considered constant for dt. Equating we have $\rho\ dx=\frac{1}{2}\left(\frac{k}{g}A\ z^2\right)d\,x$ or $\rho=\frac{1}{2}\frac{k}{g}A\ z^2$. But we have $z^2=\frac{U'^2}{a^2}A^2$, hence $\rho=\frac{1}{2}\ \frac{k}{g}\ A^3\ \frac{U'^2}{a^2}$. If in this case "$a$" is constant, $\rho\propto U'^2$, but if ρ = constant, "$a\propto U'$. The first case corresponds to a constant orifice, and hence, as the equation shows, to a variable resistance and the second to a variable orifice, and hence a constant resistance (if $a\propto U$).

The tendency at present is to adopt a constant value for ρ, because it distributes the pressure more evenly over the time of recoil, thus reducing the maximum and enabling the carriage to resist a greater total amount of energy in a less space. This change involves the same principles which led to the adoption of slow burning powders.

As both the Bureau of Ordnance of the Navy and the Army Ordnance Department have adopted a constant value for ρ, the discussion will be limited to that. Then the total work is $\rho\, l = \frac{1}{2}\frac{W}{g}U_o'^2$; a simple relation between ρ and l which is an additional advantage in taking ρ constant. It is true this constant $\frac{1}{2}\frac{W}{g}U_o'^2$ is rather an uncertain one and only approximately determined, but still on its determination, or on some quantity of which it is a function of known form, depends all the deductions for pressure and length of recoil. In any case, this value whether assumed, calculated or obtained by experiment is the basis of calculation, and, as before stated, gives for a constant ρ the simplest relation between the resistance and length of recoil.

Determine the value of "a" for ρ constant, as follows:—The energy still in the carriage at any point of recoil, as x, is $\frac{1}{2}\frac{W}{g}U'^2_x$, hence that lost is $\frac{1}{2}\frac{W}{g}(U'^2_o - U'^2_x)$ but this equals the work of the brake $\rho\, x$. We have from previous equations $U'^2_x = \frac{2\rho g a^2}{k A^3}$ and $U'^2_o = \frac{2 g \rho l}{W}$. Substituting these values, reducing and solving with respect to "a" we have, $a = \left(\frac{k A^3}{W}(l-x)\right)^{\frac{1}{2}}$.

The initial value of a is obtained by making $x = o$, which corresponds to the position of the carriage when the first period ends. If "a" be taken so that its area varies as one of its dimensions, the other being constant, the locus of the extremity of its variable side referred to the locus of the other extremity of same side as an axis, will be given by the equation $a'^2 = \frac{k A^3}{b^2 W}(l-x)$; hence a parabola with the origin of co-ordinates on the axis of x, and at a distance from the vertex equal to "l." This gives the value of "a" for second period only.

It has been shown how to take into account the resistance of friction of the carriage on the chassis, but it may be as well to omit that, because of a tendency to adopt rolling friction, and further because its omission gives a factor of safety.

It is frequently the case that recoil is taken up by raising weights, or by practically adding mass. The calculation for any special case may be readily made in a manner entirely analogous to what precedes. Attention will be again called to the difference of the two methods. Both practically add mass, which acts to prevent the attainment of velocity during the first period. If the added mass is made a part of the system, the analogy ceases at the beginning of the second period for work will then have been stored in it, which work will itself have to be overcome; whereas in the buffer this is not the case, as this work was transferred to the shot and gas.

If the mass consists of a weight to be raised with a flexible connection as a cable, we have the following considerations:—During the first period while there is acceleration to the system, the weight acts as a brake, and if it is the only brake it continues to do so, and the length of recoil is easily calculated. The total energy in the system divided by the mass raised gives this length. If, however, it is combined with any other brake, and if such brake reduces the velocity of the carriage more rapidly than gravity does that of a body projected vertically upward, the weight ceases to affect the system.

It seems best to consider in this connection, what suggests itself as the best form of brake for heavy pieces. The hydraulic or other form of buffer, usually acts on the piece by the intervention of the carriage. A couple is produced resulting in inaccuracy of fire, great stress on the pintle, and a racking and destroying of the system. If the simple counterpoise is used it must be of great weight. The greatest stress occurs when the carriage is taking up velocity, and this is increased as the action of the buffer is more developed.

The theoretical system would require an addition of considerable mass at the breech of the piece, so arranged as to offer resistance in the line of the action of the powder gas. It should be detachable and separately acted on by some check after the end of the first period. This gives the advantage of no rotation, and also leaves only the energy stored in the piece itself to be taken up by stress on the carriage. The carriage itself could then be only so heavy as strength required, and thus the stress produced by its taking up velocity reduced to a minimum.

In the counterpoise system when the whole mass swings about some axis, the angular velocity must not reach such a value as will make the centrifugal force equal to, or greater than the component of gravity acting to hold the piece in the trunion beds. The law of resistance for this species of brake depends on the distribution of the mass with respect to the axis, and may theoretically be made anything desirable.

Point of maximum velocity.—The total time of recoil has been divided into two periods by the epoch at which π ceases to act. Evidently π begins to act effectively when the piece begins to move, and continues till the gas has expanded to a density corresponding to a pressure of one atmosphere. The pressure, although well sustained with slow burning powders, decreases as the projectile approaches the muzzle and the law of change is fairly well known, so far as concerns the resulting velocity of the shot. As before stated, this is however not the pressure that produces recoil, and differs more and more from it as the acceleration of shot, and hence of gas, increases. This pressure on the shot again approaches the recoil pressure as the acceleration decreases, but it never reaches the same value.

The curve of pressure of recoil will then always be above that of the pressure curve given for a gun and calculated from the muzzle velocity of the shot. What happens to this curve when the shot leaves the bore is not definitely known. It is probably continuous but the law must change very rapidly, as the mass is suddenly lessened, and hence the acceleration must be suddenly increased for the same pressure. The effect of this is to hasten the reduction of weight of gas in the bore, and hence to diminish pressure more rapidly than before. If the pressure vary directly with the weight of the volume of the gas in the bore (as in Boyle's law), both terms of the expression for acceleration remain constant and the velocity is uniformly varied. This is under the hypothesis of no resistance by the air at the muzzle.

The problem is quite complicated, for, as the velocity increases, the density diminishes, and hence, the weight of gas escaping in two consecutive elements of time may or may not be equal. This is specially true when the complication of a varying density from muzzle to breech is added, with this very law varying with the varying velocity. These complications have caused a resort to experiment, based on the fact that in free recoil there is an acceleration so long as π acts.

EXPERIMENTS.—A pointer is attached to a slide resting on a rail parallel with the axis of the piece. The slide is attached to the carriage by a steel wire, and the pointer on the motion of the carriage, traces a line on the blackened surface of a metal plate. A second relative motion is given to the pointer, as the plate itself is actuated by a rubber band. The rate of motion of the plate is known. As these motions are made simultaneously and at right angles, the resulting curve, referred to an axis parallel with the directing motion of the plate gives the vaiues of $S = f(t)$. Hence by taking equal or small values of t we may have $\frac{\Delta S}{\Delta t}$, as before noted. Electric attachments for making signals indicate the point of this curve corresponding to any given position of the shot. This may be used as before stated.

The point where the acceleration ceases is determined as follows:—A tube is prepared containing two plungers, one at each end, which are held in place by light springs. There is a contact point at each extremity of the tube, making separate electrical connections through the plungers. The tube is attached to the piece with its axis coinciding in direction with that of the piece. At the start the rear plunger by its inertia breaks the circuit and makes a signal. So long as there is acceleration the front plunger remains in contact; when retardation begins, this plunger by its inertia is separated from its contact and makes a signal. This last is necessarily slow to act, and in *perfectly free* recoil would not act at all.

The plunger that made the signal at starting, being under pressure of the spring, will return to its place before the retardation begins or even before the acceleration is zero, making a signal; a mean of these two signals is taken. An experiment shows that this maximum occurs after a time equal to about double that of the shot in the bore. As a function changes very slowly near its maximum, it is rather questionable if this instrument gave more than very approximate results. A thought makes it evident that in restrained recoil, the maximum velocity takes place betore π ceases to act or when it equals R.

An instrument like the last attached to the shot, gave a signal coinciding with that given by the instrument on the piece, showing the simultaneity of the motions in the piece and shot.

Efflux.—Before giving examples of the modern application of the hydraulic buffer, there is one point that seems worthy of note not found mentioned elsewhere.

In deducing the area of the orifice "a," a purely theoretical value for the velocity of issue, and the amount of flow through this orifice was taken. In practice with small orifices we find that there is such a thing as "contraction of the vein." This in thin plates amounts to a reduction of the areas to sixty-four per cent. of its actual value. Friction also reduces the velocity to ninety-six per cent. of its theoretical value. These two combined, when the velocity is low and the opening circular, make the mass of fluid issuing in a time "t" equal to sixty-one per cent. of what theory calls for. In the case under consideration the velocity is higher and the sides of the cylinder or obturating bar act to increase the thickness of the plate, and hence to increase the effective orifice.

Comparing the case under consideration with experiments made in this line, it seems that eighty per cent. of its actual area is about all that is effective. To the calculated orifice then should be added about twenty-five per cent. Frequently the resistance is made by having more than one orifice when, theoretically, their sum should equal the value calculated for one. However, as the orifice grows smaller the coefficient of reduction increases, and so the sum of several should be slightly in excess of that value calculated for one. The data in each case is necessary for a calculation.

Number of buffers, point of application, etc.—In order to make the stress on the carriage symmetrical, there are often more buffers than one, usually two. In some cases to insure an equal pressure, there is a connecting tube which regulates the fluid pressure in the cylinders so connected.

The point of application of the resistance varies with the system. In our old carriage one buffer was attached to a transom of the top carriage. The effect of this is to produce a rotation, and hence a disarrangement of the piece when fired. When the axis of the buffer can be kept in line with the direction of the pressure π, no lever arm results and hence no jump.

In heavy guns the matter of return to battery is of much importance, requiring much force to effect it. The inclination of the chassis rail gives what is known as gravity return, eccentric axles being sometimes used to give rolling friction. To hold the piece from battery for loading a spring clutch is sometimes used, but in some of the newer patterns there is a channel passing around the piston, which remains closed during recoil. All the orifices being closed automatically or at will, the piece per force remains from battery. An opening of this side channel allows the piece to run in, and its partial automatic closing insures against jar. Where gravity is not sufficient, an additional force is stored up during recoil by compressing springs.

In the Maxim rapid fire gun, the force of recoil is utilized to operate the mechanism. This is the only system known where the necessary, though objectionable by product, is really utilized. Further particulars of attachment, &c., pertain to the subject of carriage construction.

Navy and Army buffers.—The smaller calibers of the Navy guns have two buffers to each piece, the cylinders being a part of the carriage. For the 5″ R. F. R. the piston has a solid head which fits the interior of the cylinder. The orifices, three in number, are made by cutting away the interior of the cylinder to a depth of 0.15″. This channel has one edge, an element of the cylinder, and the other, referred to the first as an axis, is a parabola of the form $y^2 = 2\,p\,x$, the vertex being at the limiting position of recoil.

The parabola extends from the vertex to the point corresponding to a maximum velocity of the carriage, and from that point forward the curve becomes a right line parallel with the axis, giving a constant orifice during the first period of recoil. The cross section of the channel is not quite rectangular, the sides being cut radially. The interior diameter of cylinder is 7″ and the sides are $1\frac{1}{4}$″ thick. The orifice is constant for 3.17″ where its area is 0.46 square inches. The total length of recoil is 12″.

The fluid and piston occupy about one-third of the cylinder; the remainder is arranged for Bellville springs, which are compressed initially to 2,000 lbs and at the end of recoil to about 4,000 lbs. This force is used to return to battery.

Formerly the channel was bounded by a curved line from the beginning to point of maximum velocity, so that the orifice increased from zero at the origin. What the form of this part of the curve was could not be determined from the drawings, but it is now of no importance since it has been changed to a right line as described above "on account of giving too great pressure."

The buffer for the 5″ Army gun differs in these particulars. The cylinder is about the same length, 36″, but the whole is occupied by the piston and fluid. The first period is supposed to end when the piston has moved 4″, and the total length of recoil is 36″.

The longitudinal section of the orifice is a parabola as in the Navy buffer, but near the vertex the curvature is considerably lessened so that the curve cuts the axis at an angle of about 45° instead of 90°. It differs also in the forward part where the orifice is not, as in the Navy gun, constant, but varies from zero at the origin, to its maximum at about 4″, or the curve for the first period is a parabola. What the effect of this is, does not seem to be considered so far as the first period is concerned. It is said to be so constructed to lessen the shock of return to battery.

The initial orifice for the second part is .833 square inches. The orifice is made by cutting out a rectangular piece from the piston head 1.74″ deep and 1.00″ wide. There is an obturating bar attached to the inside of the cylinder, and rectangular in cross section which fits in this slot. The width of the bar is just .01 less than the slot in the piston giving a snug fit, and its thickness (radially) varies, thus leaving an opening. Theoretically the orifice is zero at the beginning and end of recoil, but the working drawings show that the opening is never quite closed, its final value is $.04 \times 1.01 = .04$ square iches.

In the Navy buffer, where theoretically the orifice is zero, we find an opening $.15 \times .2 = .03''$ about the same as the Army buffer. It is not necessary to entirely close the outlet of the fluid in order to stop the piece, for as noted, the friction takes up some recoil and a small remaining orifice gives, as it were, a safety valve.

OTHER SYSTEMS OF CHECKING RECOIL.—There are many other systems, some quite novel, if impracticable. One proposes to make the piece itself the piston of a buffer. On firing, the piece recoils into its cylinder displacing the fluid.

Maxim suggests for his piece a curved shield attached to the muzzle and convex to the rear. An opening is made just large enough to allow the projectile to pass through. The after blast is supposed to act on the shield and so take up the after recoil. Krupp attaches some of his pieces by ball and socket joint to the shield pieces of the turret, and so secures a non-recoil mount.

Returning for a moment to the hydraulic buffer it is noted that there seems to be much doubt as to the proper amount of fluid that should be put in the cylinder. If the cylinder in front of the piston is not full, there will certainly be a sudden increase or resistance as soon as the piston has moved througth the space not occupied by fluid. This should not be, and the time and amount of resistance should be determined by the area of orifice.

EFFECTS OF RECOIL.—To show the necessity of studying and properly controlling recoil, the following effects of recoil are presented:—

First, to lessen muzzle velocity. Let e = the expansion of the gas s and l the travel of the shot and gun, $\pi\, de = \pi\,(ds + dl)$ for work in dt, but as shown, $l = \frac{s(m + \theta u)}{M}$ $\therefore \int \pi\, de = \int \pi\, ds \left(1 + \frac{m + \theta u}{M}\right)$ or if $E = \int \pi\, ds$ = effective energy of shot, we have $E = \int \pi\, de - E\frac{w + \theta u}{W}$, or the greater the recoil the less is the effective energy for the shot. This however, is not a very important factor as relatively the energy lost is small.

A second effect is a motion or displacement of the piece, other than that of translation to the rear. A moment is usually formed about some point of the system, as the trail of the field piece, and rotation results producing what is known as jump. There is also a rotation of the piece about its axis, due to the pressure on the lands; this tendency is to turn the piece in a direction, the reverse of that of the shot.

For heavier guns there is another element producing jump. When there is any play at all in the trunnion beds the line of contact of trunnion with its bed, is the lowest element when the piece is at rest. In action the resultant pressure will change the line of contact to some other element higher up. Now in passing from one to another the friction, which is considerable, will have a tendency to roll the trunnion up the side of the bed and so raise the muzzle. To counterbalace this to some extent we consider the position of the shot; as it passes to the front its lever arm for lowering the muzzle increases. A calculation shows that the friction on the trunnions will prevent this motion, but the force will be effective in counterbalancing other forces acting in an opposite direction. The tendency to turn about the trunnions is resisted by the elevating gear; if there is any play a blow will be received.

Jump is that displacement which occurs while the projectile is in the bore. That this does take place has been shown by experiment. That its amount is small is not surprising, as the time element is so small that acceleration cannot become velocity. This error will probably be constant, and if not prevented may be reduced to a minimum and then allowed for in laying. The point frequently comes up as to whether it is worth while to allow for this error. A calculation with ballistic formulæ is simple, but we have from MacKinlay's Gunnery the following table for variation of 5′ in elevation:—

GUN.	RANGE.	VARIATION IN RANGE.	VARIATION VERTICALLY.
8″ B. L.	1000 yards.	104 yards.	4.4 feet.
"	2000 "	87 "	8.7 "
"	4000 "	60 "	17.0 "
"	6000 "	46 "	26.0 "

From this table the value of knowing the jump is evident. It is often said that since the piece is its own range finder, these refinements are not necessary. The reply is, the nearer the first shot the less time and ammunition wasted, and again the range may be found by a smaller caliber rapid fire gun, when the relative ranges of the two pieces must be known to make this determination of any effect. From what has preceded as to the cause of jump it is seen to be quite a complicated problem, and would vary so for different circumstances, that an experimental determination seems the proper solution.

Before proceeding let us understand what jump is. In discussing it from a purely theoretical point of view, it is usually understood to mean the actual angular displacement of the axis of the bore due to certain forces, and taking place while the shot is in the bore. When however we consider it ballistically as a disturber of calculated trajectories, we find authorities correcting the elevation for the jump, or in other words they consider it as the difference between the quadrant elevation and the angle of departure of the shot. The writer has never seen any distinction made, but the necessity for it and the fact that the difference does exist seems evident.

During jump the axis of the bore will occupy successively all the different positions between its original and final positions, while the shot moves from its seat to the muzzle. The locus of these successive positions is a curve, concave upward or a right line hence on leaving the muzzls, the shot has a motion along the tangent to this curve, and hence begins its flight with a greater elevation than that of the axis of the piece. The same thing becomes evident when we remember that the shot has a motion about the center of motion of the system, as well as in the direction of the bore. As this rotation is upward, it is evident that the resultant of these two is above the axis of the piece.

Still another result of vertical displacement of the piece due to recoil is the racking effect on the carriage. The control of jump, or what may be termed after jump, is difficult. The general plan is entirely similar to that for controlling recoil proper, and consists in adding mass either actually or by increasing the resistance to motion. The piece must be attached to the carriage or slide, and that to the chassis which in its turn must be held down. This is done by cleats to the racer tracks, and in some English casemates by props to the roof. Where there is a front pintle this control is not so difficult, and the effect is principally shown in the deformation of the rear racers and tracks.

Measurement of jump.—Since jump must exist, it is as already shown quite desirable to measure it. Two general methods may be followed and these two will give different results, unless the distinction already noted is observed.

The first method is to determine by the necessary appliances the actual angular displacement (δ) of the muzzle, and then calculate the angular velocity (ω). This velocity and that of translation being at right angles are easily compounded, and the true angle of departure made known.

The second method consists in finding the true angle of departure directly, and thus the jump plus the effect of angular velocity.

Assume that for short distances, say 100 feet, that two trajectories differing by only a few minutes elevation will, at any point, have ordinates differing from each other by the same amount as do the corresponding ordinates of their tangents, drawn at the point where these trajectories meet, say the trunnions. Place in the muzzle and breech cross wires centered accurately, sight a point on the target, say 100 feet away, calculate the time of flight of the shot to the target, and from this the fall due to gravity. Lay off from the point sighted, this fall and locate the point the shot should strike. Fire the piece and find out where the center of the shot does strike; any deviation of this from the point previously determined, in a vertical plane, is fairly attributable to vertical displacement of the piece before the shot leaves the bore.*

The tangent of this angular displacement is evidently the actual vertical distance on the target, divided by the distance from the target to the center of motion. This reduced to arc at the muzzle should be the same as δ, measured in any other way if there is no angular velocity to the shot.

A third method consists in firing a shot, computing and measuring the range, calculating what variation in the angle of elevation

* Method used by Captain Ingalls.

would make these agree, and call that the variation due to jump. No comments necessary.

For the first method the following is suggested:—One metallic plate is attached to the muzzle of the piece, and one as far back along the piece as convenient. The surfaces are prepared to receive the trace of a pointer. Two pointers are attached to stationary supports opposite the plates, and so that the pointers rest on the plates. The initial points are joined by a right line marked on the plates. The piece is fired and any jump will cause the pointers to pass below the initial line. When the projectile leaves the bore it breaks a wire and sends a signal spark through the pointers connected in series, and thus gives their positions at that instant. Now the difference of the ordinate of the curves traced, divided by the distance between the initial points, gives the tangent of the angle of jump.

Errors enter or may enter of the same order as the quantities measured, but that is equally true of the second method, for an error in sighting the point on the target, or in determining the center of the shot hole has the same effect on the result as though the shot had struck a point some distance from that actually hit. Whether the method suggested will be vitiated by the vibrations of the piece remains to be seen. The writer had hoped to make some experiments in this line, but so far time and facilities have been wanting.

Just one thought more on this subject of angular velocity. It may in some measure account for the lowering of the point of an oblong shot. The base, the last to leave the piece, may get a final impulse upward, and thus produce the effect mentioned.

APPENDIX I.

(See page 366.)

The barrel of a Springfield rifle was suspended from a beam by four wires attached at two points of the beam. One wire from each of these points was attached near the muzzle and the other near the breech. There was a circuit formed by wires running from a battery of two small bichromate cells; this wire crossed the muzzle and was cut by the shot at that point. The circuit was not quite completed, and the distance between the wires could be regulated as desired. One of these ends was attached to swing with the piece, the other was made fast to a stationary rest, but projected in such a way that the end of the first would touch it and complete the circuit, if the piece was thrown backward by recoil.

The firing-pin of the breech-block was taken out thus admitting two fine insulated wires leading to the primer through the hole in the rear end of the cartridge shell, which was then filled in to make obturation. The primer was low tension and acted very satisfactorily. It consisted merely of a small block of wood with two iron tacks driven in the end about one-eighth inch apart, and a piece of platinum wire stretched across for the bridge. The leading wires were those already mentioned. A piece of paper pasted around the block made a small chamber around the bridge, which was filled with powder ground up on manilla paper. The paper fiber gave ease of ignition to the primer composition. In the principal circuit was a drop annunciator so connected as to ring a bell whenever any current passed.

Operation.—The ends of the wires of the principal circuit being placed a short distance apart, the piece is fired. The recoil brings these ends together, and a current passes and causes the annunciator to drop and bell to ring, *provided* the circuit is not first broken at the muzzle by the shot. In this case of course no current could pass. If the bell rang it showed conclusively that the piece had recoiled over the space separating the ends of the wires *before* the shot cut the wire at the muzzle. Repeated trials showed recoil while the shot was in the bore. The instrument was too crude to make any accurate measurements, but showed all that was intended.

Note.—**Acknowledgement is here made to Lieutenants Russel and Barrette, 3rd Artillery. for valuable assistance in the foregoing experiment.**

APPENDIX II.

(See page 368.)

Suppose all the powder turned into gas at once, or that we have a tube of uniform cross section throughout, with gas compressed in one end in a space "*c*" and held there by the projectile.

Liberate the shot and it will be thrown forward by the gas with a velocity v'. The gas follows and is supposed to remain of uniform density. After the shot has moved a given distance it has a velocity v. The velocity of the layer of gas just in its rear is also v, while the velocities decrease as we go to the rear until reduced to zero. Each elementary layer thus has a velocity of its own, and hence the elementary quantity of work done on any layer is $\frac{1}{2}\, d\, u\, v^2$ and the total is $\frac{1}{2}\int d\, u\, v^2 = Q$.

Take the origin of the co-ordinates at the point where the velocity is zero, and let x refer to the initial positions of the layer of gas; let δ be the displacement undergone by a layer at the time "t" and y its position referred to the same origin as is x and corresponding to δ. As the mass is always homogeneous, the weight of gas in rear of any section considered, bears always the same ratio to the whole weight. Since the cross section is constant the ratio may be expressed by that of the abscissas of the layer considered and the extreme layer, or $\frac{c}{x}$ is the ratio before and $\frac{s+c}{y}$ after expansion, s being travel of the shot. Writing an equation we have $\frac{c}{x} = \frac{s+c}{y}$ or $y = x\left(\frac{s+c}{c}\right)$. But the displacement equals $y - x = \delta$. Eliminating y we have $\delta = \frac{x}{c}\, s$. For any given layer, x is constant; hence differentiating we have $\frac{d\delta}{dt} = \frac{x}{c}\,\frac{ds}{dt}$ or $v = \frac{x}{c}\, V$, but $\frac{x}{c} = \frac{\delta}{s}$, $\therefore\ v = \frac{\delta}{s}\, V$. Putting this value for v in the integral equation of work we have for the work on one of the layers when the shot has been displaced "s" $Q = \frac{1}{2}\frac{V^2}{s^2}\int d\, u\, \delta^2$. For any given position of the shot, s is constant while δ varies for each layer.

If in this equation $\delta = \frac{x}{c}\, s$, x be a variable, we shall consider the displacements of *all* the layers when that of the shot is s. Making x variable and putting for δ its value from this expression in the integral expression above, we have $Q = \frac{1}{2} \frac{V^2}{s^2} \frac{s^2}{c^2} \int du\ x^2$. As before we may consider the abscissas to measure the mass up to any point, and thus $du : dx :: u : c$ or $du = \frac{u}{c} dx$. Putting this for du in preceding expression there results $Q = \frac{1}{2} \frac{V^2 u}{c^3} \int x^2\ dx$ and integrating between the limits of c and o, remembering that if $x = 0$, $Q = 0$, and we have $Q = \frac{1}{2} \frac{V^2}{c^3} \frac{c^3}{3} u = \frac{1}{2}(\frac{1}{3}) u V^2 = \frac{1}{2} \theta u V^2$. Whence $\theta = \frac{1}{3}$.

APPENDIX III.

(See page 370.)

Assume the fundamental equation $\frac{\pi}{M} = \frac{d^2 s}{dt^2}$ and let π be a variable force, as in the case of powder pressure in a gun.

Integrating and placing $C = 0$ when $\pi = 0$, we have $\int \pi dt = M \frac{ds}{dt} = M v$ (1), and again we have $\int dt \int \pi\ dt = M s$ (2). For any other mass M' we have $\int \pi\ dt = M' v'$ (1′) and $\int dt \int \pi\ dt = M' s'$ (2′).

The integration cannot be performed, but whatever are the values of the first members of (1), (1)′, (2) and (2)′, they are repectively equal since the elementary quantity $\pi\ dt$ is the same in all, when the force acts *for and at the same time* on the two masses.

Dividing we have $\frac{M}{M'} = \frac{v'}{v} = \frac{s'}{s}$, hence the *velocities* attained and *spaces passed over* by *two masses* when acted on *for* and *at the same time*, by a force *constant* or *variable* are *inversely as the masses.*

DEMOLITION OF CONCRETE GUN-PLATFORMS AND MAGAZINES AT FORT MONROE, VIRGINIA, 1892.

By First Lieutenant GEO. A. ZINN, Corps of Engineers, U. S. A.

The first work undertaken at Fort Monroe, Virginia, under the fortification bills of 1890 and 1891, after the completion of the mining casemate, was the construction of two emplacements for 10″ guns on disappearing carriages.

The site selected by the Board of Engineers for this work is known as the Redoubt, which, originally built for small guns and infantry defense, was changed in 1874 to a battery of six 15″ guns, but was left uncompleted in 1875 because of the lack of appropriations for fortification work.

In clearing the site for the new work, it therefore became necessary to remove six stone and concrete gun-platforms and two concrete magazines.

The construction of these platforms and magazines is shown in plan and cross section on plates I and II.

The platforms were arranged as shown in sets of two, with the magazines in the intervals; the magazines with their sand covering, serving also as traverses.

The pintle stones were 6′ 3″ × 6′ 3″, set in concrete 25′ apart from center to center, in each set. The breast walls of numbers 1, 2, 3 and 4 were 7′ 9″ high, of cut stone backed by concrete increasing in thickness from top to bottom. In ground plan they were almost two intersecting circles with wings at each side. The platforms were 19′ 3″ radius from center of pintle to inner edge, three feet thick at the inner edge, increasing to 6′ 9″ at the pintle stone. The traverse circles were cut stone set in the concrete. Platforms number 5 and 6 were only partially finished , having the concrete foundation laid and the traverse and pintle stones set approximately in place. The breast walls in all were independent of the platforms, so that any settlement of the latter would not injure the walls.

Magazine number one (see plate II) had two entrance passage-ways 7′ 6″ high, 3′ 6″ wide, with a total length of 60′, a filling room 8′ × 12′ × 8′ high, a main room 8′ × 24′ × 8′ high, constructed entirely of concrete 4′ thick at the rooms and 3 feet thick at the passage-ways. Magazine number 2 was constructed in the same way but with only one entrance, 22′ long, as shown by the dotted lines on plate II.

The magazines and platforms number 1 and 2 rested on a foundation of heavy rough blocks of stone.

The masses of concrete were, of course, removed in the order required by the work in progress, the most interesting operation being the demolition of the magazines.

In order to gain some idea as to the best method of breaking them up, six holes were drilled in platforms number one and two, 2″ diameter and 4′ deep between the inner and outer circle of traverse stones. About a pound and a half of Tonite was put in each hole, tamped with wet clay, and fired by an electrical machine with quintuple force detonaters. The only effect was a small crater at each hole. One hole was so little injured that another charge was put in with no better result. Several other charges of Atlas powder and Tonite gave the same result and proved that a large number of holes would be required and that a high explosion was too quick in its action for concrete.

The latter statement was afterwards verified by a direct comparison between Atlas powder and gunpowder placed in holes of equal size and similarly situated in masses of concrete.

The Atlas powder invariably shattered the concrete in the vicinity of the charge while the gunpowder broke the mass into large pieces without shattering it.

It was hoped however that the work might be done more quickly at the other platforms than by the slow process of drilling and blasting.

A chamber was dug under platform number four, 15′ from the inner edge, in which were placed twenty-seven eight ounce cartridges of Atlas C+ and D+ powder and four six ounce Tonite cartridges. This charge exploded by two quintuple force detonators produced no visible effect. The chamber was again excavated, a charge of eighty-six six ounce Tonite cartridges put in 12′ from the inner edge, and exploded as before with no visible result.

The position of these charges is indicated on plate I by the letter P.

The chamber was not excavated again, but it was found afterwards, while this platform was being removed piecemeal, that the bottom part was considerably shattered.

The result of these experiments was to cause the use of gunpowder in drilled holes. Charges of one to one and one-half pounds were placed in holes varying from 1′ to 2′ 6″ deep, drilled at intervals of about four and one-half feet.

Better success was obtained with the magazines in the way of demolition. The sand parapet was cleared away at magazine number two to the foundation, fifty pounds of Atlas B powder in six ounce cartridges was placed loosely in the middle of the floor of the main chamber and twenty-five pounds in the middle of the filling room floor at the points marked P, plate II. Two triple force electric fuzes in multiple circuit were placed in each charge. A wooden frame and door was set in the entrance gallery six feet from the outer end and sand thrown against it loosely to a thickness of two feet at the top.

This charge was exploded by a small magneto-electric machine. The destruction was complete, the magazine being broken into about seventy-five large pieces and a number of small ones, which were thrown from 10′ to 40′ in directions at right angles to the faces of the walls. One piece 18′ × 5′ × 4′, forming one side wall, was moved bodily six feet and thrown on its side.

The lines of fracture were at the intersections of the plane faces, at the spring lines of the arches and in lines at an angle to the axis of the arches. There appeared to be none at the crown of the arches.

The floor immediately under the charges was almost pulverized but the remaining concrete was still in such shape as to require considerable blasting to get it into pieces convenient for handling.

The sand was cleared away from magazine number one as with number two, 200 pounds of gunpowder (blasting) and four pounds of Atlas B in six ounce cartridges were placed in a barrel in the middle of the main room floor, 100 pounds of blasting powder and one six ounce cartridge Atlas B in the filling room, fifty pounds of blasting powder and one six ounce cartridge Atlas B in the middle of the north entrance gallery. The positions are shown at P, P, P, plate II. It was hoped to control the lines of fracture by drilling holes in the walls, and for this purpose 44 holes 10" to 12" deep, were drilled in vertical rows of three holes each below the spring of the arches. In seventeen of these (one in each vertical row), one six ounce cartridge of Atlas B was placed without tamping. More cartridges would have been used, but it was feared that the electrical machine would not explode them, as its power had not been accurately determined. The twenty fuzes (three in the large charges) were connected in series, the wires led out of the south gallery, which had already been partly blasted away, and both entrances closed with wooden frames and sand as at magazine number two.

The demolition was much more complete than with number two. Some very heavy pieces were thrown fifty feet. The lines of fracture were as before and apparently not at all affected by the drill holes. The cracks in the floor were parallel to the longer walls and the floor was not pulverized as with magazine number two. Seven of the cartridges in the drill holes were not exploded, one of which undoubtedly failed because the fuze wires were crossed; the cause of failure in the others was not determined. The fuzes were all tested and found good before they were put in. The unexploded cartridges were afterwards used with new fuzes.

The shock of these two explosions was considerable inside the fort. This fort is an enclosed work containing eighty-six acres of ground, surrounded by a wet ditch and situated on a sand spit. The Redoubt is outside of the main ditch about 200 or 300 feet. The first explosion (magazine number two) took place about five o'clock in the afternoon. It was unexpected by those inside the fort and was taken by many to be the discharge of a field piece inside the ramparts as an alarm of fire. The second explosion (magazine number one) seemed to an officer who was in a casemate of front number one at the time, like the discharge of a heavy gun on the ramparts. Windows were broken in some of the buildings inside, but none outside the fort.

The concrete in all cases broke with an irregular fracture, making it frequently very difficult to separate the fragments when a small charge was used.

In the platforms, the horizontal layers of concrete separated so easily that it was found better to remove each layer by itself than to drill the holes through one layer into the next, showing the necessity for avoiding such layers in fortification work.

The following table gives some data in regard to the cost of drilling, blasting and removing the stone and concrete, from which it will be seen that it required about 0.92 pounds of powder (regarding the dynamite as three times stronger than gunpowder) to remove one yard of concrete. The total cost of removing one yard and piling it up in another place was $2.23—for drilling and blasting alone eighty-three cents per cubic yard. Two men with sledge hammer and drill, drilled one foot of hole in one hour, at a cost of thirty-two cents, the rate of wages being $1.25 per day of eight hours.

THE TIME FUZE WITH SHRAPNEL FIRE.

By First Lieutenant A. D. SCHENCK, Second Artillery, U. S. A.

It is a well known fact that artillerists in many quarters have met with very unexpected and unsatisfactory results in practical shrapnel fire. In the past, the want of a good time fuze accounted for the fact that practice with shrapnel fire was poor, so much so, that with the advent of a rifle gun of considerable power and greatly flattened trajectory, the abandonment of this species of fire was quite generally advocated, to be supplanted by that of specially constructed shell to be burst on graze. This latter practice obviously required a very flat trajectory to insure any considerable range in battle, otherwise the fragments of the shell when burst on graze were thrown up into the air at too great an angle and over the target, or at even moderate ranges the angle of fall became so great as to bury the projectile too deep in the ground to permit effectiveness. With the improvement in gun construction, carriages, &c., greatly increased velocities and flatter trajectories were insured, and every energy was exerted toward improvement in this direction; but to little or no purpose, as the extended ranges deemed necessary in battle could not be secured with this kind of fire, and attention was again turned to shrapnel fire with time fuzes. The result now is that the fuze fire has been so greatly improved that its error is less than are those of the gunner, and even of the gun itself, accurate as is the modern gun.

This result secured for the fuze, it has generally been sought to obtain with the velocities developed for the shell fire, the great results believed possible with shrapnel fire, and much surprise and disappointment has been evinced because the great power predicted for shrapnel fire has not materialized in practice.

It goes without saying that sufficient velocity for the shrapnel at burst must be secured, to insure the effectiveness of the bullets it contains. This done, the efficiency of shrapnel fire (correct aim and fuze supposed) depends upon the angle of the cone of dispersion of the bullets, and the angle of fall of the projectile (for the latter see *Shrapnel Fire*, Journal Military Service Institution, March 1892, pages 321 *et seq*). The angle of this cone depends upon that of the rifling of the gun at the muzzle, and can be regulated at will within desirable limits by giving a proper twist to the rifling. Placing the burster either in the head or base of the projectile, practically has little or no effect upon this angle. When placed in the head of the projectile it generally tends to destroy the regularity of the cone and to impair the effectiveness of fire. Erratic shrapnel burst on graze count as misses and add little or nothing to the power of fire, at extreme ranges absolutely nothing; at short ranges where the graze might be of some effect, the burst in air can readily be regulated as it can easily be seen.

The angle of the cone of dispersion can very accurately be determined by the formula (MacKinlay's Text Book of Gunnery, London 1887, page 186).

$\theta = 2\,\varphi\,\frac{d_{\prime}}{d}\left(\frac{V}{v_{\prime}}\right)^{0.7}$ in which,

$\theta =$ Angle of cone of dispersion in degrees.

$\varphi =$ Angle of rifling at muzzle, $= 6^{\circ}.30$ for the 3″.20 gun.

$d =$ External diameter of shrapnel in inches $= 3.185$ for the 3″.20 gun.

$d_{\prime} =$ Internal diameter of shrapnel in inches $= 2.785$ for the 3″.20 gun.

$V =$ Initial velocity in f. s.

$v_{\prime} =$ Remaining velocity in f. s.

From an inspection of this formula it is apparent that for any given shrapnel the curve of dispersion varies directly with the range, and also inversely with the remaining velocity, consequently, to insure the least change in this angle necessitates the maximum possible approach to uniformity of velocity, which obviously can only be secured by the use of a long projectile of good sectional density, which loses its living force and velocity slowly through atmospheric resistance. This resistance varies as follows:

2900 to 1330 f. s., as v^2
1330 to 1120 f. s., as v^3 }
1120 to 990 f. s., as v^6 } Ballistic "bad limits."
990 to 790 f. s., as v^3 }
790 to 100 f. s., as v^2

It is quite evident that the ballistic expert will use every endeavor to avoid the "bad limits," which is so important a feature of the law of atmospheric resistance as applied to projectiles. On the hither side they will not be entered if it be possible to avoid so doing, and on the other once safely beyond, every effort is made to prevent getting back into them again, within reasonable and practical battle ranges. In other words, if the desired end can be obtained, the initial velocity should never exceed 790, or at most 990, or say 1000 f. s. If this will not suffice, the other extreme, to get through the "bad limits" with such a projectile and velocity that the latter shall not fall below 1330 f. s. at any ordinary battle range, should be the distinctive feature of the modern high power gun.

For instance, assuming that the extreme battle range for shrapnel fire is 5500 yards, and that 646 f. s. is the minimum velocity which will insure effectiveness to bullets 34 to the pound. The 3."20—13.5—1000 f. s. will fall to 646 f. s. at only 3000 yards range, and to insure the necessary velocity at 5500 yards with 1000 f. s. initial velocity, will require a shrapnel weighing 22 pounds, and 3.78 calibers length of shell, not counting the fuze. This is by no means an excessive weight or length of shell, but the weight is impracticable in that it cannot be carried with a light field battery in proper number. On the other hand were a high power gun desired, giving the maximum practicable ballistic power within 5500 yards with the least initial velocity, and say an 18-pound projectile, then 2201 f. s. will give 1331 f. s. at this range, velocity being increased as the range decreases. With the present 13.5 pound projectile, this result cannot be accomplished at all with any velocity yet obtained from a gun.

With 2700 f. s. the velocity would be reduced to 1330 f. s. at only 2500 yards and one-half the desired range. In the first case the muzzle energy is only 605 f. t. and the range 5500 yards with the desired velocity; In the second the energy is 753 f. t. with less than one-half the range attained with the desired velocity. The use of such an abnormally short and obsolete projectiie as a 3″.20—13.5-pound the shell being only 2.38 calibers long, and expecting to obtain good ballistic results, is far too much like lifting at ones boot-straps expecting thereby to be raised to a house top.

An 18-pound shrapnel is about the greatest weight of projectile which we can carry with a light field battery, with a suitable number of rounds (140) per gun, and adhere to the loads behind our teams which existed for our light 12-pounder batteries during our late war, which carried only 128 12-pounder rounds per gun. That a 3″.20—18-pound projectile is by no means unusual is readily evinced by comparison. The shrapnel shell will be 3.15 calibers long. The old English three inch M. L. gun had a shrapnel of 13.25 pounds the shell being 3.39 calibers in length, while the common shell of 13.4 pounds was 3.56 calibers long. The modern Canet 2.95 gun has a 13.67-pound shrapnel shell, longer than either of the above, and this too with 1804 f. s. and 309 f. t. energy. Our 3″.20 gun with a similar projectile and the same velocity would give 423 f. t., 87 f. t. more than for our 3″.60—20-pound heavy field gun. Similar projectiles are proportional to the squares of the calibers into the sectional densities from which $\overline{2.95^2} : \overline{3.20^2} :: 2 : 2.33$. The area of 3″.20 $= 8.04 \times 2.33 = 18.73$ pounds. as the weight of a shrapnel similar to that for the Canet 2.95 gun.

By adding about 2.5-inches to the length of the present shrapnel, there will be added a fraction over 4.5 pounds weight, giving a 3″.20—18-pound shrapnel. Also there will be added six tiers, 108 bullets or 278 in all. The length of the shell will be only 3.15 calibers, as against 3.39 for the ancient English three inch shrapnel, or the modern one of about the latter length for the Canet gun. The fuze practically does not count in a ballistic sense, for though it adds 0.56 of a caliber to the length of our shrapnel, it weighs only one pound, and even of this nearly one-half is screwed into the shell proper. In these days of long projectiles for every kind of gun, to adhere to a shrapnel shell only 2.38

calibers long is simply ridiculous, to call attention to its initial velocity of 1668 f. s. with the idea that it is a high one and proves a good gun is equally so. No one pays any attention to initial velocity until coupled with the sectional density or ballistic coefficient of the projectile. The actual power of a gun is in general very nearly as the initial velocity into the square of this density, giving a result under, rather than over the truth, and 1668 f. s. $\times \overline{1.68}^2$ is to, say 1380 f. s. $\times \overline{2.24}^2$, as 4780 to 6924, showing that for the practical development of useful ballistic power, 1380 f. s. with a 3".20—18pound projectile is a much higher velocity than 1668 f. s. with a 3".20—13.5-pound projectile. This proportion as applied to battle ranges is verified by the fact that at a mean battle range of 2750 yards (5500 yards being the extreme, the energies of these two projectiles are 13.5—73 f. t. and 18—103 f. t. To give effect to shrapnel bullets at this same range the velocities are 13.5—872 f. s. and 18—899 f. s. This for the ballistics. The man-killing powers are in general as the number of bullets contained in the shrapnel respectively, or as 13.5—170 bullets and 18—278 bullets. As the gun is above all things for man-killing purposes, it will be 60 per cent. better and more effective with an 18 than with a 13.5-pound projectile, as will more fully appear hereafter.

To fight with shrapnel is simply pot hunting, after rather dangerous game it must be confessed. If one has a modern small bore rifle, with a high velocity long bullet with great sectional density and a very flat trajectory, and desires to pot as many ducks as possible out of a bunch resting on the water, he will get down as nearly as possible to the level of the water, because the bullet has sufficient penetration to go through as many birds as can be got into line. But having a shot-gun (corresponding with shrapnel fire conditions wherein the shot or bullets will not go through one bird or man), he will get above the water level and fire down upon the birds in order to bag the greatest number. When it comes to potting men the same conditions are requisite, viz: a flat trajectory and the least possible angle of fall for the rifle bullet, and a curved trajectory and a definite angle of fall to insure the best results with shrapnel fire.

Now the area presented by the average man standing is about

8.25 sq. ft., kneeling less, and for a mounted soldier a greater area, so that we may take this as about the average size of our "bird" and the "pattern" for our gun should be regulated accordingly. As has already been seen, the increase of the present weight of our shrapnel to 18 pounds will add 108 bullets to the 170 it now contains, giving 278 bullets, 34 to the pound. Then $278 \times 8.25 = 2294$ sq. ft. as the area of the circle to which the pattern should conform, the diameter being 54.5 feet, which is the front of men standing in a rank, which this pattern will cover with one hit per man, and we of course desire to maintain this *invariable pattern no matter what the range.* But as the angle of the cone of dispersion varies directly with the range, it is obvious that, to insure the desired uniformity of pattern, the distance short at which the shrapnel must be burst will vary inversely as the range; complications apparently too great to be readily governed in practice. But such is by no means really the case.

It is quite evident that in order to avoid the evils of the ballistic "bad limits" we cannot make use of the 3".20–18–2200 f. s. Not because such results cannot readily be obtained under suitable conditions, but because the necessary gun and carriage can not be constructed within the limit as to weight for a light field gun. As a 22-pound projectile will be too heavy to be carried with the battery in sufficient number, we cannot keep to the 1000 f. s. limit on the other side without changing the present caliber of the gun, and therefore must per force enter the undesirable region of velocities between 990 and 1330 f. s., but of course with the intention of getting no further into it than possible, or of getting out of it as quickly as possible. To render bullets 34 to the pound effective, requires a velocity of not less than 646 f. s. Prince von Hohenlohe gives 5500 yards as about the greatest practicable range for field-artillery.

To secure 646 f. s. at this range with a 3".20—18-pound projectile will require an initial velocity of 1380 f. s., which, under the conditions imposed, is avoiding the evils of the "bad limits" to the greatest possible extent, *i. e.*, passing 50 f. s. beyond, but getting out again at a range of 1534 yards. The 13.5—1668 f. s.

passes 338 f. s. beyond, and does not get out until a range of 1920 yards is reached.

3''.20—18—1380 f. s. 278 bullets. log C = 0. 29003.							
Range	V	v_1	θ	Burst.	t (short)	Pattern.	
						Area.	Diam.
yds.	f. s.	f. s.	° ''	yds.	''	sq. ft.	ft.
800	1380	1166	12.47	81.0	0.208	2294	54.5
1500	"	1036	13.54	74.4	0.215	"	"
2500	"	923	15.04	68.8	0.223	"	"
3500	"	834	16.11	63.0	0.227	"	"
4500	"	741	17.34	55.6	2.239	"	"
5500	"	646	19.21	53.5	0.249	"	"

From this it appears that, in order to secure the invariable pattern desired, requires the shrapnel to be burst 81 yards short at 800; 74.4 yards short at 1500 yards range, &c. But let the times of flight of the shell for the 81 &c. yards be considered—supposing it continued to the target. It will be seen that by determining these several times, and then applying them according to the times for the several ranges in graduating the fuze, we will always get the proper burst short necessary to insure the invariable pattern desired, the fuze of course being correctly set for the range. While a fuze cannot be cut to 0''.22, its scale can readily be so measured and this correction accurately applied. Thus, if the actual time of flight of the projectile to the target be 2''.09 for a range of 800 yards, the fuze would be measured for 1''.87 and marked 800, the shell bursting 85.5 yards short. The 0''.22 being applied as a mean of the times, giving results as follows:

Range.	t.(1)	t Corrected 0''.22	Burst.	Corrected. Burst.	Errors
yds.	''	''	yds.	yds.	yds.
800	2.09	1.87	81.0	85.5	+4.5
1500	4.06	3.84	74.4	76.0	+2.6
2500	7.29	7.07	68.8	68.0	—0.8
3500	11.28	11.06	63.0	61.0	—2.0
4500	15.53	15.31	55 6	54.0	—1.6
5500	19.93	19.71	53.5	47.0	—6.5

(1)—Assumed.

The actual times can be discovered and applied of course, but it is apparent that the uniform correction makes very little difference even at the extremes of the range, and that for all common battle ranges the errors are immaterial. But these errors are after all more apparent than real, as the calculations are based upon the supposition that the bullets follow the elements of the angle of the cone of dispersion to the target. As a matter of fact this is not so, as the bullets curve inward toward the axis considerably at short ranges where the velocities are high, but very little where the velocities are low. Consequently the calculated distance of burst above should be increased—just how much can be computed. But this is exactly what the use of the uniform time correction has accomplished for all of the shorter ranges when the angle of fall is inconsiderable. Passing to the extreme ranges where the velocities are reduced, the bullets tend more nearly to follow the elements of the cone, but here the uniform correction works the other way from what it did at the shorter ranges, but also in the right direction, strange as it may at first appear. At 5500 yards the angle of fall will be say 26°, at which the average man of five feet seven inches and 8.25 sq. ft. area will be "foreshortened" to 5'.03 and 7.4 sq. ft. area, and the pattern must be closed up accordingly; the actual burst short should be 51 instead of 53.5 yards short as given in the table, while the correction makes the actual burst 47, a real error of four yards and too small to be of consequence, especially at such an extreme range.

These corrections or "compensations" are of the greatest utility to the gunner, as they leave him free to aim his gun and attend to his proper duties without having to consider or calculate what is necessary as a correction to insure good practice with his shrapnel.

It now remains to be seen what difference will be made by changing the weight of the 3".20 shrapnel from 13.5 to 18 pounds, and why actual practice with shrapnel shell of small sectional density and high initial velocities have given such unexpected and unsatisfactory results.

3.''20—13.5—1668 f. s. 170 bullets. Log $C = 0.13672$.

Range.	V	$v_{,}$	θ	Burst.	t (short.)	Pattern.	
						Area.	Diam.
yds.	f. s.	f. s.	°	yds.	''	sq. ft.	ft.
800	1668	1300	15.11	61	0.141	1403	42.6
1500	"	1072	15.29	52	0.145	"	"
2500	"	905	17.26	46	0.152	"	"
3500	"	788	19.23	42	0.160	"	"
4500	"	667	21.36	37	6.168	"	"
5500	"	609	23.00	35	0.173	"	"

TIME, DISTANCE, &c.

Range.	t (1)	t (2) (corrected.)	Burst.	Corrected burst.	Error.
yds.	''	''	yds.	yds.	yds.
800	1.53	1.38	61	65	+4
1500	3.18	3.03	52	54	+2
2500	6.12	5.97	46	45	+1
3500	9.71	9.56	42	39	—3
4500	13.62	13.47	37	33	—4
5500	18.44	18.29	35	30	—5

(1)—Assumed. (2)—Correction applied 0''.15.

The first thing that will be noted is the great difference in the angles of the cones of dispersion for the two projectiles; that for the 13.5 being about as great at 800 yards, as is the angle for the 18-pound shrapnel at 2500 yards range. From this it follows that, as the lighter shrapnel contains only 170 bullets, in order to secure the same pattern (one hit to 8.25 sq. ft.) it must be burst very close to the target, about twenty yards closer than for the heavy shrapnel. Right here lies the secret of all the trouble with light shrapnel of this character, together with this difference of 20 yards and the velocities which cause it, are the measures of the superiority of one projectile over the other. To make this apparent, suppose we consider the effects of two errors in cutting the fuze; one of 0''.1 and the other of 0''.25.

3.''20—18—1380 f. s. 278 bullets. Error±o''.1.

Range.	v,	Correct burst.	Burst.		—o''.1 Target+o''.1.		Files Hit.	
			—o''.1	+o''.1	Hit to sq. ft.	Length.	—o''.1	+o''.1
yds.	f. s.	yds.	yds.	yds.		ft.		
800	1166	81.0	120	42	18	27.0	11.3	11.6
1500	1036	74.4	109	39	18	28.5	11.3	12.2
2500	923	68.8	100	38	17	29.5	12.6	12.6
3500	834	63.0	91	35	17	30.0	12. 6	13.0
4500	741	55.6	81	31	16	30.7	13.4	13.1
5500	646	53.5	75	30	15	31.6	14.3	14.0

This shows that an error ±o''.1 in the fuze will, for the —o''.1, give one hit in about 17 sq. ft. as an average for all the ranges, or about twelve files in a line of thirty-three files standing. For the error+o''.1 all of the bullets hitting will be concentrated within a length of about thirty feet of the target, and fill about twelve files full of bullets.

3''.20—13.5—1668 f. s. 170 bullets. Error ±o''.1.

Range.	v,	Correct burst.	Burst.		—o''.1 Target+o''1		Files Hit.	
			—o''.1	+o''.1	Hit to sq. ft.	Length.	—o''.1	+o''.1
yds.	f. s.	yds.	yds.	yds.		ft.		
800	1300	61	104	18	24	12.6	9.0	5.4
1500	1072	52	88	16	23	13.0	9.0	5.4
2500	905	46	76	16	22	14.6	9.7	6.2
3500	788	42	68	16	21	16.0	10.0	6.8
4500	667	37	59	15	20	16.8	10.7	7.0
5500	609	35	55	15	19	18.0	11.2	7.6

Here the error of $-0''.1$ in the fuze will give one hit in about 22 sq. ft., or about ten files in a line of thirty. For the error of $+0''.1$ the bullets hitting will be concentrated in about fifteen feet length of the target and fill about six files full of holes. If the error of the fuze be $\pm 0''.25$, neither of the shells will burst in front of the target when the error is $+0''.25$, and no hits will be scored in either case—except of course that the projectile itself might make a hit in passing. When the error is $-0''.25$ the 18-pound shrapnel will give one hit in about 37 sq. ft. (average for all ranges), or six files in a line of forty-nine, while the 13.5-pound shrapnel will give one hit in about 65 sq. ft. or three + files in a line of fifty.

The efficiency of the heavy shrapnel exceeds the other thirty-six per cent. for direct hits upon a single rank, and by area of pattern fifty-two per cent. not taking into consideration the angle of fall. Beyond 2200 yards the angles of fall for both guns will project all bullets to the ground within the limits of their effective velocities, and the chances of hitting will be exactly proportional to the number of bullets, *i. e.*, as 170 : 278. Within the range of 2200 yards the trajectory for the light shrapnel will be flatter, and consequently a greater proportion of the bullets at the top of the cone of dispersion will be projected into the air, at such an angle that they will only come to the ground after their power for harm is lost, and the effectiveness will be greater than as 170 : 278 in favor of the heavier shrapnel. Effect is claimed from ricochet, but this would only be true for smooth and hard ground. As battles are fought upon rough, cultivated or grass lands, the shrapnel bullet when it once reaches such ground has practically lost all power for damage.

The velocities again illustrate the value of sectional density. While 1380 f. s. with the heavy projectile renders the bullets effective up to the full limit of 5500 yards, 1668 f. s. with the light one renders it effective for less than 5000 yards.

The conditions represented make clear the reasons why shrapnel practice with light projectiles and widely varying velocities or flat trajectories have proved so unsatisfactory. The angle of the cone of dispersion is so great, coupled with the relative exaggeration due to any error in the fuze, &c., that when the pattern is increased *there are no bullets to fill it in*, and when contracted *the contraction is excessive.*

It is quite evident no matter what the projectile, that *in battle* the fuze must be such that it can be readily cut with an error less than 0".1, and that as the weight of the projectile is increased and the velocities become more nearly uniform, the less effect will this error produce.

That the sight and fuze should be graduated in yards is evinced by the practice of all experienced artillerists. The one stupid objection raised is that powder will change with time, while the fuze, being better protected, is very much less subject to such change. This takes for granted that the ingenuity of man is so limited that he will always adhere to a fixed weight of powder for a charge, no matter what may be its condition. As the fuze will remain practically unchanged for years, it is obvious that if it and the sight be graduated in yards, there must be an invariable and *standard initial velocity*, and if the powder changes, the weight of charge must also change. So long as the standard velocity is assumed, when the sight and fuze are graduated alike they will work alike, no matter what the conditions of firing.

Some foreign artillerists seem disposed to look upon our field-guns as howitzers. Of course they are, though they are not by any means so intended. If there be any validity in the claim, that shrapnel is above all the proper man-killing projectile for field-guns (and beyond doubt it presents vast possibilities as such if properly used), foreign shrapnel practice proves pretty conclusively that to secure good results with shrapnel fire, necessitates not only a genuine "gun-howitzer" for the more powerful direct shrapnel fire with the full service charge, but also that the same gun must be converted into a real howitzer with a reduced charge and high-angle fire, if any adequate results are to be obtained against an enemy protected by even very slight cover.

Special guns have been constructed for this latter purpose fired at great angles, and whole companies knocked over behind excellent cover so far as "hits" counted; but when the velocities of many of these hits came to be investigated, they were hardly sufficient to cause the bullets to penetrate a soldier's clothing. As the shrapnel shell must reach the ground with a velocity sufficient to render its bullets effective, and as this velocity is not inconsiderable, gravity cannot be depended upon to insure it. Consequently the angle of projection has a definite limit which cannot be exceeded, and which can only be increased for any given gun by increasing the length and weight of its projectile, and thereby keeping up the remaining velocity proportionally with the increase of this angle. As this angle is small under any ordinarily practicable condition, for the useful battle ranges which are not great with this high-angle fire, if the gun be given a long and heavy projectile for direct fire with full charges, with a reduced charge it will give all the results that can be secured with a special howitzer, supplied with an equal weight of ammunition, Of course there is no sense in comparing a field-gun with a siege-howitzer; the question of mobility renders this impossible, though artillerymen have never been slow to use siege as field-guns, if any were at hand and could be utilized for the purpose.

A high explosive in a proper shell would change matters decidedly, for then the explosive force is depended upon to give the necessary velocity to the fragments. But even under this condition as the gun will admit of 20° elevation—and the carriage can readily be constructed to give 26° if necessary—at all practical battle ranges for such fire in a *battle*, the gun will answer every purpose. Quasi sieges are different. Explosive shell, in order to be more effective must of necessity be very heavy for any given caliber, as so small a proportion of the fragments take the required direction. As the remaining velocity is no longer a matter of great consequence, this shell can be fired at a high angle with a reduced charge and we can avoid the ballistic "bad limits" entirely, consequently the velocity will not only be low, but at its maximum in its approach to uniformity and the efficiency of the time fuze will be at its greatest, as under such conditions it can readily be cut with an error much less than 0".1. Therefore, if the value claimed for this kind of fire for searching out an enemy behind cover exists, the long and heavy projectile for its development is of even greater necessity and value than it is for shrapnel fire, and if taken for this purpose it must be taken for all purposes, for all the projectiles for a battery must be alike in weight.

If a common shell be considered, the value of weight is again apparent as it tells against obstacles, both by energy and penetration, and by the increased weight of bursting charge it will contain.

No matter what conditions of fire may be be stated for field-guns, a careful investigation will prove that, in order to secure the maximum effect and destructive power against an enemy, a long and heavy projectile is just as necessary as it is for the modern small-bore rifle, though the conditions of actual firing are altogether different.

There is of course a very restricted limit to the practicable length of the time-fuze, but with the double gallery-fuze one can readily be constructed with very slow burning composition, which will cover a range of 5500 yards if deemed necessary, which will not be the case unless we have a good telescopic sight.

It will be possible to construct such a fuze with an error considerably less than $\pm 0''.1$, and if with an 18-pound shrapnel and 1380 f. s. or even a considerably higher velocity if desired, good practical results are not secured, far exceeding any that can be obtained with the present projectile it will not be the fault of the fuze, shrapnel or gun.

COMMENT AND CRITICISM.

A Study of the Effects of Smokeless Powder in a 57mm. Gun.

Mr. Benét's valuable and interesting paper on "A Study of the effects of Smokeless Powder, etc.," presents conclusions which I was not entirely prepared for, and which I should question as inapplicable to all kinds of smokeless powder. I refer particularly to the deduced curves of pressure. The generally accepted opinion is that not alone do the smokeless powders maintain the maximum pressure for a longer period than either the brown or black powders, but that the fall of pressure is, throughout the gun, less than of these latter.

I have seen cubes of Nobel's ballistite* (used by both Germans and Italians) found after firing, only partially consumed. But these were as regular in shape and dimensions as were the original grains, although smaller than the latter. This indicates a regular ignition and progressive combustion. Besides this, a much larger volume of flame issues from the muzzle than when either the brown or black powders are used, indicating that a considerable quantity of the powder grains are still burning after leaving the muzzle and even a larger number in proportion, than when the other powders are used. This would appear to indicate the longer continued time of combustion and desirability of lengthening the guns as well as strengthening the chase. Both of these conclusions are directly opposite to those arrived at by Mr. Benét when using the BN_1 and BN_{144} smokeless powders.

Without questioning these when applied to the particular smokeless powders which were used in Mr. Benét's experiments, it will be necessary to await further similar investigations, with the other smokeless powders before accepting the conclusions, as of general application to all smokeless powders.

The relative energy per unit of weight of various smokeless powders are as follows, brown powder being taken as unity:

BN	2.48.
Nobel's	3.44.
Cordite	4.16.

The Nobel powder gives about the same velocities as the brown powder in short guns, but gives increased velocities as the guns are lengthened.

As there was no practical difference in the maximum chamber pressures obtained, it would appear that other smokeless powders either continue their maximum pressures, or these fall much less rapidly than does the BN powder.

* Nobel's Ballistite is a modified explosive gelatine, consisting of fifty per cent. nitrocellulose and fifty per cent. nitroglycerine.

It would not be safe to base the building of guns as to strength of chase, etc., upon the conclusions formulated by Mr. Benét unless limited to the use of the BN smokeless powders.

The "grains" or rather "plates" of the smokeless powder used in these experiments were so thin and presented, relatively, so much surface, that one would expect a rather quick completion of the burning and failure to maintain the pressure well towards the muzzle. Although the BN_{144} plates were slightly thicker than the BN_1 plates (by 0.1 mm), yet the composition may have been somewhat different to account for the higher pressures at the breech. Had the BN_1 powder been in thicker plates or even in thick cords or cubes, the results as to the pressures in the chase might have been better. It might be well, in passing, to mention the arguments in favor of the cords. The surfaces being as the diameters, the rate of ignition and combustion is more easily controlled than where cubes or other granular forms are used, as the burning surfaces of the latter would be as the squares of any one dimension. The rates of burning can thus also be measurably controlled when *plates* are used. But it would appear that, in this case a somewhat thicker plate than that used might have given better results. The necessity of regulating shape and size of grains for each caliber and length of gun appears to be of greater importance with the smokeless powders than even with the black and brown powders.

The greater amount of work accomplished by the smokeless powder used, is not made clear in the curves of pressure as given. The imagination is required to carry the three curves back to a point representing the maximum pressure in order to comprehend, by the relative enclosed areas, the greater amount of work and the higher velocities of the smokeless powder.

Further investigations of this character might very easily be carried on at the Artillery School and it is hoped that much work of this nature will be taken up in the near future.

Artillerists are indebted to Mr. Benét for giving them the benefit of his work in so clear and comprehensive form, in the new and interesting field of the smokeless powders.

E. L. ZALINSKI,
Captain 5th U. S. Artillery.

History of the Mexican War, by General Cadmus M. Wilcox.

In the JOURNAL OF THE UNITED STATES ARTILLERY, for July 1892, Colonel John Hamilton, U. S. Army, has reviewed or commented on, General Cadmus M. Wilcox's History of the Mexican War.

I have read the review, and parts of it, several times, and it seems to me the glaring mistakes he has made should be corrected, and the erroneous impressions he appears to have of certain events treated of, by him, and with which he is likely to impress his reader, should be set right. I will try to do this, and principally by quoting from official records; after which, or intermingled with the authorities cited, I will say a few words on my own account.

Colonel Hamilton thinks, in speaking of "Palo Alto and Resaca de la

Palma," that "to the unprejudiced reader of a critical turn of mind, Taylor's campaigns would scarcely be taken as models." Perhaps not, but it should be taken into account that General Taylor likely knew, to a certain extent, the character of the people with whom he was dealing, and it should also be borne in mind, that he was a man of splendid common sense (as good a thing in a general as in other people), and knew what was expected of him, and how to do it, without stopping to consider the question of "Grand Tactics," or any other question which would delay the results he wished to accomplish.

He knew the government wanted him to establish his army on the left bank of the Rio Grande as soon as possible, and if he had halted, after the battle of Palo Alto, to intrench and wait for reinforcements, or to discuss the question of fortifying Point Isabel, or have retreated to that place, it is probable he would not have reached his "objective point" by this time.

Colonel Hamilton, in speaking of General Kearney's "affair" at San Pasqual, California, seems to lean to the side of one "Warner," and the Mexicans, who insisted that the Americans were whipped at that place.

"Warner," or his wife, was the owner of the ranch spoken of by General Kearney, in his report to the Adjutant General, of December 12, 1846, and was (Warner), according to Colonel Hamilton, very loyal to the Mexican side of the question.

Colonel Hamilton further says of this affair: "Warner claimed that the Americans were whipped at San Pasqual, because Davidson's mules and dragoons' horses had been stolen from him, and the animals being unused to the soft American bit, refused submission to it, and went where their will or fear carried them; many into their old pastures, and some into the ranks of the Mexican cavalry." General Kearney in his report of the 13th of December, 1846, from San Diego, to the Adjutant General of the army, speaks of *two* mules*, which were attached to the howitzers (under Lieutenant Davidson's command), "having become frightened, freed themselves and escaped to the enemy;" according to General Kearney, *that* (two mules) *was all.*

Warner's ranch was reached on December 2d, 1846, and the fight took place on the 6th, and including both those dates, and until the party reached San Diego (and not then), there is no mention by General Kearney or Lieutenant Davidson, of any mules or horses being *stolen*, taken, borrowed or purchased, from Warner. In this same report, of General Kearney's, he further says: "My aide-de-camp, Captain Johnson, 1st Dragoons, was assigned to the command of the advanced guard of twelve dragoons, mounted on the best horses we had; then followed about fifty dragoons, under Captain Moore, mounted, with but few exceptions, on the tired *mules* they had *ridden* from *Santa Fe* (New Mexico), 1,500 *miles* * * then followed about twenty volunteers of Captain Gibson's company, under his command and that of Captain Gillespie: then followed our two mountain howitzers, with dragoons to manage them, * * then the remainder of the dragoons, volunteers and citizens employed

* All italics in this paper are mine.—W. B. L.

by the officers of the staff, &c. * * * " Where is the evidence of a *steal* of horses and mules? The report continues: "At dawn of day (the 6th), our men approached the enemy at San Pasqual, who was already in the saddle, when Captain Johnson made a furious charge upon them, with his advanced guard, and was in a short time after, supported by the dragoons, soon after which, the enemy gave way. * * * Upon the retreat of the enemy, Captain Moore led off rapidly in pursuit, accompanied by the dragoons mounted on horses, and followed, though slowly, by the others on their tired mules.

"The enemy, well mounted and among the best horsemen in the world, after retreating about half a mile, and seeing the interval between Captain Moore with his advance, and the dragoons coming to his support, rallied their whole force, charged with their lances, and on account of their greatly superior numbers, but few of us in front remained untouched; for five minutes they held the ground from us, when our men coming up, we again drove them and they left the field, not to return to it, which we *occupied and encamped upon*. * *"

That is what General Kearney says, and it does not look much like a victory for the enemy, notwithstanding Mr. Warner, or anybody else. Captain Moore was lanced; Captain Johnson was shot dead, and Lieutenant Hammond was lanced and died in a few hours. General Kearney received two lance wounds, and there were twelve dragoons killed and eleven wounded; of these, General Kearney's report speaks as follows: "The great number of killed and wounded proves that our officers and men have fully sustained the high character and reputation of our troops, and the victory thus gained over more than double our forces, may assist in forming the wreath of national glory. * * * "

Colonel Hamilton goes on to say: "Our surviving officers of the affair resent the charge of defeat, but certainly they were penned, famishing for food and water, on San Bernardo hill, for two days, until relief came out to them from San Diego. * * ". Who says so? However, let a further quotation from General Kearney answer this statement, but recollect the fight took place on the 6th. "On the morning of the 7th, having made ambulances for our wounded and interred our dead, we proceeded on our march, when the enemy showed himself occupying the hills in our front, which they left as we approached, till reaching San Bernardo, a party of them took possession of a hill near to it, maintained their position until attacked by our advance, who quickly drove them from it, killing and wounding five of their number, with no loss to our men.

"*On account of our wounded men*, and upon the *report* of the *surgeon* that rest *was necessary* for them, we remained in this place until the morning of the 11th, when Lieutenant Gray of the Navy, in command of a party of sailors and marines, sent out from San Diego, by Commodore Stockton, joined us. We proceeded at ten A. M., the enemy no longer showing himself, and on the 12th (yesterday) we reached this place; and I have now to offer my thanks to Commodore Stockton, and all his command, for the very many kind attentions we have received, and continue to receive from them."

Is it not probable, that if General Kearney's command had been "penned and famishing for food and water on San Bernardo hill for two days," that he would have said something about it in his official report? And is it not more probable that, had the troops been "penned" during that time, there would have been some fighting or skirmishing, and that General Kearney would have mentioned the fact in his official report?

Colonel Hamilton has evidently been deceived as to the reliability of the evidence on which he bases such an unfavorable opinion of our success, or want of success in this affair; not only that, but one might believe (if such a thing was possible) he rather enjoyed the supposed failure on the part of our side. And this is, I think impressed on one, when reading the following statement in his review: "Andres Pico treated the whole affair as a joke, says they never had an idea of more than annoying the 'Gringos' as a kind of boastful lark of young men, * * they had neither infantry nor artillery; * * * " and that they "were penned and famishing for food and water." We had no infantry, and the mules ran away with our two mountain howitzers, and it should not be forgotten, that our men had just finished a march of over *fifteen hundred miles*, and were confronted by an enemy on fine and fresh horses, and were two to our one.

However General Kearney was a very truthful, straight-forward man, andI for one, propose to take his account as the correct one, and so, it seems, did General Wilcox.

I will now try to speak briefly of Colonel Hamilton's account of the battle of Buena Vista. Of course I don't propose to "pit" my knowledge of the "Science of War" against his, but I do claim to understand things, when written as plainly as General Taylor's report of that battle.

I will not, however, pretend to try to prove whether or not General Taylor should have established himself at Monterey, or at the more advanced (about eighty miles) position of Agua Nueva. My opinion is, however, that General Taylor was right.

I will quote a few of Colonel Hamilton's statements in regard to the battle (Buena Vista), and then let the results answer them.

In speaking of the "Bob" Garnett story, when General Wool said to General Taylor, "General, we are whipped," and Taylor replied: "That is for me to judge," Colonel Hamilton says: "That was not so, they *were* whipped clearly enough." In reading General Taylor's, and the official reports of other officers engaged in this battle, the reader will be impressed with the fact that Colonel Hamilton is about right, and that we were whipped, or nearly so, but fortunately for the reputation and glory of the United States, General Taylor's early military education had been neglected to such a degree, he did not know it, and his soldiers did not believe it, because General Taylor had not told them so.

Colonel Hamilton says further: "It was simply Taylor's task to regain the losses by throwing in the overworked and much exhausted troops that he had just brought back from Saltillo with him. As they were choice troops, by five o'clock, P. M., they succeeded in making a drawn battle. Of course it was a victory for us, because Santa Ana retreated that night to Agua Nueva, and General Taylor next day to Monterey."

Colonel Hamilton is mistaken, General Taylor did not retreat the next day to Monterey, nor for many days after, in fact he did not do it at all, in the sense in which Colonel Hamilton puts it. But on the contrary, he moved his army to the front, eleven miles, and occupied his old camp, at Agua Nueva on the 27th. General Taylor's first and brief report of this battle is dated, "On the Field of Battle, Buena Vista, February 24th, 1847," and his detailed report is dated, "Head-Quarters Army of Occupation, Agua Nueva, March 6th, 1847." That is eleven days after the battle, and eleven miles further to the front. This should be sufficient to establish the fact, that General Taylor did not retreat to Monterey "on the next day," the 24th. General Wool's report is dated "Agua Nueva, twenty miles south of Saltillo, March 4th, 1847." Captain Washington's report February 28th, from the same place as General Wool's. Colonel Humphrey Marshall's, Kentucky Cavalry, from the same place, and dated March 1st, 1847. Colonel May's, Captain Bragg's and Captain Sherman's reports, and in fact nearly every commanding officer of the troops engaged, reported at or near the battle field, or eleven miles to the front. Colonel Jefferson Davis' report is dated at Saltillo, March 2d, 1847, which is the only report, I think, dated north of the battle field, and he was *not* retreating.

Another point in Colonel Hamilton's paper requires some explanation. General Taylor made two trips from his army to Saltillo, during the operations of 21st, 22d and 23rd of February. The first one, in the afternoon of the 21st, when he took with him, what Colonel Hamilton calls the "flower of his troops." These troops were Colonel May's squadron of 2nd Dragoons; Captains Sherman's and Bragg's batteries, and the regiment of Mississippi Riflemen, under Colonel Jefferson Davis. General Taylor returned with these troops early on the morning of the 22d. Then when the firing had ceased at dark, on the 22d, General Taylor again returned to Saltillo, but took with him this time only Colonel Davis' regiment and Colonel May's squadron of dragoons. He returned the next day (23rd) in the midst of the fighting, with the squadron of dragoons and Colonel Davis' regiment, minus two companies, which he had left at Saltillo.

Now in referring to the "Return of troops engaged in the battle of Buena Vista," we find Colonel May's squadron of dragoons (enlisted men) numbered seventy-two, and the eight companies of Mississippi Riflemen (enlisted men) numbered 328, giving a total for both, 400.

This is the force, according to Colonel Hamilton, with which General Taylor, after he had been "whipped," succeeded in making a drawn battle.

The facts as to the retreat of General Taylor (or that he did not) "the next day," have been disposed of. But the mistake Colonel Hamilton makes, and which he is liable to induce his reader to make, is that these 400 soldiers brought back from Saltillo on the 23rd saved the day or made a "drawn battle." This requires a little attention.

In a few minutes after reaching the battle field, Colonel Davis with his eight companies, was directed to our extreme left, meeting en route, a large number of stragglers from the 2nd Indiana, which had just given way. Colonel Bowles of this regiment, at once joined Colonel Davis' regiment, and many of the fleeing men were induced to follow Colonel Bowles's example. Colonel Davis almost immediately engaged the Mexicans, who outnumbered him three or four to one. He drove them back rapidly, and at one time, according to General Wool, held in check a column of Mexican troops numbering 4,000 men.

The squadron of cavalry did not, like Colonel Davis's regiment, go immediately into the fight, but joined the other regular cavalry. After Colonel Davis became thoroughly warmed up to the work, on the left, as above stated, the 1st and 2nd Illinois, 2nd Kentucky and 3rd Indiana, all became engaged with four or five times their number, of the enemy; drove them, and were driven back, and they again and again were reformed and led against the Mexicans, until the first three regiments mentioned, had it not been for the assistance rendered them by Washington's battery, would have been annihilated. At one time during the battle, the Colonel of the 3rd Indiana seeing he was about to be charged by a large force of Mexican cavalry, and having, or rapidly taking a good position, waited until the cavalry galloped to within thirty yards of his line before a shot was fired; then as the colonel of this regiment says: "The column immediately broke and fled in the utmost confusion, and was closely pursued by our whole force." Why did not this, or some other of the occurrences I have mentioned, make the "drawn battle" spoken of?

Why not take the case of the charge of volunteer cavalry, under Colonel Marshall, with his (Kentucky) regiment and a part of Colonel Yell's Arkansas cavalry regiment, as the particular incident which was the means of making the "drawn battle?"

These two regiments were sent to our extreme left, in the mountains on the 22nd, and were the first troops to engage the enemy. They fought on foot on the 22nd and on the 23rd until the 2nd Indiana gave way, when they were recalled from, or driven out of the mountains, but finally collected and remounted after reaching the plain. Colonel Marshall (in command) then moved in the direction of the Hacienda of Buena Vista, which was in rear of our army. En route he was confronted by the brigade of General Torrion's cavalry, numbering over 1200 men. Colonel Marshall halted his little command of 400 men, and waited until the Mexican column was within sixty yards, then fired into it at that short range, drew pistols and sabers, and in a few seconds, dashed right into this, now shattered, column of Mexican cavalry. After a short but severe hand to hand fight, the Mexicans were driven to the right and left, and it is believed not a man of this entire Mexican column ever appeared in the fight again. All this took place after Colonel Davis had engaged the Mexicans on our left.

With these facts, and others not mentioned, how can it be established that any particular body of troops was the means of making a "drawn battle," after we had once been "whipped clearly enough?"

It is true that General Taylor said, in his official report, when speaking of the last struggle on the Plateau, that Captain Bragg's battery saved the day. He puts it in this way: "The first discharge of canister caused the enemy to hesitate; the second and third drove him back in disorder, and saved the day." But this should be taken in connection with other incidents of the battle, for I think it can easily be shown that the "day was saved" on several occasions, and in different parts of the field.

I do not understand what Colonel Hamilton means when he says, in referring to the landing at Vera Cruz, that "as the author was with the first landing party, and names his regiment, it shows a little human nature *not* to designate the battalion of artillery with him; not being of his arm, they were entitled to but distant reference."

General Wilcox's regiment was the 4th Infantry, and in looking over his history (Chapter II) under the head of "Siege of Vera Cruz," &c., I can see nothing to object to, as to arm of service. After it had been decided, by General Scott and Commodore Stockton, where to disembark on the beach, General Wilcox in speaking of it (page 243), says: "The Fourth Infantry and a battalion of artillery, were transferred from transports to the *Raritan*, Commodore Connor's flag-ship." It will be seen from this, that General Wilcox *did designate* the "battalion of artillery." It is more than probable that this battalion of artillery was landed at the same time as the 4th Infantry, but if General Wilcox says anything in particular in regard to the order of landing of his, or any other regiment, I have been unable to find it. If Colonel Hamilton felt at all hurt that this battalion of artillery had not received a sufficiently prominent notice, the following from General Wilcox should satisfy him: "The capture of Vera Cruz was an affair, in the main, of the staff and artillery."

Again Colonel Hamilton takes exception to the manner, or order, in which Wilcox mentions infantry and artillery at Cerro Gordo. He continues: "As again, on page 288, at Cerro Gordo he is specific as to Penrose and Davis, 2nd Infantry, but they were joined by two companies of the 4th Artillery."

If Colonel Hamilton had read carefully the reports of commanding officers of the 4th Artillery and 2nd Infantry, and also the reports of the division and brigade commanders (General Twiggs and Colonel Riley) as to the operations of their respective commands, he, I think would have discovered why General Wilcox mentioned the names of Penrose and Davis, and did not mention the names of the officers commanding the two companies of the 4th Artillery, and also why it was that Wilcox names these two 4th Artillery companies as having "joined" Penrose's and Davis's companies of the 2nd Infantry. There was no feeling of preference in Wilcox's mind, I am satisfied, for any particular arm of the service, and I found none throughout his whole book.

The facts are, in brief, that by General Scott's battle order, or order of battle No. 111, dated Plan del Rio, April 17th, 1847, General Twiggs with his division, was expected, on the morning of the 18th to turn the enemy's left, and take position in his rear, across the Jalapa road, which was done, in part, as ordered.

General Harney (General Smith being sick) commanded the first brigade of Twiggs' division, and on the 18th made an attack directly in front on the hill (as at that time known) of Cerro Gordo, the left of the Mexican position. At the same time, Colonel Riley with the second brigade of Twiggs' division, moved in the direction contemplated for the whole division, and as the 4th Artillery (2nd brigade) had been engaged all the night before, in guarding batteries, and in dragging guns up the hill, directly facing Cerro Gordo. the 2nd Infantry (2nd brigade) was thus thrown in front and moved off to the left of Cerro Gordo, and in the direction of the Jalapa road, as originally contemplated for the whole division. Very soon the 4th Artillery was ordered to follow the route taken by the 2nd Infantry. When the 2nd Infantry moved off, guided by Captain Lee, Engineers (escorted by Company "D," 4th Artillery, commanded by Lieutenant Benjamin) and had reached a ridge, or spur from the hill of Cerro Gordo, the regiment was fiercely attacked by the Mexicans, when two companies ("A" and "I") were thrown out as skirmishers, and these two companies happened to be commanded by Penrose and Davis, and the regimenral commander, Captain T. Morris, 2nd Infantry, gives their names in his official report, as well as the letters of the companies. And from this report of Captain Morris, Wilcox got the names of the officers commanding these two companies. Colonel Riley says: "Orders were at the same time given to Major Gardner (commanding 4th Artillery) to make similar detachment when the head of his regiment should reach that point. The remainder of the brigade moved on in the original direction, until halted by the orders of the brigadier general commanding, who also detached in succession Company "B," Captain Smith, and Company "H." Captain Anderson, of the 2nd Infantry, and the 4th Artillery, to support the companies first thrown forward. * * " These "companies first thrown forward" were the two commanded by Penrose and Davis. Now if two of the companies of the 4th Artillery succeeded in overtaking Penrose and Davis, would it not be proper to say they "were joined by two companies of the 4th Artillery." The two infantry companies could not have "joined" the 4th Artillery, unless they had faced about, and moved to the rear, because the 4th Artillery was following for the purpose of supporting them. Colonel Riley continues. "The remainder of 2nd Infantry was immediately afterwards ordered up for the same purpose"—to support them—"Companies 'B' and 'H,' 2nd Intantry, joining 'A' and 'I,' already engaged." Here we have companies of same regiment "joining" the companies commanded by Penrose and Davis.

Wilcox could not have done otherwise than fail to give names of officers of the 4th Artillery, commanding companies, because Captain Gardner, the regimental commander, did not do so in his official report, neither did any one else, except in the case of Benjamin. When on the other hand, the brigade commander (Riley) in speaking of the companies of the 2nd Infantry, gave the letters of the companies, and the regimental commander gave names of officers as well as letters of companies.

Enough has been said on this point, but it might be proper to add that the successive detaching of companies of the 2nd Infantry, to support the first two thrown out (Penrose and Davis), and afterwards ordering the whole of the 4th Artillery to follow, resulted in storming the hill of Cerro Gordo from the rear, and in sight of the Jalapa road. When the rush was made, and the top of the hill reached, the first and second brigades met, the first storming the hill directly in front, and the second from the rear. In a few minutes, the battery on the Jalapa road was attacked, and with the help of Shields' brigade (which had been supporting Riley's movement) it was taken, and the day won.

In the mingling of officers and soldiers of the different regiments of the two brigades, on the top of Cerro Gordo, and while congratulating each other, I do not believe there was a thought, as to whether his fellow soldier had a red or white stripe on his pants.

In those days, every regiment, company, battery, officer and soldier, had such implicit faith in the courage and skill of the other, that when one became more distinguished than the other, or there were more or less men killed and wounded than in the other regiments, companies and batteries, the fact was set down to opportunity, or the want of it, or to good or bad luck, as the case might be. The 2nd Infantry, on the 18th, had five men killed and sixteen wounded; and the 4th Artillery had three wounded. I have no doubt the 2nd Infantry thought they had better luck than the 4th Artillery, by getting into the fight earlier.

Colonel Hamilton (except in a few instances, some of which I have pointed out) speaks very favorably of the book, and thinks it leads the reader " well and minutely through as stirring, romantic and chivalrous events, as ever graced history." But if he had wished to convince them and others, that "it is stirring reading, and should be to Young America, now," it is a great pity he did not select for favorable comment, some of the battles, about the result of which he could have no doubt, rather than have taken San Pasqual and Buena Vista, of which he appears to be uncertain. Had he done so, "Young' and Old America, and many others, might have been induced to become better acquainted with a few very bright pages of American history.

Why did he not, for comment, select Cerro Gordo, Contreras, Cherubusco, Molino del Rey or Chapultepec? But then, Santa Ana claimed Molino del Rey as a victory for the Mexicans, and tried to impress his army and the inhabitants of the city of Mexico that, this time, he was telling them the truth. However, as at San Pasqual and Buena Vista, we held the ground fought over, and the Mexicans left.

Since writing the foregoing I have met General Lawrence P. Graham, U. S. Army, who served through the Mexican War, as captain and brevet major of dragoons. After peace was declared between the United States and Mexico, Major Graham, then in Monterey, was ordered to take command of two squadrons of dragoons (one of the 1st and one of the 2nd) and march them to California, which he did via Chihuahua, the Gila river and "Warner's" ranch.

I asked General Graham about Colonel Hamilton's statement of Kearney's defeat at San Pasqual. I was, I must say, somewhat startled when General Graham said, in his emphatic way: "Kearney was defeated, and badly defeated." I of course, wanted to know who said so. He replied: "It was the talk of the country (California) and besides Andres Pico (the commander of the Mexicans) said so." It was November, 1848, when General Graham reached "Warner's" ranch, nearly two years after Kearney's fight took place, and it seems to me "the talk of the country," and the statement of Andres Pico, was not very good evidence in the face of Kearney's official report.

I suggested the name of "Warner" to General Graham. He said: "I knew Warner well. He *stole* from me thirty government mules, for which I put him in the guard house. He (Warner) tried to obliterate the government brand and substituted his own." Warner is Colonel Hamilton's principal witness to our theft of mules and horses, and an important one as to our defeat at San Pasqual. But now, with this witness' much damaged character, and the little weight that should be given to the opinion, or statement, of Andres Pico, and the want of strength in such evidence as "the talk of the country," or what "they say," we can, when supported by General Kearney's positive written statement afford to "rest our case."

W. B. Lane,
Major, U. S. Army.

BOOK NOTICES.

Die Militaer-Feuerwehr. Ein Instructionsbehelf fuer das militaerische Fuerwehrwesen, by A. G. von Eichensieg, Captain in the Engineer Staff, Vienna, 1892, pp. 95. Published by the Imperial and Royal Military Committee.

Under the Austrian Army regulations the duty of extinguishing fires in state buildings devolves, in the absence of regular fire companies upon the engineers. Under certain circumstances, troops may in general be called upon to assist in the discharge of this duty. The work under notice furnishes rules and principles that ought to govern in the cases specified, passing from general considerations—fire-police, alarms, transmission of signals—to the details of fire apparatus, fire service and fire organization. Special cases are separately considered, as conflagrations in factories, theatres, mines, barracks, bridges, &c., &c.

A difference from our own regulations may be noted in respect of magazines. Ours (par. 372) forbid all attempts to remove explosives in the case of a neighboring fire. It would seem however that such removal is contemplated in the Austrian Service, but only under special direction.

Captain von Eichensieg has treated his subject fully and thoroughly. His work is a valuable contribution on an important subject. Of its usefulness to the service for which primarily intended there can be no question, and it would be remarkable if its influence were not appreciated in any service.

C. De W. W.

Notes on the Construction of Ordnance, No. 60, Washington, May 11th, 1892. On the Energy Absorbed by Friction in the Bores of Rifled Guns, by Captain Noble, C. B., F. R. S., etc., late Royal Artillery. From the Proceedings of the Royal Society, London, Volume 50, No. 306.

Captain Noble's paper "On the energy absorbed by friction in the bores of rifled guns," given in Notes on the construction of Ordnance No. 60, is an extremely interesting contribution to artillery lore, and will be likely to produce a change in the character of the rifling used. An increasing twist has been universally adopted, although a number of artillerists have shown that the parabolic form which is most commonly used is not the most advantageous. Judging from Captain Noble's experiments, it is doubtful whether a better twist can be used than the uniform twist. The mean energy consumed by the uniform twist is 1.52 per cent. of the total energy. The mean gain of the latter over the parabolic rifling is 2.36 per cent. of the total energy. In some of the series the energy lost by the parabolic rifling was four times that consumed by the uniform rifling.

It is strange that the increasing twist has been so generally adopted without investigations having first been made similar to those presented by Captain Noble. He suggests that the parabolic twist may have been given because of possible greater accuracy attainable when the latter is used, and suggests experiments to determine this point. But if the band is properly placed and the twist is sufficient to give necessary rotation, it can hardly be questioned but that the uniform twist will give as great accuracy as is obtainable with the increasing twist.

It is interesting to note the difference of energy obtained when ordinary gunpowder is used, with the bore clean and with it fouled. In the latter case the loss was 2.73 per cent. greater than when the barrel was clean. With the Amide and Cordite powders the fouling was so slight as to make no essential difference in successive rounds.

With the uniform twist the driving edges of the lands formed on the band must necessarily wear away and lead to loss of energy by escape of the gases as well as increase of erosive action on the gun bore. This might be obviated both by a very slight shallowing of the grooves, and narrowing them by an amount equal to the wear of the driving edges on the band.

E. L. Z.

BOOKS RECEIVED.

Interior Ballistics, by COLONEL PASHKIEVITSCH, (*Professor at the Michael Artillery Academy, St. Petersburg, Russia.*) Translated from the Russian by 1st Lieutenant T. H. BLISS, 1st Artillery, A. D. C.—*Adjutant General's Office*, 1892.

Krupp v. Canet, a controversy by a German Artillerist and a French Artillerist.—[*Reprinted from Engineering*, 1892.]

Canons á Tir rapide de gros Calibres.

SERVICE PERIODICALS.

Revue d'Artillerie.

July.—Remarks on the laws of resistance of the atmosphere. $6^{mm}.5$ repeating rifle, Mannlicher system. Note on the influence of the method of aiming on the value of the correction for inclination of axis of trunnions. The artillery of the future and the new powders.

A translation by Captain Moch, of Mr. Longridge's work.

Notes.

August, 1892.—I. Remarks on the laws of resistance of air. Influences of the initial velocity of a body in its fall through the air (completed). II. On the pointing of field guns. III. Re-organization of the Spanish Artillery. IV. The artillery of the future and the new powders, Study of the application of new powders to high-power guns (continued).

Revue Militaire de l'Etranger.

June.—The German war-budget for 1892-93. Present organization of engineer troops in the Russian army. The canal from the Baltic to the North Sea, and the maritime defense of Germany.

July.—The development of the military and naval power of the United States.

August.—The railroad troops of the Italian army. The military forces of Denmark. Military news.

Revue du Genie Militaire.

Revue Maritime et Coloniale.

June, 1892,—The mechanical theory of heat. Part II. Former bodies of Marines (1622-1792) (continued). Problems of the British Empire. Translated from the English (continued).

The opinion of the author of the effect upon the commerce of the United States should England engage in a war with any of the maritime powers of the continent, is of especial interest to Americans.

"Disaster to England would bring joy to the United States, * * Holland, Belgium and Sweden would purchase most of our merchant ships, provided the United States should not modify its existing regulation refusing national privileges to foreign built ships. It is most probable that, in view of possible wars in which England may be engaged, a change in this law will be made in the United States, and, in this case the greater part of our commerce would pass under the American flag. * * The carrying trade of the entire world would undoubtedly leave our hands, and, should the war end favorably for us, it would be at the cost of heavy sacrifices. The commerce of all belligerents would, up to a certain point, be transferred to other nations, etc."

The progress of artillery during 1890. Aerial voyages of great length (continued). Balloons and the exploration of the African continent (to be continued). Miscellaneous. Book notices.

AUGUST, 1892.—The District of Martigues. Journal of the surgeon of the Frigate *l'Aréthuse* (1812-1814) (to be continued). Aerial voyages of great length (continued). Balloons and the exploration of the African continent (to be continued). The voyage of a slaver (1787-88). Former bodies of Marines (1622-1792). The origin of French India (to be continued). A vocabulary of powders and explosives. Miscellaneous. Book notices.

SEPTEMBER, 1892.—Statistics of ship-wrecks and other accidents at sea, for the year 1890. Journal of the surgeon of the Frigate *l'Aréthuse* (1812-14) (continued). The origin of French India (continued). Historical study of the Marines of France. The French Marines before and during the seven years' war. Aerial voyages of great length. Balloons and the exploration of the African continent. Miscellaneous. Book notices.

Revue du Cercle Militaire.

JULY 3.—Dahomey. The "Lagunari" Italians. The fortification of Switzerland. The English Navy and Parliament.

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JULY 31.—The divisional ambulance service. The neutrality of Switzerland. The first combats of the Army of the Rhine.

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AUGUST 14.—The new drill regulations of the German Field Artillery. The first combats of the Army of the Rhine. The divisional ambulance service.

AUGUST 21.—The attack of Havre by a squadron from the north. Divisional ambulance service. The first combats of the Army of the Rhine.

AUGUST 28,—The Swiss Army in 1891. The first combats of the Army of the Rhine.

SEPTEMBER 4.—The Austro-Hungarian Technical Corps. Swiss Army in 1891. The first combats of the Army of the Rhine.

Revue Militaire Suisse.

JULY, 1892.—Military questions before the federal assembly. Society of the officers of the Swiss Confederation, Program of the general meeting at Geneva on the 30th and 31st of July and 1st of August, 1892.

Archiv fuer die Artillerie-und Ingenieur-Offiziere.

JUNE.—Changes within the organization of the Russian Engineers and present organization of same.

JULY.—Kreil: on the causes which produce changes in long bore guns.

AUGUST.—On experiments made with gun-cotton from 1855 to 1862.

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JANUARY.—Swiss autumn manœuvres of 1891. The value and importance of transportable turrets for field artillery. The arming of the cannoneers of "position artillery" with the small-arm rifle.

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MARCH.—The Austrian drill regulations as compared with those of Germany. The projectile with steel head and paper rotating band. Italy's military situation considered in the triple alliance.

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JUNE.—The use of bicycles in European armies.

AUGUST.—Of the use of a better head for projectiles and the results obtained thereby.

Mittheilungen ueber Gegenstaende des Artillerie-und Genie-Wesens.

SIXTH NUMBER.—Gas, benzine and petroleum motors. Upon electric illumination of battle-fields. The question of protection from lightning.

SEVENTH NUMBER.—The fortifications on the Franco-German frontier. Upon the electric transmission of power (continued).

EIGHTH NUMBER.—The artillery firing "game." The effect on living targets of the 8^{mm} small-arms. Upon electric transmission of power (conclusion).

Internationale Revue ueber die Gesammten Armeen und Flotten.

JULY.—Upon the reduction of the time of service in the German army. Firing regulations for field artillery and the artillery firing game (continued). England's military strength and her defenses. Military positions (in French), continued. The present condition of the fortifications of Copenhagen.

AUGUST.—Fortification by means of turrets (continued). Firing regulations for field artillery and the artillery firing game (conclusion).

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Jahrbuecher fuer die deutsche Armee und Marine.

Memorial de Artilleria.

JUNE, 1892.—Primers. Discussion of a special design of hollow projectiles.

III. General solution of the problem discussed in the former chapter.

On the tactics of our mountain batteries. Modern small arms and their ammunition. Practical school of the first battalion of fortress artillery. Our arm in the East Indies. A visit to the second battalion of fortress artillery. The progress of aerial navigation. Memorandum of regulations for 1886-7-8.

JULY.—The manufacture of the Steyer small arm. The mobilization of a field battery. Our arm in the East Indies. War-ships. Artillery Museum.

AUGUST.—"Covolumen."

Discussion of previous paper entitled *Dudas sobre explosivos* in which the adaptability of the existing formulas of interior ballistics to the new smokeless powders is considered.

Discussion of the arrangement and use of projectors. Modern small arms and their ammunition. War-ships. Artillery Museum.

Boletin del Centro Naval.

Proceedings of the Royal Artillery Institution.

JULY.—The battle of the velocities. Sir Henry Shere, Kt. Achievements of field artillery (by Major E. S. May, R. A.)

"In addressing some officers of the regiment at the practice camp at Delhi last winter, Lord Roberts pointed out that no single record existed in which an account of what artillery had accomplished could be found, and suggested that some artillery officer should make good the deficiency. In response to this invitation, I have ventured to write these pages."

Notes of lectures on artillery in coast defense (conclusion).

AUGUST.—Fire discipline: Its necessity in a battery of horse or field artillery, and the best means of securing it. (Duncan Gold Medal Prize Essay, 1892.) The organization of a garrison company. Achievements of Field Artillery. The field gun of the future (translation).

Journal of the Royal United Service Institution.

JUNE.—Military geography. Electricity as applied to torpedo and other naval purposes. Military education. The place and uses of torpedo-boats in war. Professor Froelich's new method for determining the velocity of a projectile in the gun. (Translation from the "Rivista Marittima.")

JULY.—Modern aerial navigation. The late war game in the open. Combined tactics.

AUGUST.—Ambulance work and material in peace and war. The French manœuvres of 1891. The dimensions of modern war-ships.

The United Service Magazine (London).

JUNE.—On the strategical condition of the English channel in an Anglo-French war. "Imperial defence."

JULY.—Is war inevitable? Germany and Austria. "Imperial defence" by "Statistician." Volunteer field batteries. England's policy.

AUGUST.—Is war inevitable?—Italy, Russia, etc. Australian defence. "Statistician's" attack on imperial defense (by Spencer Wilkinson).

Journal of the United Service Institution of India.

FEBRUARY, 1892.—The French manœuvres of 1891.

This article gives date, object and troops engaged in the exercises. The plan of the campaign is also followed in some detail and gives the reader a tolerably clear idea of what took place. The time and movements were divided into three periods. 1st period, army corps against army corps. 2nd period, army against army. 3rd period, the army against a skeleton army. In addition to the final review and march past, we find study and comments on the effects of smokeless powder at the exercises and General Saussier's instructions before the commencement.

The velocipede in military service. Notes on the Waterloo campaign. Revolving targets. Some of the probable results of the introduction of the new magazine rifles. Monuments of historical interest.

MARCH.—The Siberian railway. A comparison.

A discourse upon the treatment of sick and wounded in the field, with remarks upon improved methods within recent years.

The Berthier rifle.

APRIL.—Native infantry reorganization. Some tactical and other considerations likely to follow the introduction of the magazine rifle. The terrain in its relation to military operations.

Being a Prize Essay by Lieutenant H. A. Reed, 2nd U. S. Artillery, published in the January Journal of the United States Military Service Institution.

MAY.—A musketry signalling dummy. Safety arm-rack for use in barrack rooms, guard rooms, &c. The capture of Noisseville. Notes on the attack formations of the French army. Speeches delivered in the Austrian delegations on medical services in the field, 2nd and 3rd December, 1891.

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Engineering.

JUNE 17.—Modern United States Artillery—No. XIII. (Continued, July 1, 8, 15, 22, 29, August 5, 12, 19, 26, September 2 and 9.)

JULY 1.—The Royal United Service Institution.

JULY 8.—The *Jean-Bart*. The dimensions of war-ships.

JULY 15.—The Ward Ram. Torpedo boat attack.

JULY 29.—H. M. Cruisers *Indefatigable*, *Iphigenia* and *Intrepid*.

AUGUST 1.—New French torpedo-boats. Electrical appliances in the Navy. Electricity in the Navy.

AUGUST 12.—Sea-going torpedo-boats. Q. F. guns in the French navy. Armor plate trials.

"An important private trial of an armour-plate took place at Shoeburyness on the 4th inst. The conditions were generally similar to those of the Admiralty official tests, but were more severe, in that, while the gun, range, charge and number of rounds remained the same, the thickness of the plate was ½ in. less than the regulation 10½ in., and all the projectiles were Holtzer steel, instead of three only being of this quality, and the remaining two Palliser chilled cast iron, as usual at Portsmouth. The particulars are as follows: Plate, "Ellis-Tresidder" compound, manufactured by John Brown and Co., Limited, Sheffield, dimensions, 8 ft. by 6 ft. by 10 in.; weight, 8½ tons; backing 3 ft. 8 in. of oak and 1 in. iron skin-plate in rear. Number of bolts, eight. Gun, 6-in. breechloader. Range, ten yards. Charge, 48 lb. Striking velocity, 1950 foot-seconds. Projectiles, five Holtzer armour-piercing shot of 100 lb. weight, issued from naval stores. Striking energy of each shot, 2637 foot-tons. All the shot broke up into such minute fragments on impact that the total weight of pieces large enough to be collected was only about 50 lbs. out of the 500 lbs. fired. The penetrations obtained by the first and second shots could be measured, as the embedded fragments fell out during the subsequent rounds; they were respectively 2.17 in. and 1.09 in. The other three penetrations could only be estimated, as the points of the shots remained lodged; they were probably somewhat greater than the above. On the completion of the third round no cracks were detected in the face of the plate, but an hour later, after an adjournment for lunch, two fine superficial hair cracks were observed. At the end of the trial these were somewhat prolonged, and one or two new ones added, but the total extent of the cracking was quite superficial and insignificant, and indicated, by its discontinuous character, great toughness in the plate. On removal of the backing the rear of the plate displayed five bulges, four being uncracked and less than ½ in. high, while the fifth, caused by the last shot, was 1 in. high, and exhibited a single crack 1 ft. long."

AUGUST 26.—The naval manœuvres. Boring and turning mills at the United States Gun Factory, Watervliet Arsenal.

Army and Navy Gazette.

JUNE 11.—Sir Lintorn Simmons on the army. The general officers list. The training of French Naval Officers. Russian Cavalry. The garrison artillery and shore defense.

June 28.—Home army efficiency.

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July 2.—The Royal Navy in 1866 and 1892. The Royal United Service Institution. Bedfordshire Regiment (16th Foot).

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July 30.—Modern field-artillery. Australian defense. Magazine rifle fire.

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August 27.—Aldershot manœuvres. The health of the Indian Army. Military education.

September 3.—Our garrison artillery. The Royal Irish Regiment (18th Foot).

September 10.—Mobilization. M. Weyl's torpedo-boats, etc.

United Service Gazette.

July 2.—The French manœuvres of 1891.

July 9.—The dimensions of modern war vessels. Evolutions of the war-ship.

July 16.—Officers and their weapons. Our naval strength. Rifle shooting.

July 23.—The 1892 naval manœuvres. Experiments with smokeless powders. Mounted branches of the army. Our naval strength II. The Aldershot summer manœuvres.

July 30.—Penetrative powers of the German small bore rifles. The naval manœuvres. Aldershot summer manœuvres II.

AUGUST 6.—The naval manœuvres. Aldershot summer manœuvres III. Our latest battle-ship. Spanish quick firing guns.

AUGUST 13.—The naval manœuvres. Optical sights in the French Navy. The Aldershot summer manœuvres IV.

AUGUST 20.—Lord Roberts on magazine rifles and smokeless powders. The naval manœuvres. Professor Hebler on ogival headed bullets. The Aldershot summer manœuvres V. Royal Military College Sandhurst. The naval manœuvres of 1892. Have they been a success?

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SMPTEMBER 3.—Recent grounding of war-ships, The messing of the soldier. The torpedo-boat attack.

SEPTEMBER 10.—The late naval manœuvres

Mining and countermining at Belfast.

The recent grounding of warships II. Our position in the Mediterranean.

Proceedings of the United States Naval Institute.

VOLUME XVIII, NO. 1. WHOLE NO, 61.—The Driggs-Schroeder system of rapid-fire guns.

This article, by Lieutenant W. H. Driggs, U. S. Navy, gives a clear description of the above system of rapid-fire guns. One interesting feature of this article to artillerymen, generally, is the summary of tests made with this and rival systems. The trials consisted in tests for (1) pressure and strength of gun, (2) operation of breech mechanism, (3) operation with defective ammunition, (4) accuracy. Targets made and data obtained are given. The description of the gun is complete and fully illustrated. Tables of dimensions and weights of different parts and manual of drill and exercises are included.

Remarks on the organization of naval engineer forces. The signal question up to date.

The writer advances a strong argument in favor of adopting the Myer-Very code, "bringing the system down to four instead of five lanterns in a permanent hoist." The writer, Ensign A. P. Niblack, U. S. Navy, asserts that "the American Morse code is not adapted for naval purposes" and brings forward five cogent reasons to establish this proposition.

The statics of launching. Notes on the literature of explosives.

It would be impossible to mention all the interesting and valuable information in this series of notes. To those interested in the subject, the series will be of great value.

Professional notes. Bibliographic notes.

VOLUME XVIII, NO. 2. WHOLE NO. 62.—Torpedo-boats: Their organization and conduct. Prize Essay for 1892. (By Wm. Laird Clowes, *Associate and Honorary Fellow of Kings College, London.*) Cellulose and its application as a protection to vessels. Official report on the behavior of the U. S. S. *Baltimore.* Electric welded projectiles, manufactured by the American Projectile Company, under the patents of Professor Elihu Thomson and William Maxwell Wood, U. S. N.

Description of the machinery and operation of welding given.

The influence of range-finders upon modern ordnance, gunnery and war-ship construction.

The author holds that for two reasons incident to long range actions, range-finders on war-ships "will revive the era of citadels, central casemates and turrets." 1st, rapid-fire guns will play a less important part than at short ranges. 2nd, the chance of a high-explosive shell bursting between decks will be decreased. The range-finder will prevent mêlées. Deliberation, accuracy, and good gunnery at long range will decide the battle. Rams and torpedo-boats will give the final thrust to a disabled adversary.

Notes on the date of manufacture of the three guns at the U. S. Naval Academy, captured in Corea by Rear Admiral John Rodgers, U. S. N. Professional notes. Bibliographic notes.

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Journal of the Military Service Institution.

JULY.—Smokeless Powders. Prussian Great General Staff. Artillery service in the Rebellion (continued). Practical drill for infantry. French grand manœuvres of 1891. Civil war in Chili.

SEPTEMBER.—The terrain in military operations. Artillery service in the Rebellion (continued). Modern drill regulations. Organization of militia defense. Manœuvres and kriegspiel. Physical training of enlisted men.

Journal of the U. S. Cavalry Association.

MARCH.—I. The Union Cavalry. II. Veterinary science for cavalry officers. III. Shock action of cavalry. IV. The organization of cavalry scouts. V. A Confederate cavalry officer's reminiscences. VI. Mounted Infantry. VII. Saddling. VIII. Letters on cavalry.

JUNE.—Remarks upon a popular fallacy concerning Mexico and its recources.

The author protests against the idea that we have in Mexico a feeble neighbor of negligible military strength.

Gymnasiums and riding halls at cavalry posts.

Hammersley's United Service.

JULY.—The Modoc War. General Cullum's "Biographical Register."

AUGUST.—Infantry action and our new drill regulations (continued in September). The ram question. The Battle of Woerth.

SEPTEMBER. The supply of small arm ammunition to troops in the field and on the line of battle under fire.

Journal of the Franklin Institute.

JULY.—The Nicaragua Canal (continued in August). The development of American armor plate (concluded).

AUGUST.—A motor without fuel and the second principle of thermo-dynamics. Nicaragua Canal. Notes on blast furnaces. Present status of the storage battery system of street railway propulsion. Chemical section.

SEPTEMBER.—The electric transmission of power. Precision in the use of the tuning-fork chronograph. Electrical section.

Railroad and Engineering Journal.

JUNE.—The United States Navy. A new first class cruiser (the English *Gibraltar*). The Cruiser *Newark.*

JULY.—The Cruiser *Chicago.* The United States Navy. Steel castings for the navy. The Baker submarine boat.

AUGUST.—Experiments with dynamite shell.

Remarks on Dr. Justin's experiments at Perryville, N. Y., June 20th, 1892.

The United States Navy. The Cruiser *Baltimore.* Foreign naval notes.

SEPTEMBER.—The Watervliet gun-shop. The largest battle-ship (*Royal Sovereign*). The Gunboat *Yorktown.* The United States Navy.

The Iron Age.

JUNE 30.—Apparatus for casting cannon. War-ships building in 1892.

JULY 7.—Launch of the *Texas.*

JULY 21.—Firing the Justin Projectile, with supplement to the Iron Age.

JULY 28.—Launch of the U. S. S. *Columbia.*

AUGUST 4.—Efficiency of the naval ram.

AUGUST 18.—Seabury's breech mechanism for rapid-fire guns.

This article occupies nearly three pages of the paper and contains six illustrations of the Seabury breech mechanism. The principal consideration in rapid-fire guns is the breech mechanism. According to description this mechanism is simple, and fulfills in a marked degree the conditions required of a mechanism for rapid-fire guns. It is based upon the slotted screw principle. The breech-block is unlocked, withdrawn and turned aside by the motion of a crank in one direction. The whole combination is ingenious and interesting.

AUGUST 25.—The Sturtevant electric fan.

SEPTEMBER 1.—Making great guns.

This article occupies six pages of the paper and enters somewhat into detail as to the preparation of the parts, and their assemblage into the built up gun. The article is fully illustrated and treated under the heads—description of the parts; placing the gun in the pit; shrinkage pit; handling the jacket and hoops; cooling; the log book of the gun; physical qualities of the steel; shrinkages; time required to heat jackets and hoops; average clearances; the joint between hoops; cost.

SEPTEMBER 8.—Time required to build a modern gun. Guns for the Battle-ship *Illinois.* J. W. R.

Scientific American.

JULY 9.—The Nicaragua Canal. Gun-cotton.

JULY 16.—Great guns and armor plates.

JULY 23.—The Battle-ship *Texas.*

JULY 30.—The oscillating disappearing turret (illustrated). The Baker submarine boat.

AUGUST 20.—The new steel armor plate tests.

A note on the first armor plate test made on the proving grounds of the Bethlehem Iron Company. An increase of ballistic resistance is reported as compared with the Annapolis test of 1892. The plate was a 10''.5 Harveyized nickel steel, 8'x6' and weighed 18,600 pounds.

AUGUST 27.—Satisfactory progress of American armor.

SEPTEMBER 3.—A multiple fuze igniter. Mast-head electric illumination.

SEPTEMBER 10.—Recent armor plate trials. The *Columbia*.

Army and Navy Journal.

JULY 23.—The new navy bill.

JULY 30.—The fortification bill. The latest armor trial.

AUGUST 27.—The lesson for the day.

SEPTEMBER 3.—The War Department and the militia.

SEPTEMBER 10.—The Krag-Jorgensen Gun. The state troops.

SEPTEMBER 17.—Ships for the navy. The state troops.

Engineering Magazine.

JULY.—Engineering off Cape Hatteras.

AUGUST.—More of the Mississippi problem. I. The levees indispensable. II. The Yellow River and the Po.

SEPTEMBER.—Electric power in mining.

Electrical Review.

AUGUST 6.—Electric welded projectiles.

AUGUST 27.—A submarine search light.

Western Electrician.

JULY 9.—Blake submarine boat and Sims-Edison Torpedo. Electrical forging and tempering.

JULY 30.—The Italian submarine boat *Audace*.

SEPTEMBER 3.—Search light signalling from Mount Washington.

American Journal of Mathematics.

Journal of the American Chemical Society.

Aldershot Military Society.

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JOURNAL

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[SPECIAL NUMBER.]

KRUPP *v.* CANET.

A CONTROVERSY BY A GERMAN ARTILLERIST AND A FRENCH ARTILLERIST.

[REPRINTED FROM ENGINEERING, BY PERMISSION.]

KRUPP *v.* CANET GUNS.

So long ago as 1889 it was widely recognised that a rival to Armstrong and Krupp had arisen in France, and that the Forges et Chantiers de la Mediterranée, who, some years before, had established a gun factory at Havre, were beginning to compete with the older and famous firms for the supply of artillery to foreign nations. The spirit of conservatism that ruled over the English and German works has prevented much detailed information from becoming public as to the guns made there; the Forges et Chantiers, however, have considered it good policy to publish—through our columns—the fullest particulars of every type of ordnance they produce, being well aware that such publication would only redound to the honour of France and their own credit, and could in no way afford information that could be hostile to either.

In the course of the articles published by us on the Canet system of artillery, we from time to time, made some general comparisons between that and the Krupp system. The materials for detailed comparison were then not available, but recently a minute comparison has been made and published in the *Internationale Revue über die gesammten Armeen und Flotten.* Coming from a German writer it was, of course, both natural and fitting that all points in favour of Krupp should be fully insisted on, and it is our present purpose to summarise, without any comment, the comparison referred to, leaving to M. Canet the privilege of replying should he think fit.

The investigation deals with two calibres of very similar value, the 32-centimetre Canet and the 30.5-centimetre Krupp. For particulars of these guns see Table I.

The weight of gun given in the table is not that with which the results recorded in Table II. were obtained, but is intended for firing larger charges. The gun used in the trials weighed only 48 tons, or nearly 18 tons less than the Canet gun.

The three rounds fired from the Krupp gun would, if they had been fired from the normal type, have afforded 524.5, 579.9, and 723 foot-pounds of energy per pound weight of gun. It is to be regretted that the trials were not made with the normal type, as the deduction leaves room for controversy. The data given in the Tables of velocities, pressures, &c., of the Canet gun were taken from the "Revue d'Artillerie," vol. xxxviii., page 70. Two of the results from the Krupp gun were taken from the official firing report vol. lxxxvi., and the round fired with a powder charge of 441 lb. is from an experiment made after the report was published.

In the firing test of the Canet 66-ton gun, before the Japanese Commissioners, twenty rounds were fired; in thirteen of these, brown powder (mark $P.B._1S.$) was used; in six rounds mark $B.N._1$ powder, and in one, mark B.N., sample 6, 1890. From these rounds three were selected for comparison which closely agreed, as to weight of projectile and charge, with those of the Krupp gun, The last Krupp round recorded in the Table, with a charge of 227 lb. of powder (mark W.P.C., 1889), is compared with the rounds from the Canet gun giving the highest efficiency, and special reference is made in the article under consideration to the phenomena attending these rounds.

The points deduced from the Table are as follows:

A.—Rounds Fired with Brown Powder.

I. The Canet 987.7-℔. (448 kilos.) projectile had velocities respectively of 1885 ft. per second (575 m.) and 2010 ft. (613 m.), with charges of 396.6 ℔. and 439.5 ℔. of P.B.$_1$S. brown powder, and with gas pressures of 9.9 and 13.25 tons per square inch. The Krupp projectile, weighing 1003 ℔., recorded velocities of 1902 ft. and 2000 ft. per second (580 m. and 610 m.) with charges of 396.6 ℔. and 441 ℔. of P.P.C./82 powder, the pressures recorded being 15.55 tons and 17.48 tons per square inch.

2. The total and relative strains on the Krupp gun are not greater than with the Canet, but the powers of penetrating a wrought-iron plate with the former are 35.71 in. and 38.54 in. and in the latter, 32.88 in. and 36.30 in.

B.—Rounds Fired with B.N.$_1$ and W.P.C./89 Powders.

1. With a charge of B.N.$_1$ powder of 242.5 ℔. a velocity of 1845 foot-seconds was obtained with a Canet projectile of 995 ℔.; while the Krupp gun, with a charge of 227 ℔. of W.P.C./89 powder, imparted a velocity to the projectile weighing 1003 ℔. of 2234 foot-seconds. The total and relative energies are greater in the case of the Krupp projectile, and its penetrating power is also higher, being 45.6 in. of wrought iron at the muzzle, while that of Canet is only 31.18 in. In comparing the efficiency of the Krupp gun with the three best recorded rounds of Canet, it is noticed that notwithstanding the higher initial velocity and total energy of the Canet projectile, the energy of the Krupp projectile is greater per square inch of projectile section, per pound of powder charge, and per pound weight of gun, and the deduction is drawn that the Krupp gun is superior as regards average energy of projectile and efficiency of gun. The Canet gun is capable of piercing 44.9 in. of wrought iron at the muzzle, and the energy per pound weight of the weapon is 563.5 foot-pounds. The Krupp gun, on the other hand, can pierce 45.6 in. at the muzzle whilst the energy per pound of gun is 564 foot-pounds, and this superiority is the more noteworthy

in that the Krupp gun is at the same time shorter and of less calibre.

Referring more particularly to round No. 7, in which the Canet gun was fired with 562 lb. of $P.B._1S.$ powder, the report states: "Après chaque coup, la culasse était ouverte par un seul homme, sauf après le 18^e coup (No. 7 of our Table), où l'on a dû mettre deux hommes à la manivelle." This remark leaves it to be inferred that the charge of 562 lb. of $P.B._1S.$ powder rendered the loading troublesome, but no information is given as to the time required for this operation. As no further shots were fired on that occasion, it seems fair to assume that the gun would be incapable of standing a succession of shots with such high charges without more serious trouble ensuing. This difficulty with the breech is the less excusable in that the maximum pressure in the chamber was only 16.69 tons per square inch, an amount which experience proves the Krupp guns are capable of withstanding indefinitely, without injury to either the breech-block or its mechanism.

Taking now the two rounds Nos. 8 and 9 of our Table, in which the Canet gun was fired with charges of 297 lb. and 304 lb. of $B.N._1$ powder, it will be noted that the results show a great want of uniformity. Although the shell was lighter, and the charge heavier in No. 9 than in No. 8, the muzzle velocity, instead of being greater, is actually less than it was in the preceding shot. The report merely remarks, "Au 16^e (No. 9 of our Table) coup le chargement avait été fait dans de mauvaises conditions et la combustion de la poudre a été incomplète, ce que explique la faiblesse relative de la pression et de la vitesse." Nothing is said, however, as to the nature of the unfavourable conditions, or of the cause of the incomplete combustion of the powder. Such defects as these pointed out give rise to the opinion that the safe working limit of the gun had been exceeded, and that, therefore, no practical value is to be attached to the results obtained.

Let us now compare the results obtained with a 5.9-in. quick-firing Canet gun of 48 calibres long with those obtained with a 5.9-in. Krupp gun 40 calibres long. Particulars of the guns and tests are given in Table III.

The data as to the dimensions and weight of the Canet gun are taken from the "Revue d'Artillerie," vol. xxxv., page 86, whilst the firing data are an extract from a report on nine shots fired at the Sevran-Livry proving grounds in March, 1890, published in the thirty-sixth volume of the same journal, page 85. Referring to the table of dimensions, it will be seen that the Canet gun was nearly $\frac{3}{4}$ ton heavier than the Krupp gun, and its carriage is also $\frac{1}{4}$ ton heavier, so that taking the guns as mounted, the Krupp is the lighter by a full ton.

For the purpose of comparison two shots have been selected from those fired by each gun. The first pair of results were obtained under very similar conditions. The powder charge in each case weighed 28.7 lb., and the projectile 88.2 lb., but whilst the Canet gun gave a velocity of 2389 ft. per second, with a pressure of 13.71 tons in the chamber, the Krupp gun gave a velocity of 2684 ft. per second, with a pressure of 17.33 + .49 tons.

With 33 lb. of powder the Canet gun gave its maximum velocity of 2703 ft. per second, the pressure being 18.43 tons. This result was exceeded by the Krupp gun with a charge of but 29.3 lb. of powder, the pressure being 17.87 + .36 tons, and the velocity 2733 ft. per second. The work stored in the Krupp projectile, whether taken as a whole or referred to the several units as in Table IV., is the greater in both examples. At the muzzle the Canet gun would be capable of piercing a wrought-iron plate 18.39 in. thick in the one case and 22.09 in. thick in the other, whilst under the same conditions the Krupp gun could pierce a plate of 22.05 in. and 22.69 in. in thickness respectively. Besides its greater power of penetration, the Krupp gun, though 8 calibres shorter, also shows a materially higher efficiency per pound weight of gun.

As another example let us compare the 4.72 in. Canet siege gun, 26 calibres long, with the Krupp gun of the same calibre, 24 calibres long. The dimensions and weights are given in Table V.

The particulars as to dimensions of the Canet gun have been taken from the "Revue d'Artillerie," vol. xxxiv., page 559, and the firing data from vol. xxxvi., page 175, of the same journal.

The figures have been selected from those obtained at a series fired at the Hoc Polygon, twelve of which were fired with C_2 brown powder, one with C_2 black powder, and thirteen with C.N. powder, sample 155-1889. The black C_2 powder proved less satisfactory than the others. The best results obtained with the C_2 brown powder and with the C.N. powder have been selected for comparison with the Krupp gun.

The first pair of results shows that with the Canet gun a projectile weighing from 39.7 lb. to 42.3 lb. was given a muzzle velocity of 1687 ft. with a charge of 10.1 lb. of brown C_2 powder, the pressure on the chamber being 13.84 tons per square inch. The Krupp projectile weighing 44.1 lb. was given a velocity of 1640 ft. by a charge of 11 lb. of powder, the pressure being $14.17 + {}^{.23}_{.29}$ tons per squre inch. Both the total energy and the energy per pound per inch of circumference, and per square inch of section, are greater for the Krupp gun. (See Table VI.)

If now we compare the results obtained with B.N. and W.P.C. powders, it will be seen that the Krupp gun again shows to advantage, as it gives a velocity of 1943 ft. to a projectile weighing 44.1 lb. with a charge of 5.3 lb. of powder, and a pressure of $15.54 \pm {}^{.13}_{.26}$ tons per square inch. On the other hand, the Canet gun with 7.2 lb. of powder and a pressure of 10.23 to 12.2 tons, only gave its projectile a velocity of 1893 ft. per second, and the energy both total, and, as referred to the several units, is less than in the case of the Krupp gun. The experiments further show that the German smokeless powder is much more effective than the French.

Again, let us compare the 3.94-in Canet quick-firing gun with the Krupp 4.13-in. quick-firing gun. The dimensions of the two weapons are to be found in Table VII.

The data for the Canet gun are taken from the "Revue d'Artillerie," vol. xxxv., 1889-90, page 86; those for the Krupp gun from the "firing reports of Krupp's establishment," vol. lxxxii. The ballistic results for the Canet gun are extracted from a report published in the "Revue d'Artillerie," vol. xxxv., pages 560-563, on twenty-seven shots, fourteen of which were fired at Havre with brown "C_2 special" powder, and thirteen at Sevran-Livry with the new "B.N." powder. The shots selected for comparison were fired with same charges as the Krupp gun, but two others, representing the highest velocities obtained with the Canet gun, have been added. It should be noted that the Canet gun, though only 44.09 in. longer than the Krupp gun, weighs 1982 lb. more. The carriage too is 55 lb. heavier, and the total weight, all included of the Canet gun is 2040 lb. more than that of the Krupp. This excess of weight is of importance when the guns are intended for warship service. In spite of this greater weight the Canet is designed only for projectiles of 28.66 lb. weight, whilst the Krupp gun fires considerably heavier ones.

Comparing the results obtained with brown powder, as given in Table VIII., it will be seen that with a charge of 8.8 lb. and a pressure in the chamber of 14.17 tons per square inch, the Canet gun gave a velocity of 1825 ft. per second to a 28.7-lb. shell. With a charge of 11 lb. the velocity was 2063 ft., the pressure in the chamber being 20.27 tons per square inch.

The Krupp gun firing a heavier projectile of 39.7 lb. weight, gave it a velocity of 1640 ft. per second with 8.8 lb. of powder, and one of 1870 ft. per second with 9.9 lb. of powder; the gas pressure in the one case was $12.26 {+.17 \atop -.13}$ tons per square inch, and in the other 14.30 ± .52 tons. Hence, if the projectile had been of the same weight as that of the Canet gun, viz., 28.7 lb., the velocities would have been 1928 ft. and 2220 ft. per second respectively, or 103 ft. and 157 ft. per second in excess of the corresponding shots with the Canet gun. It will also be noticed that the energies, both total, and referred to the various units, are in every instance greater in the case of the Krupp gun, more particularly the energy per pound weight of gun, which is double that of the Canet projectile.

Considering the rounds fired with the B. N. and W. P. C./89 powders, it will be noted that the Canet projectile, weighing 28.7 lb. as before, attained a velocity of 1828 ft. per second, with a charge of 5.3 lb. of powder, the maximum pressure being 6.3 tons per square inch. When the charge was increased to 6.2 lb. the pressure was 8.46 tons per square inch, and the projectile attained a velocity of 1987 ft. per second. The Krupp projectile (35.3 lb.), though 6.6 lb. heavier, and fired with 5.2 lb. of powder, as compared with 5.3 lb. of powder in the case of the Canet gun, attained a velocity higher by 203 ft. per second, the powder pressure being 14.10 tons per square inch. When the weight of the projectile was reduced to 26.5 lb., and the gun fired with 5.9 lb. of W. P. C. powder, the initial velocity was 463 ft. greater than that of the corresponding shot from the Canet gun fired with 6.2 lb. of B. N. powder. The several energies of the Krupp gun are again greater than those of the Canet gun, and the energy per pound weight of the Krupp gun is once more double that of the Canet. Hence, generally, it appears from the data that the Krupp gun, with equal charges of powder, is superior to the Canet gun both in penetrative power and in efficiency. The small difference in calibre does not materially affect these conclusions. The greater penetrative power results from the greater energy per square inch of section. The four rounds in which the Krupp gun was fired with a 39.7-lb. projectile, show that in spite of the lower velocity, the gun has still a greater penetrative power than the Canet weapon fired with a lighter shell, this excess ranging from 2.3 to 5.2 per cent. When the Krupp gun was fired with a 35.3-lb. shell, the penetrative power was 28.7 per cent. greater than that of the Canet gun when fired with an equal charge. Finally, when the Krupp gun was fired with a light projectile of 26.5 lb. weight and the same charge as the Canet gun, the penetrative power was still 10.7 per cent. greater.

These results would be found even more favourable to the Krupp weapon if the target were placed at some distance from the muzzle of the gun, as the heavier projectiles used, retain their velocity better than the light ones adopted by Canet. The two shots in which the Canet gun gave its highest results are of no practical value, as the pressures in the chamber became excessive, reaching limits to which the material of the gun could not be repeatedly exposed.

It is, moreover, well established that of two projectiles arriving at a target with equal energies, the lighter one will perform the least useful work, in spite of its higher velocity, as when a certain limiting velocity is exceeded, only part of the energy is expended on the obstacle, whilst the remainder is devoted to smashing the projectile itself. Data as to the accuracy of aim and rapidity of fire of the Canet gun are missing, so that no comparison in this respect is possible, but we may note that twelve well-aimed shots can be fired by word of command from the Krupp gun per minute, which under other conditions can be increased to sixteen shots per minute.

Finally, if we compare the field guns of the two makers we shall find Krupp has still the advantage. Thus, takiug the first heavy field gun of 2.95 in. calibre and 32 calibres long, manufactured by Canet, and comparing it with a heavy field gun of the same calibre and 28 calibres long, we have the general results given in Table IX.

The dimensions of the Canet gun are quoted from the "Revue d'Artillerie," vol. xxxvi., page 559. The weight of the complete gun is strikingly high, viz., 5487 ℔., as compared with 3527 ℔. in the case of the Krupp gun. Even if it be assumed that this figure includes the five gunners, the weight of the Canet gun will still be 1130 ℔. heavier than the Krupp. Neither the number nor the nature of projectiles carried accounts for the difference in weights, since both weapons carry the same number, and those for the Krupp gun are slightly heavier. The ballistic data for the Canet gun (see Table X.) are taken from the "Revue d'Artillejie," vol. xxxv., page 564, where the results of ten rounds are tabulated, five of which were fired with a charge of 1.984 lb. of B. N. powder, sample B, and the remainder with the same type of powder, sample D. The round selected for comparison was the best of the series. An examination of the Table shows that: 1. The Canet gun when fired with a charge of 1.984 lb. of B. N. powder gives its projectile a velocity of 2030 ft. per second, the pressure in the bore reaching 16.01 tons per square inch. The Krupp gun, firing a projectile weighing 12.89 lb., gives it a velocity of 1863 ft. per second, with a charge of 1.289 lb. of powder and a powder pressure of 16.27 · $\frac{.30}{.35}$ tons per square inch. If the projectile had been of the same weight as that for the Canet gun the velocity would have been 1978 ft. per second. 2. To fairly estimate the comparative efficiencies of the weapons it is necessary to consider not only the ballistic data, but the weights of the guns. Taking the Canet gun, we find that the energy per pound weight of the Canet gun alone is 928 foot-pounds, or 392.3 foot-pounds per pound of gun as mounted. In the case of the Krupp gun these figures are 1018 and 416 foot-pounds respectively. Hence it appears that the Krupp 75-mm. field gun is considerably more efficient than the heavy Canet of the same calibre. As regards the ranges, accuracy and destructive powers of the two guns, no comparison can be made since the requisite data are lacking. The Canet common shell and shrapnel being of different weights, the results obtained with one shell are inapplicable to the other, and therefore two separate range tables are required.

Finally, let us compare the 2.95-in. mountain guns of the two makers. The dimensions of the weapons are as shown in Table XI.

The data for the Canet gun are taken from the "Revue d'Artillerie," vol. xxxiv., page 559, and vol. xxxv., page 564, the latter article giving the results of eight rounds, three of which were fired with B. N. powder, sample C, and five with B. N. powder, sample D. The one selected for comparison was the best of the series. Mountain guns are not usually supplied with a special mounting, as the gun, carriage wheels, &c., and ammunition is usually carried separately on mules, but the Canet gun is thus provided. The Ballistic Table XII. shows that the Canet gun gives to a projectile weighing 10.14 lb. a velocity of 1188 ft. per second, the charge being .661 lb. of B. N. powder, sample D, and the pressure in bore 8.59 tons per square inch. The energies, both total and referred to the different units, with the exception of that per pound of powder, are greater in the case of the Canet gun, but it would be a mistake to assert the superiority of the gun on these grounds. Its apparent advantages have been dearly purchased, as the limits prescribed by proper mountain gun practice have been passed, and the carriage is unsuitable for its work and would not stand the usage to which it would be subjected in practice. There is moreover a danger of tilting, and after a few rounds breakage would occur. The powers of gun when fired under normal conditions have not been published, nor are any data given as to accuracy of fire and destructive powers of the weapon. There is, therefore, no basis for any rational comparison of the two guns. As we stated last week at the commencement of this article, we confine ourselves to an actual reproduction of the criticism by the German author, and we await M. Canet's rejoinder to the various allegations against his system when compared with that of Krupp.

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BY A FRENCH ARTILLERIST.

In the October number (1891) of the *Internationale Revue* there appeared an article entitled "Uber Canet Kanonen." An exhaustive summary of this article appeared in Engineering under the dates of December 25 and January 1, last. It is evident that the article was inspired, if not written, in the offices of the works at Essen, and a tone of complaint runs through it that the Canet system of artillery has been too favourably criticised by certain French and English writers. Quite as a natural and justifiable consequence, the author of this German criticism shows in his turn a partiality which it is impossible not to recognise. It is not unlikely that the author of the present rejoinder may be open to the same criticism, but in answering the attack that has been made upon the Canet system, he proposes, as far as possible, to eliminate the personal element, and to answer categorically the criticisms made by the German writer, and to answer them in the same order in which they were set forth.

If the Société des Forges et Chantiers felt an unlimited satisfaction in the exhaustive publication made by Engineering of the Canet system of artillery—a publication suggested by the magnificent display made by them in the Pavilion of the Minister of War, during the Paris Exhibition of 1889—it is because they have had nothing to conceal, but, on the contrary everything to gain, by thus making known to the whole world the real value of their system, the excellence of the material they employ, and the practically perfect workmanship which characterizes all the artillery manufactured at Havre. While rendering to the famous establishment of Krupp all the praise which is so justly its due; while recognizing that it was the first practically to produce efficient steel guns; and that it has for many years entirely merited the high reputation which it enjoys; it is nevertheless desirable to suggest that it is not sufficient to affirm that the guns sent out from the works at Essen are the best guns in the world ; it is necessary to prove it. Younger and more modest workers in the science of artillery have been labouring quietly at the same problems for a number of years, and they have arrived at results superior to those which have been obtained by the German system of construction. Krupp no longer possesses a monopoly in the fabrication of artillery, or at least he realises that this monopoly must shortly terminate. If the Canet system had appeared to him without value, he would scarcely have taken the trouble to organise an elaborate attack on a series of types of such guns, establishing an unfavorable comparison one after another with his own. Until quite recently he professed to ignore the very existence of a French competitor ; to-day however, it would seem as if he feared him. It is worthy of note that Mr. Krupp no longer bases the alleged superiority of his guns upon the exceptional quality of the steel with which they were made ; probably he recognises the fact that in France—to say nothing of England—there are steel manufacturers who not only contend that the metal they produce is equal to the highest grades of Krupp steel, but who assert that it is far superior for the purpose of gun manufacture, especially for the higher calibres. To sum up these introductory remarks it may be safely assumed that Mr. Krupp no longer regards the gun factory of the Forges et Chantiers de la Mediterranée and the Canet system of artillery as a negligible quantity.

The author of the article in the *Internationale Revue*, under the veil of absolute good faith, and with the assumption of a desire to lay before the world a serious and a careful investigation, in which are ostentatiously given all the official sources from which he obtained the data he employs, shows in every line a far less active tendency to reproduce exact facts, than a preoccupation to present his figures in a light intended to divert his comparisons to the advantage of the Krupp guns. His data are often inaccurate or incomplete, and it is entirely insufficient for him to excuse himself by saying that the very small number of experiments which have been made, do not permit him to give other figures. Moreover, the comparisons established between the Krupp and the Canet material are based upon considerations which, examined independently, do not allow of any useful estimate being made of the real value of a gun, no matter what its system might be. The author takes as his *point de départ* the weight of the powder charge and its relative efficiency per pound of powder, or per pound of projectile, or per ton of gun ; establishing his comparison between guns of different lengths, and sometimes even of different calibres.

The reasoning which consists in saying the best gun is that in which we obtain the best utilisation of each pound of powder, or of each pound of metal, is correct, when the investigator takes into account all the conditions of employment and the most economical utilisation of the gun. He assumes, moreover, that it is a question of guns of the same calibre, or of the same length, firing powder charges of the same composition. But this reasoning cannot be applied to artillery in any absolute fashion. The desideratum would evidently be to have a gun as light as possible, and giving a maximum efficiency with a minimum of powder charge. Unfortunately there are a large number of varied considerations, and particularly those which relate to the carriages upon which guns have to be mounted ; to the practical manipulation of such guns ; to the limits of weight, &c. All these conditions render the realisation of an ideal gun impossible, and enforce in some cases the employment of a greater weight of steel than is theoretically necessary. Certain guns, for example those which are intended for service in turrets on board ship, are designedly made heavy to throw the weight towards the rear, and to diminish the diameter of the turret. The considerable reduction thus rendered possible in the weight of the armour-plating and in the machinery auxiliary to the gun, more than compensates for the comparatively slight addition of weight voluntarily introduced. In the same way with quick-firing guns. In order that the carriages may be easily handled ; that the man pointing the gun, and the others who serve it should be independent of each other in such a way as not to be interfered with ; and that these same men should be properly protected by shields, it is necessary to increase the weight of the gun towards the rear. Taking another class of artillery, that for land turrets, which should project as little as possible beyond the enclosing armour, and for siege and garrison guns, which should be easily transportable, there is a special necessity for reducing the length. But in such guns, in order to obtain the same initial velocity, it is necessary to fire heavy powder charges, so that in spite of the relative shortness of the bore, the same penetrating energy can be obtained as with the longer guns. In the first case considerable additional weight is designedly added, and the powder efficiency per pound of metal is reduced; in the second case the efficiency per pound of powder is also diminished. Under many conditions, therefore, it is found preferable to increase the weight of the gun in order to diminish the strains thrown upon the mountings.

Every artillerist is aware that the whole problem is much more complicated than the writer of the German article wishes to make out, but it is evident that he himself is none the less aware of its complexity. The best that can be done is to harmonise as far as possible the various conflicting elements, and in the actual condition of artillery practice, what is sought above all is to obtain with a sufficiently light gun that will remain in good serviceable condition, the maximum of efficiency without attributing too much importance to the weight of the charge, in reference to that of the gun itself. But as Mr. Krupp has not up to the present time manufactured any very long guns, the author of the review has compared relatively short pieces of his system with Canet guns of considerable length and consequently of greater weight. Moreover, the nature, the composition, and the density of the powders employed in the tests recorded, being very different, all the results obtained are falsified and are not comparable in any way. Lastly, it is of primary importance that the powders employed should produce the smallest possible amount of erosion in the bore. This result is obtained with the French smokeless powders. But according to the very detailed information which has been given on this subject, the Krupp factory has been unfortunate with the smokeless powder it has hitherto employed. The German powders, which cause a very rapid destruction to the bore of a gun, are not adapted for actual service; it is of small importance that their efficiency is very high, because the results they give are only theoretical, and are constantly of secondary value to the artillerist.

The German writer compares rounds fired with the same weight of charge, and consequently has to admit a much higher pressure in the Krupp than in the Canet guns; the latter being much longer in the bore, have their chambers specially designed for the employment of higher powder charges. From this it follows that such charges, which must be regarded as the maximum possible in the Krupp guns, are too small when they are fired from Canet guns. This initial error leads the writer of the article, for example, in contrasting a 30.5-cent. (12-in.) Krupp with a 32-cent. (12.6-in.) Canet, to compare a round fired with a charge of 179 kilos. (394.6 lb.) in the latter, with a round fired with 180 kilos. (396.8 lb.) in the former. From this it results that the pressure in the Krupp gun is 2370 kilos. per sq. cent. (15.05 tons per square inch), which is its normal pressure, whilst it is only 1510 kilos. (9.59 tons per square inch) in the Canet gun, which scarcely corresponds to the strain produced by a reduced charge. And further, a round from the Canet gun with a strain of 1153 kilos. per sq. cent. (7.32 tons per square inch), is compared with a round from the Krupp gun resulting in 2640 kilos. (16.76 tons per square inch) strain. In the comparisons of the 15-cent. (5.94-in.) quick-firing guns, we find a strain of 2090 kilos. (13.27 tons per square inch), for Canet; and of 2720 kilos. (17.27 tons per square inch), for Krupp. For the 10-cent. (3.94-in.) quick-firing gun, the strains are respectively 960 kilos. (6.1 tons per square inch), and 2150 kilos. (13.65 tons per square inch). No wonder that the initial velocities and the penetrating efficiency of the projectiles are less for the Canet than for the Krupp gun, under such conditions. Certainly no serious artillerist would allow himself to be deceived by such a manner of presenting facts. Nevertheless, it is useful to record things as they are, and to insist on figures passed over in silence by the German author, and for this reason it will be useful to give a number of data and some conclusions, the accuracy of which it would be certainly difficult to dispute.

When a comparison is to be established between two guns which are as nearly as possible fired under the same conditions, it is necessary to take, as a point of departure, not the weight of the charges, but the maximum pressures in the bore, and from these can be deduced the efficiency of each gun under conditions of normal fire. The gun which is the most powerful and has the flattest trajectory, is the best gun. Moreover, when a cannon which can resist very high pressures, and with maximum charges, gives very considerable velocities, it is interesting to record the results obtained even when the working pressures are exceeded, because such results show the efficiency possible under extreme conditions, and at the same time information is afforded as to the confidence which can be reposed in the gun if errors in loading are made which may result in setting up extreme pressures.

Taking first the Canet gun of 32-cent. (12.6-in.) and a Krupp gun of 30.5-cent. (12-in.). A certain weight of powder charge, which is excessive for a 30.5-cent. (12-in.) gun, may be relatively slight for one of 32-cent. (12.6-in.). And from this it results that the pressures in the Krupp gun are 2370, 2665 and 2640 kilos per sq. cent. (15.05, 16.92 and 16.76 tons per square inch), whilst with the Canet gun they are 1510, 2020, 1153 and 2545 kilos. (9.59, 12.82, 7.32 and 16.16 tons per square inch). In this case the comparison is drawn between rounds fired from the Krupp gun, which gave a pressure in excess of the normal working strain, and others from the Canet guns in which the charges only set up pressures that were absurdly small. Naturally, if a comparison is made between a Canet round with 1153 kilos. (7.32 tons per square inch) pressure and a Krupp round with 2640 kilos. (16.76 tons) pressure, it is not astonishing that the projectile from the former should give a smaller penetrating efficiency. In order to make the comparison a correct one it would be necessary to take the Krupp round fired with 200 kilos. (441 lb.) of brown powder, and giving 610 metres (2001 ft.) initial velocity, with 2665 kilos. (16.92 tons) of pressure. If the comparison had been made with the round fired from the Canet gun, with 255 kilos. (562 lb.), also of brown powder, giving 2545 kilos. (16.16 tons) of pressure, it would have been found that the efficiency per kilogramme of powder and per kilogramme of metal in the gun, as well as the penetrating energy, would have been very greatly superior in the Canet gun, as the following figures will show:

	Velocity.		Energy per Kilogramme and per Pound of Powder.		Energy per Kilogramme and per Pound of gun.		Penetration in Wrought Iron.	
	m·	ft.	m.-tons	ft.-tons.	kilo.-met.	ft.-lb.	cm.	in.
Krupp . . .	610	**2001**	43.15	**63.2**	138.2	453	97.9	**38.26**
Canet . . .	702	**2310**	43.43	**63.07**	171.7	563	114.2	**44.97**

This argument is absolutely correct, but is not sufficient of itself to prove the superiority of the Canet system, as has been already stated above. Nevertheless, this very simple comparison demonstrates that when the figures are rationally arranged, the balance remains largely in favour of the Canet gun. The German author states in a note that the weight of the gun, to which the published data referred, should not exceed 48.8 tons when compared with the projectile fired. If the round were not fired from the light type of gun, the reason was that the Krupp gunnery officers did not consider it prudent to expose this class of weapon to such high pressures as those indicated. Mr. Krupp intimates that the weight of his 30.5-cent. (12-in.) gun, 1886 model, is 56.85 tons; this may therefore be assumed as its standard weight. Now it is beyond dispute that these guns have experienced many serious failures; thus in the 12-in. cannon supplied to Russia for the armament of the ironclad Tchesma, it was found necessary to reduce the guaranteed initial velocity of 610 metres (2001 ft.) to 538 metres (1765 ft.), which corresponds to a dimunition of effective energy of about 2500 metric tons (8072 foot-tons), which is a very considerable amount; after all the powder chamber was enlarged, when the pressure exceeded 2250 atmospheres (14.29 tons per square inch). It is hardly probable that as a result of this somewhat disastrous experience, the Krupp Company will feel tempted to reduce the weight of their heavy guns. In any case, as the rounds fired refer to the gun of 62.650 tons, they ought only to be considered as an indication given by experiments on the trial ground, and not as data to be accepted in actual practice.

With a French smokeless powder, the 32-cent. (12.6-in.) Canet gun is able, with a pressure of 2553 kilos. per sq. cent. (16.21 tons per square inch), or less than that of the Krupp gun, 2640 kilos. (16.76 tons), to fire a projectile of 450.5 kilos. (994 lb.) with an initial velocity of 727 metres (2356 ft.) per second, as was proved by the experiments made in July last. This is a result which the author of the German article has overlooked. The striking energy was thus 12,149 metric tons (38,877 foot-tons), instead of 10,755 metric tons (34,416 foot-tons) in the Krupp gun, a difference of nearly 20 per cent. in favour of the former, and representing a penetrating energy of 120.3 cent. for Canet, as compared with 116 cent. for Krupp. This result is worked out by the formula of Jacob de Marre, which gives results most closely approximating to the Krupp formula. For the Canet gun the efficiencies per ton weight of metal are certainly higher than those for Krupp, reaching 181, as compared with 172.2, and this in spite of the fact that the former had to be made more than 6 tons heavier at the breech in order to reduce the diameter of the turret. For the German and French cocoa powders, the results given by which are fairly comparable, the efficiency figures indicated on Mr. Krupp's table are 43.34 for his own gun and 44.43 for the Canet gun, so that by his own showing the efficiency of the latter is notably superior. As regards the smokeless powders used in France and in Germany, the compositions being absolutely different, it is quite impossible to make any useful comparison, weight for weight, between the results obtained by them.

Continuing the comparison between the Canet 32-cent. (12.6-in.) and the Krupp 30.5-cent., we may carry the investigation a little farther and compare this Canet gun with the 112-ton Armstrong, and the 40-cent. (15.75-in.) Krupp guns, which are popularly considered as the two most powerful weapons in existence. We shall find that in assuming initial velocities of 655 metres (2148 ft.) for the first and 579 metres (1900 ft.) per second, the penetrating energies are as given on page 456.

It is true that in the Krupp and Armstrong guns the charge is of ordinary powder, but these guns are of relatively short length compared with their calibres, and the advantages to be

Comparison of Armstrong, Krupp, and Canet Guns.

	metres.	in.	metric tons per kilo.	foot-tons per lb.
Armstrong	1.20	47.2	159	232.9
Krupp	1.20	49.5	148.8	217.9
Canet	1.20	47.2	185	271.0

derived from very slow-burning powders are not to be obtained. The Canet gun weighs 66 tons; thus at half the weight and at a price less than half that of the Krupp and Armstrong guns, it possesses the same penetrating energy, and as the velocity of the projectile is much greater, the trajectory is flatter and the accuracy of firing is superior. It may be mentioned that the figures given in the *Yacht* have been preserved, these figures not having been challenged by the *Internationale Revue*. We are, therefore, justified in assuming that the 32-cent. Canet guns mounted on the three Japanese coastguard ships Matsushima, Itsukushima and Hashidate belong to one of the three types of the most powerful guns in any service. It should be added that when under test the Canet gun, without showing any traces of injury, resisted twenty-five rounds with maximum charges, while everybody interested in the subject knows the mishaps that were experienced with the monster Krupp guns that were supplied to Italy, the inner tubes of which were displaced and shifted forward whilst they were being tested.

The German author enlarges upon the alleged contradictions and incompleteness in the report of the firing experiments published by the "Revue d'Artillerie." Whatever imperfections there may be in the report of the firing trials made by the Forges et Chantiers, they are reproduced exactly as they were set down on the firing ground, and were in no way re-arranged in order to make them consecutive, a method followed by some makers of ordnance; the Forges et Chantiers always give the figures obtained just as they are read off from the various ballistic apparatus. The author is somewhat hyper-critical when he finds fault with a system which enables the breech of a 66-ton gun to be opened in twenty seconds, and that —so long as the normal pressure is not exceeded in the powder chamber—can be easily done by one man. At the firing tests of the 66-ton guns above referred to, this operation was performed by a Japanese officer, whose muscular power was far below that of the average European naval gunner. With a practised and strong man this period of twenty seconds is reduced to one-half that amount. With powder pressures ranging from 2600 kilos. to 2800 kilos. per square centimetre (16.5 to 17.8 tons per square inch), two men were required at the opening lever, an additional amount of power which does not call for adverse criticism.

One thing is very certain, that the large-calibre Krupp guns closed with a wedge cannot be opened so easily. In order to open the breech of such guns, when they are of large calibre, it is necessary to add to the turning lever a very long bar on which several men can exert their strength in order to start the massive steel wedge. It will be interesting to consider what happened to the guns of large calibre on this latter system, which were supplied to Russia, and to the 24-cent. (9.45-in.) Krupp guns furnished to the Japanese Government for the armament of the Japanese cruiser Unebi. During these trials, according to the report of the officers who assisted at them, the gas checks became almost entirely useless and caused considerable delay, as well as difficulty in manœuvring. With a 32-cent. (12.6-in.) Canet gun, on the other hand, the working of the gas check was perfect, although it was being tried for the first time. Mr. Krupp attempts to prove too much when he says that the pressure of 2545 kilos. (16.16 tons) per square inch has no influence on the easy working of his breech system, or on the quality of the metal he employs, All the foreign officers who have operated the Krupp gun maintain that when the pressure exceeds 2400 kilos. (15.24 tons) per square inch difficulty of working commences. As to the gun itself, there have been instances in which, when pressures in excess of 2250 kilos. (14.24 tons) per square inch had been reached, the metal itself began to fail much in the same manner as in the 12-in. guns delivered to Russia and referred to.* In the tests of the Canet gun, it is pointed out by the German writer that the results recorded for the sixteenth round did not at all agree with

* See Russian Official Report, 1887.

those for the preceding round. That is perfectly correct, and the reason is a very simple one. The round was fired with a new powder which required a special way of igniting, so arranged that the powder should be ignited under the best conditions. The powder had not been placed uniformly in the cartridge, with the result that there was a great irregularity of combustion in this round. It was in fact an entirely imperfect test, but it was not eliminated from the official report, because these exceptional conditions are always worth placing on record. At a series of trials made in July last all necessary precautions were taken, and with the same powder results of very remarkable regularity were obtained.

If Mr. Krupp has never experienced excessive and abnormal results on the trial ground he is certainly much to be congratulated, for he is the only artillerist to whom such good fortune has happened.

There is good reason to hope that in spite of "the uncertainties and the contradictions" contained in the firing reports, competent artillerists will not share the opinion of the *Internationale Revue* on the subject of the comparison between the Krupp and Canet guns, and they will prefer to be informed about the irregularities in firing, instead of having these irregularities carefully concealed. To the foregoing information about these 32-cent. guns are added in Table XIII. data on the trials made with the 27-cent. (10.63-in.) Canet guns, and during which with a projectile weighing 200 kilos. (441 lb.) a velocity of nearly 800 metres (2625 ft.) was obtained; these are the guns which have been built for arming the war-ships recently bought by the Grecian Government.

We now pass on to a consideration of the 15-cent. quick-firing guns; with regard to these the same general observations that have been already made, can also be applied. In criticising the 15-cent. (5.9-in.) guns, the German author compares a round fired with 13 kilos. (28.7 lb.) of B.N. powder, which has a different composition, with the 13-kilo. (28.7 lb.) charge fired from the Krupp gun. The pressure was 2090 kilos. per square centimetre (13.27 tons per square inch), in the former gun and 2700 kilos. (17.14 tons) in the Krupp gun; the velocities naturally were inferior in the former, but there being no similar conditions it was obviously impossible to establish any useful comparison. It is in this way that all the conclusions arrived at are misleading.

The velocities given by Mr. Krupp to the Canet guns are entirely inexact; the correct ones are recorded in Table XIV. Mr. Krupp taking for his guns the actual initial velocity, it is equally necessary to take for the Canet guns the speed at the muzzle calculated from the velocities at the screens. Moreover, the writer omits one round which gave, during some experiments made in 1890, at the Polygon of Sevran-Livry, an initial velocity of 878 metres (2880 ft.). This was the first time that such a high speed was obtained from a gun of so large a calibre. The pressure of 3300 kilos. per square centimetre (21 tons per square inch) is evidently too high to be admitted as a working pressure, but these rounds proved that the Canet guns were able to resist without any injury pressures greater than 3000 atmospheres; this was certainly a result worthy of being placed on record. The initial velocity of 833 metres (2733 ft.) mentioned by Mr. Krupp, was obtained with nearly a pressure of 2800 atmospheres, a strain which he admits to be inadmissible in service, especially for quick-firing guns. The same remark applies for the velocity of 818 metres (2634 ft.) obtained with a pressure of about 2700 kilos. per square centimetre (17.14 tons per square inch).

On the other hand, with a 12-cent. (4.72-in.) Canet gun 45 calibres in length, an initial velocity of 800 metres (2625 ft.) was obtained with the entirely practical pressure of 2350 kilos. (14.92 tons per square inch). The powder employed to produce this result was a B.N.G. powder similar to that used by Mr. Krupp. The efficiency of the powder under these conditions was, in spite of the comparatively low pressure, 152 metric tons (225 foot-tons per pound), an efficiency higher than anything obtained by Mr. Krupp. During a series of firing trials made in December, 1891, with a Canet gun of 15 cent. (5.90 in.) and 48 calibres in length, in which the B.N.G. powder was used, initial velocities were recorded of 825 metres (2706 ft.), with pressures of 2600 kilos. per square centimetre (16.51 tons per square inch), and 870 metres (2854 ft.) with pressures of 3000 kilos. (19.05 tons). This brought the efficiency per kilogramme of powder to 158 and 160 metric tons (231.4 and 234.3 foot-tons per pound), figures very largely in excess of the 106.4 and 104.9 (155.8 and 153.6 foot-tons per pound), so complacently indicated by Mr. Krupp. It will thus be seen, as in the case of the cocoa powders, that when the results obtained with smokeless powders are compared, the superiority so far as efficiency is concerned, is always in favour of the Canet guns.

With equal pressures the penetrating energy is also superior. It is worthy of note that in the "Revue d'Artillerie" for 1891, the article published from documents furnished by Mr. Krupp himself, does not contain figures anything like so large as those given in the *Internationale Revue.* Mr. Krupp does not include any rounds which gave pressures higher than from 2400 kilos. to 2500 kilos. (14.87 and 15.20 tons per square inch), which he rightly considers as the highest pressures that should be admitted in the service. In the table published on page 157 of the "Revue d'Artillerie," he only gives the volocities of 747, 716, 738 and 742 (2451 ft., 2346 ft., 2421 ft. and 2434 ft.) for the four calibres of 10.5 cent., 12 cent., 13 cent. and 15 cent. (4.13 in., 4.72 in., 5.11 in. and 5.90 in.), with projectiles of 12 kilos., 18 kilos., 23 .kilos. and 34.5 kilos. (26.45 lb., 39.7 lb., 50.7 lb. and 76.0 lb.) weight, which are much lighter than those fired from the Canet guns. Now with the latter 45 calibres in length, a speed of 800 metres (2625 ft.) is regularly obtained both for the 15-cent. and 12-cent. (5.9-in. and 4.72-in.) guns, so that their penetrating power is far higher than the similar calibres of Krupp.

Passing on to the criticism of the 10-cent. (3.94-in.) quick-firing guns (see Tables VIII. and XV.), it is neither reasonable nor practicable to select for comparison rounds fired with C_2 powders. This is a very quick-burning powder adapted especially for field artillery, and its experimental use with the Canet guns had only one object, to produce very high pressures economically in order to test the metallic cartridge cases used. Following his old line of argument, the author of the German article has been led, as has already been pointed out, to compare a round fired from the 10-cent. Canet quick-firing gun, at a pressure of 960 kilos. (6.09 tons per square inch), which is scarcely the pressure resulting from a reduced charge, with a Krupp round at 2150 kilos. (13.65 tons per square inch). A careful examination shows that at 2400 kilos. (15.24 tons) pressure the velocity obtained is 761 metres (2497 ft.) with a Canet gun, and 747 metres (2450 ft.) with a Krupp gun, with a lighter projectile, which represents a difference in penetrating efficiency of from 32.3 cent. to 27.9 cent. The author has forgotten to refer to a Canet round at 3000 kilos. (19.05 tons per square inch), which gave 814 metres (2670 ft.) of initial velocity. He also forgot to refer to the fact that in October, 1890, with this same 10-cent. (3.94-in.) gun a charge of 3 kilos. (6.61 lb.) of B.N.G. powder imparted to a projectile weighing 13 kilos. (28.66 lb.) a velocity of 843 metres (2765 ft.) with 2600 kilos. (16.51 tons) of pressure; in this case the striking energy was no less than 474 metric tons (1531 foot-tons). In this last-named instance the penetrating energy was 37.8 cent. (14.88 in.) with the Canet gun, whilst it did not exceed 27.9 cent. (10.98 in.) with the Krupp gun. It can be stated, without fear of contradiction, that all the experiments made with this class of guns of the Canet and Krupp types, show a penetrating efficiency 15 per cent. greater for the former than for the latter at normal pressure, whilst with an increase of pressure of 200 kilos. (1.27 tons) in the Canet gun, the increase in penetrating efficiency is no less than 27 per cent. The table given by the German author says nothing about penetration; it would appear from this curious omission that the results obtained were too unfavourable for the Krupp system to be recorded. The statements in ENGINEERING, therefore, which the author criticises, were absolutely justified, because experiments fully show that the Canet 10-cent. (3.94-in.) and 15-cent. (5.90-in.) guns attained penetrating efficiencies equal to about four times their calibres.

Compared with their calibres the Canet quick-firing guns are the most powerful weapons in existence; their efficiency per kilogramme of powder is no less than 158 metric tons (232 foot-tons per pound), a figure largely superior to the 133 metric tons (195 foot-tons per pound) obtained by Mr. Krupp with powders of the same composition. But the comparison of efficiencies so ingeniously established by the Krupp advocate, are fundamentally erroneous, as in the case of the 15-cent. (5.90-in.) gun, where a comparison is made between a weapon 48 calibres in length and another of 25 calibres. Taking these figures the efficiency per ton of metal will, of course, be higher in the case of the Krupp gun. But it may be again repeated that for all practical purposes the data set forth are not fairly comparable in any sense. It is difficult to understand a remark made by the German author on the subject of the efficiencies of light guns; when a gun is properly made and of the best material, it ought not to deteriorate with any fair amount of service; if such wear is more rapid with light guns than with the guns of a heavier type, as Mr. Krupp so emphatically asserts, why is he so anxious to emphasise the assertion that the guns made by himself are so much lighter than those made by M. Canet?

Next in order comes the 12-cent. (4.72-in.) garrison and siege gun. It will be seen from Tables VI. and XVI. that the rounds fired from the Krupp gun of this nature record pressures of about 2400 kilos. (15.24 tons per square inch), which is much too great for this class of material. The Canet gun gives the same velocity of 592 metres (1942 ft.), and almost an equal efficiency, without exceeding 1850 kilos. (11.75 tons) per square inch, or 25 per cent. less pressure than is thrown upon the Krupp gun. Comparison has, therefore, been established between rounds fired with excessive pressures and other rounds fired at a normal pressure, the former corresponding to strains that Mr. Krupp himself would not admit in regular service. Moreover, this question of penetrating energy is one of quite secondary importance for garrison and siege artillery. It is quite unnecessary to carry this part of the controversy any farther, because high initial velocities are not required for this class of material. But it would be quite easy to prove that with a charge of 3.5 kilos. (7.72 lb.) an initial velocity of 632 metres (2073 ft.) is attainable without exceeding a pressure of 2300 kilos. (14.60 tons), and that consequently the Canet guns of this class are more powerful than those of Krupp. It may, however, be remarked that the weight of the gun and carriage of the former maker is 3080 kilos. (6790 lb.), while that of the latter is 3120 kilos. (6878 lb.); this difference in weight is of course inconsiderable, but for a class of artillery in which facility of transport is a great desideratum, provided that it is not obtained at the cost of efficiency, even a small percentage of saving in weight is worth consideration. On all points, therefore, it has been clearly shown that the Canet garrison and siege guns are slightly superior to those made by Krupp.

In comparing the relative efficiencies of the 75-mm. (2.95 in.) field guns (see Table XVII.), the German author only publishes the results of a single round fired by the Krupp gun; this is a somewhat limited foundation upon which to rear a structure of adverse criticism, more especially as he laments so frequently the scarcity and incompleteness of the data available with regard to Canet. The initial velocity of 603 metres (1978 ft.) that Mr. Krupp sets forth as having been obtained with a Canet projectile, weighing 5.2 kilos. (11.46 lb.) and fired from one of his own field guns, is considerably less than the velocities of 619 and 624 metres (2031 ft. and 2046 ft.) obtained from a Canet gun firing precisely the same projectile; this velocity was raised to 659 metres (2162 ft.) per second in the case of a projectile weighing 4.6 kilos. (10.14 lb.). And it should be remarked further that the velocities of 619 and 624 metres (2031 ft. and 2046 ft.) given by the Canet gun, were obtained with a pressure of 2000 kilos. (12.70 tons) instead of the 2500 kilos. (15.87 tons) in the Krupp gun, a pressure absolutely inadmissible for field artillery. Again, we have a comparison between a round fired at normal pressure and another round fired at an excessive pressure, when probably it was desired to make a somewhat theatrical display of what the gun could do. If Canet field guns have not been fired under similar conditions, it is only because such showy experiments are absolutely without any interest to field artillery. To sum up this part of the subject, the Canet gun, with considerably less pressure, gave greatly increased velocities, and it may, therefore, be fairly considered as the more powerful weapon.

Occasion may be taken here to correct a slight error which, to some extent falsifies the efficiency calculations of Mr. Krupp. It is stated that the avant train weighs loaded 1640 kilos. (3615 lb.) instead of 640 kilos. (1411 lb.) or a difference of 1000 kilos. or 1 ton. This error was first made and afterwards corrected in the "Revue d'Artillerie" more than two years ago (see page 78 of Capitaine Veyrine's book on the Exhibition of 1889), but Mr. Krupp has not thought it necessary to adopt the correction; of course it is a mistake at once obvious to every one who possesses the slightest knowledge of the subject. As a matter of fact the total weight of the 75-mm. (2.95-in) field gun, with its carriage and avant train complete, is 1489 kilos. (3283 lb.) for Canet, and 1600 kilos. (3527 lb.) for Krupp. Recent modifications in the design of the material first named have enabled M. Canet to reduce the weight to 1360 kilos. (2998 lb.); therefore as this class of artillery stands to-day, it is much lighter as well as much more powerful than the Krupp guns of the same class.

As regards the 75-mm. (2.95-in.) mountain guns. The figures given in Table XVIII. show that the mountain guns on the Canet system are considerably more powerful than those of Krupp, although the firing strains in the former are nearly 300 kilos. (1.9 tons) less, or about 20 per cent., while the projectile is a heavier one. Moreover, the efficiency of the gun per pound of metal is greater, but this is a point of such secondary importance that it need not be dwelt upon. The total weight of the gun and its carriage is 240 kilos. (529 lb.) for Canet and 257 kilos. (566 lb.) for Krupp; as this class of gun has constantly to be transported on the backs of mules, such a considerable reduction in weight is no small advantage. The German writer is very ill-informed to have advanced the statement that the efficiency of the Canet gun with 362 metres (1189 ft.) of velocity is only a trial ground efficiency, since the gun is only fired with 1310 kilos. (8.32 tons) of pressure, instead of 1605 (10.16 tons), that is to say under more favourable conditions than the Krupp gun.

Before terminating this reply to German criticism, it may be of value to summarise a few of the principal points that have been brought out conspicuously in the course of the argument. It may be safely asserted that the wedge system for closing the breeches of guns is rapidly falling out of favour; every country, except Germany, has decided in favour of the screwed block. M. Canet has elaborated special systems for mechanically controlling heavy guns of large calibre, as well as quick-firing guns which have greatly increased the facility and the rapidity of firing and handling them. The various natures of Canet gun have been subjected to strains of 3000 kilos. per square centimetre (19.05 tons per square inch), and certain calibres have been tested up to 4000 kilos. (25.40 tons per square inch) without showing any signs of deterioration.

Mr. Krupp has not up to the present time reached this point. We have therefore here a first point determined, and we have very high guarantee of resistance, both as regards the quality of metal used in the French guns and in the system adopted for their construction. We have seen above that in the article of the German Review a line of argument is adopted which it is impossible to accept, taken by itself, as a basis of comparison. The results advanced by the author are still further falsified in the present case, as the experiments made by Mr. Krupp were experiments with short, and consequently light guns, from which heavy projectiles were fired, and a powder used which was quite of a different composition to the French powder.

The German author insists upon this point; that for equal power the Krupp guns are lighter than those of Canet. This assertion appears somewhat singular because, until recently, it has always been recognised that the Krupp guns were notoriously heavier than those of any other makers, calibres and length of bore, of course, being assumed as equal; their excessive weight was, indeed, constantly referred to as being one of the disadvantages of the system. As regards the weights given in the article published in the *Internationale Revue* there is nothing very surprising if they are lighter, for the Krupp guns are much shorter than those of Canet, and as a natural consequence they are much less powerful. Whether it is that the German maker has not had sufficient confidence in the metal which he uses, or whether it is that he cannot obtain sufficiently slow-burning powder, Mr. Krupp has only very recently commenced the manufacture of guns of which the length of bore is equal to 40 calibres, and this is a length which was, three or four years ago, largely exceeded in France.

M. Canet was the first engineer to take up seriously the question of constructing very long guns. It is an extremely difficult problem to solve, because it is of vital necessity to insure a sufficient degree of resistance in the gun, and at the same time to design a carriage on which such guns can be mounted, and on which they can be easily handled. One example may be quoted to illustrate the enormous advantages resulting from a great length of bore. Two Canet guns of 12-cent. (4.72-in.) calibre constructed for a Mexican cruiser Zarragoza, one of which had a length of 36 calibres and the other of 43, were tested at Havre. With charges of 6 kilos. (13.2 lb.) of the same powder, there were obtained without exceeding normal pressures, velocities of 744 metres (2441 ft.) and 787 metres (2582 ft.), or a difference of 43 metres (141 ft.) in the initial velocity imparted to the projectile which weighed 19 kilos. (42.2 lb.); and this increased efficiency was obtained by an addition of 7 calibres to the length of the gun. Put in other terms there was an increase in the penetrating power of the gun of from 3 cent. to 4 cent., and of about 65 metric tons (210 foot-tons) in the striking energy (see Table XIX). Does not this increase of efficiency more than compensate for the slight additional weight thus added to the gun? From these results one is permitted to draw the important conclusion, that from the point of view of efficiency in the gun of 36 calibres, the efficiency of the metal is superior. In the gun of 43 calibres the efficiency of the metal is inferior, but that of the powder increases; in spite of this reduction in the efficiency of the metal, the second gun as a weapon is far superior to that of the 36 calibres. Without changing the weight of the projectile or that of the powder charge, which is a great advantage on board ship; by the simple device of extending the length of bore a much more powerful type is produced; this is exactly the result at which artillerists wish to arrive, and the consideration of the efficiency per pound of steel has a very insignificant importance compared with the consideration of efficiency in service. If the former advantage was really of primary importance the ideal gun, according to the article in the *Internationale Revue*, would be the Canet mountain gun of 75 mm. (2.95 in.) bore, which gives 317.5 kilog. met. of efficiency per kilogramme of metal (465.1 foot-lb. per pound), whilst this does not exceed 250 kilog. met. per kilogramme (366.2 foot-lb. per pound) in the quick-firing 15-cent. (5.9-in.) gun, and 185 kilog. met. per kilogramme (271 foot-lb. per pound) in the heavy gun of 32 cent. (12.60 in.).

These facts bring out clearly the importance of an increase in length, and the advantages which can be obtained with suitable powder. It is to this latter point especially that the practical artillerist must look for progress and development, and the designs of guns must be made to accord with the physical properties of the new powders, which are becoming more and more perfect.

In the course of this discussion the writer has taken up a position entirely different to Mr. Krupp—that of maximum efficiency—which is the end towards which the efforts of all artillerists are directed.

The advantages to be derived from increased initial velocities are scarcely to be over-rated, if the result sought for is high power of penetration. With this end in view M. Canet has so far developed his practice that with a gun of 15 cent. (5.9 in.) calibre, and a projectile weighing 40 kilos. (88 lb.) fired with a velocity of about 880 metres (2887 ft.), the penetrating energy (60 cent.) is such that it will pieree a plate half as thick as that which can be traversed by the projectiles from the Armstrong or Krupp 100 and 120-ton guns; these monster weapons having a penetration of from 120 cent. (47.2 in.) and 126 cent. (49.5 in.). In the second place the increase in initial velocity allows the trajectory to be flattened, and the zone dangerous to the enemy considerably increased; this is an advantage which largely reduces the influence of errors inseparable from the estimation of distances, and consequent mistakes in training the gun. There is even an advantage in diminishing to a certain extent the weight of the projectile in order to increase its initial velocity. The Canet guns, thanks to the lighter shot which they fire, have always a flatter trajectory than that of the Krupp guns, and the handling of the charge is consequently easier. Mr. Krupp denied this principle totally, but he has at last so clearly recognised its importance that he has reduced in his new guns—notably in those for quick-firing—the weight of his projectiles which has been adapted, or nearly so, to that adopted by M. Canet. It is a matter of small importance whether, at very great distances, the remaining velocity, and in consequence the penetrating power, may be somewhat less with a light projectile, because this differ ence is sensible only at ranges so great that it is impossible to train a gun accurately, either at sea or for coast defence.

As to carriages, about which nothing was said by the German author, it is just to remember that we owe to M. Canet many arrangements which increase the facility of training; hydraulic brakes with central counter rods; turrets with central charging appliances, so that the gun can be loaded in any position, &c. A word may be added about the Canet quick-firing guns, which have been thoroughly tested. They give a regular service velocity of 800 metres (2625 ft.), without exceeding the normal pressures; they are so perfectly arranged that one man can train them; the breech is opened and closed by a simple movement of the lever; they can be fired, the 12-cent. (4.72-in.) gun at the rate of twelve rounds a minute, and the 15-cent. (5.9-in.) at the rate of ten rounds a minute. This system has been adopted in many countries, especially in Chili and Russia, and France has lately ordered a large number for the armament of her fleet.

Before concluding this reply it may perhaps be permissible to refer to the opening paragraphs of the German criticism, although they were not alluded to in the summary which appeared in ENGINEERING; they have however been somewhat freely commented on in other journals. The Forges et Chantiers de la Mediterranée commenced the construction of artillery at a time when Mr. Krupp and the Armstrong Company had already earned a high reputation, and had a well-established and very large clientèle. At that time and long afterwards all the foreign orders that were obtained by the Forges et Chantiers were only given as a result of very keen competition with these two famous and old-established factories. If, on many occasions, Canet guns have been preferred to the others, it is because these guns appear to offer surer guarantees, and because the numerous experiments that have been made proved beyond doubt the remarkable qualities which they possessed. It was only after a series of long comparative trials conducted with the greatest care that certain powers, not finding in the guns made by English constructors sufficient guarantees as regards strength, and renouncing on the other hand in a most absolute manner the system of breech-closing with the wedge, adopted guns of the Canet type.

TABLE IV.—BALLISTIC DATA O

Gun.	Nature of Powder.	Weight of Charge.		Weight of Projectile.		Muzzle Velocity.		Total.	
		kilos.	lb.	kilos.	lb.	m.	ft.	m. tons	ft. tons
Canet .	B.N	13	28.7	40	88.2	728*	2389	1080.5	3490
Krupp .	W.P.C. 89 (15/7.5) X. 90	13	28.7	40	88.2	818	2684	1364	4406
Canet .	B.N	15	33.0	40	88.2	824*	2703	1384.3	4407
Krupp .	W.P.C 89 (15/7.5) X. 90	13.3	29.3	40	88.2	833	2733	1415	4570

* These are initial velocities as calculated from the velocities at 65 m. The "Révue d'Artillerie" qu

TABLE VI.—BALLISTIC DATA OF C

Gun.	Nature of Powder.	Weight of Charge.		Weight of Projectile.		Muzzle Velocity.	
		kg.	lb.	kg.	lb.	m.	ft.
Canet . .	C_2 brown	4.6	10.1	18 to 19.2	39.7 to 42.3	514	168
Krupp . .	P.P C./82 H X. 89	5.0	11.0	20	44.1	500	164
Canet . .	B.N., Sample 155, 1889 .	3.25	7.2	18 to 19.2	39.7 to 42.3	577	189
Krupp . .	W.P C. 89 (6/3) IX.90 . .	2.44	5.3	20	44.1	592	194

F 5.9-IN. CANET AND KRUPP GUNS.

ENERGY OF PROJECTILE AT MUZZLE OF GUN.								Maximum Pressure.		Penetration in wrought-iron.	
Per centimetre and per inch of circumference of projectile.		Per centimetre and per square inch of cross-section of projectile.		Per kilogramme and per pound of powder.		Per kilogramme and per pound of weight of gun.					
m. tons	ft. tons.	m. tons	ft.-tons.	m. tons	ft.-tons.	kilog. met.	ft. lb.	atm.	tons per sq. in.	cm.	in.
22.93	188.03	6.11	127.27	83.1	121.72	168.8	553.5	2090	13.71	46.6	18.39
29.12	238.78	7.81	162.28	104.9	153.68	241.4	891.3	2645 ± 75	17.33 ± .49	56.0	22.05
29.37	240.9	7.83	163.1	92.3	135.20	216.3	709.3	2910	18.43	56.1	22.09
30.20	247.66	8.10	169.72	106.4	155.84	250.4	821.3	2725 ± 55	17.87 ± .36	57.5	22.64

otes these initial velocities as 740 m. and 838 m. respectively, or 12 and 14 metres too high.

ANET AND KRUPP 4.72-IN. SIEGE GUNS.

	ENERGY OF PROJECTILE AT MUZZLE OF GUN.										Maximum Pressure.	
	Total.		Per centimetre and per inch of circumference of projectile.		Per centimetre and per square inch of cross-section of projectile.		Per kilogramme and per pound of powder.		Per kilogramme and per pound of weight of gun.			
	m. tons	ft. tons	m. tons	ft. tons	m. tons	ft. tons	m. tons	ft. tons.	kilog. met.	ft. lb.	atm.	tons per square inch.
7	272.4	783	6.43	52.73	2.14	44.55	52.7	77.2	169.5	556	2110	13.84
ɔ	254.8	723	6.76	55.43	2.25	46.86	50.97	74.68	178.8	585.5	2160 +45 −50	14.17 +.33 −.29
ɩ	305.4	987.5	8.10	66.42	2.70	56.24	93.9	137.58	213.6	700.6	1860 1560	12.2 10.23
›	357.3	115.4	9.48	77.73	3.16	65.83	146.4	214.53	251.6	825.3	2370 +20 −40	15.52 +.13 −.26

TABLE XV.—PERFORMANCES OF KRUPP QUICK-FIRING 10.5-CENT. G

48 CAL

Nature of Powder.	Weight of Charge.		Weight of Projectile.		Initial Velocity.		ENE Total at the muzzle.		ENE Per kil of pow
	kilog.	lb.	kilog.	lb.	m.	ft.	m. tons	ft. tons	m. tons
							Krupp Quick-Firing Gun of 10		
P.P.C. /86/H/4/89 . . .	4	8.81	18	39.68	500	1641	229.4	739	65.53
Ditto	4.5	9.92	18	39.68	575	1887	303.3	977	67.41
W.P.C. /89. (5) K R /9/90	2.35	5.23	16	35.27	619	2031	312.5	1016	133.0
Ditto	2.7	5.95	12	26.45	747	2450	341.2	1100	126.4
							Canet Quick-Firing Gun of 1		
B.N.G., *h*	3	6.61	13	28.66	843	2770	474.4	1532	158.1
B.N., *b*	3.5	7.71	13	28.66	761	2500	386.2	1245	110.3
B.N. 1 *m*	3.5	7.71	13	28.66	744	2440	369.5	1190	105.6
Ditto	4	8.81	13	28.66	814	2670	442.3	1426	110.6

UNS OF 35 CALIBRES, AND CANET QUICK-FIRING 10-CENT. GUNS OF IBRES.

RGY.			PERFORATION AT THE MUZZLE THROUGH WROUGHT-IRON PLATE.						Maximum Pressure.	
gram'e vder.	Per ton of metal.		M. Krupp's Figures.		Formula of M. Krupp.		Formula of Jacob de Marre.			
ft. tons	m. tons	ft. tons	cent.	in.	cent.	in.	cent.	in.	kilog. per sq. cent.	lb. per sq. in.
.5 Centimetres and 35 Calibres.										
210	191.1	**615**	. . .	. . .	21.0	**8.26**	20.6	**8.11**	1870 $^{+26}_{-20}$	**26,500**
215	252.8	**812**	. . .	. . .	25.9	**10.23**	25.5	**10.03**	2180 ± 80	**31,000**
427	260.4	**850**	. . .	. . .	26.5	**10.43**	26.1	**10.43**	2150	**30,500**
405	284.4	**915**	. . .	. . .	28.3	**11.14**	27.9	**10.98**	2365 ± 15	**33,550**
0 Centimetres and 48 Calibres.										
510	243.3	**783**	. . .	. . .	38.5	**15.15**	37.8	**14.88**	2662	**37,500**
356	198.0	**637**	. . .	. . .	33.0	**12.99**	32.3	**12.60**	2338	**33,250**
340	189.5	**610**	. . .	. . .	32.0	**12.59**	31.2	**12.20**	1764	**25,200**
357	226.8	**730**	. . .	. . .	36.6	**14.41**	35.8	**14.09**	3092	**44,000**

TABLE XVIII.—PERFORMANCES OF CANET A

Nature of Powder.	Weight of Charge.		Weight of Projectile.		Initial Velocity.		ENE		
							Total at the muzzle.		Per ki of po
	kilog.	lb.	kilog.	lb.	m.	ft.	m. tons	ft. tons	m. tons
							Krupp Mountain Gun of 75		
W.P.C. /89 (2) VII. 90 .	0.214	0.470	4.3	9.48	356	1158	27.78	88.9	129.8
							Canet Mountain Gun of 75		
B.N.	0.3	0.661	4.6	10.14	368	1207	31.75	101.6	105.8

TABLE XIX.—EFFICIENCIES OF CANET 12-CEN

Nature of Powder.	Weight of charge.		Weight of projectile.		Initial velocity.		EN		
							Total at the muzzle.		P gr p
	kilog.	lb.	kilog.	lb.	m.	ft.	m. tons	ft. tons	m. to
							Canet Gun of 12 *Cent*		
B.N.1	6	13.2	21	46.3	709	2326	548.1	1754	91.3
Ditto	6	13.2	19	42.2	744	2441	546.5	1749	91.0
							Canet Gun of 12 *Cent*		
Ditto	5.5	12.1	21	46.3	707	2340	544.2	1741	98.
Ditto	5.8	12.8	21	46.3	732	2402	582.5	1864	100.
Ditto	6	13.2	21	46.3	745	2444	605.1	1936	100.
Ditto	6	13.2	19	42.2	787	2518	609.2	1949	101.

ND KRUPP 75-MILLIMETRE MOUNTAIN GUNS.

RGY.			PERFORATION AT THE MUZZLE THROUGH WROUGHT-IRON PLATE.						Maximum Pressure.	
ogram'e wder.	Per ton of metal.		M. Krupp's Figures.		Formula of M. Krupp.		Formula of Jacob deMarre.			
ft. tons	m. tons	ft. tons	cent.	in.	cent.	in.	cent.	in.	kilog. per sq. cent.	lb. per sq. in.
Millimetres and 13 *Calibres.*										
415.36	269.7	863.4	. . .	. . .	6.5	2.6	6.0	2.4	1605	22,839
Millimetres and 16 *Calibres.*										
338.56	317.5	1016	. . .	. . .	7.3	2.9	6.6	2.6	1354	19,267

Γ. GUNS, 36 CALIBRES AND 43 CALIBRES LONG.

ERGY.				PERFORATION AT THE MUZZLE THROUGH WROUGHT-IRON PLATE.						Maximum Pressure.	
er kilo- mme of owder.		Per ton of metal.		M. Krupp's Figures.		Formula of M. Krupp.		Formula of Jacob deMarre.			
ns	ft. tons	m. tons	ft. tons	cent.	in.	cent.	in.	cent.	in.	kilog. per sq. cent.	lb. per sq. in.
metres and 36 *Calibres.*											
5	291	193.7	620	. . .	. . .	34.2	13.7	34	13.6	2499	35,561
8	291	193.1	618	. . .	. . .	34.1	13.6	34	13.6	2571	36,565
metres and 48 *Calibres.*											
9	316	167.4	536	. . .	. . .	34.0	13.6	34	13.6	2440	34,721
4	321	179.2	573	. . .	. . .	35.8	14.3	36	14.4	2517	35,815
8	323	186.2	596	. . .	. . .	36.8	14.7	37	14.8	2499	35,561
5	325	187.4	600	. . .	. . .	37.0	14.8	37	14.8	2571	36,565

The journal the *Yacht* was absolutely correct when it stated that the quick-firing guns of the Canet system had been adopted by the Russian government. At the time when this statement was published the Russian Commission, the president of which was Captain de Brynk, and which was instructed to carry out comparative trials in France, in England, and in Germany, and later the Russian artillery committee unanimously recommended the Canet system. On August 22, 1891, the adoption of this system was officially and definitely decided upon, and all the quick-firing guns which will be used for arming the Russian fleet will be upon the Canet system. Consequently the Russian Government has entirely abandoned the wedge system of breech-closing for its quick-firing guns; and we are informed upon good authority that the same course will be adopted in the future for such guns of large calibre as it may require. This decision, taken by a power which until very recently has always been a warm partisan of the Krupp system, is one of the most conclusive proofs that can be advanced that the tendency to give a preference to French over German artillery becomes more marked every day. As to the purchase of two Armstrong guns by France, we know from the official statements made by the Minister of Marine that the only object of this purchase was to obtain specimens of these types of guns. The French Admiralty wishing to obtain information has, like the Russian Government, carried out experiments with the various systems, and was therefore, in the natural course of events led to acquire and to test these Armstrong guns; the result of the experience thus gained was the rejection of such types. On the other hand, the Canet guns, which were similarly tested, gave results which were most favourably reported upon by the Artillery Committee, and from this have followed many important orders for the armament of the French fleet. During the discussion in the Chambers on the French Admiralty budget, the superiority of these guns was asserted by the Minister of Marine. (Séance of December 9, 1891.) As regards Denmark, that Government has ordered from the Forges et Chantiers de la Mediterranée a battery of 15-cent. (5.9-in.) Canet guns, and while they are waiting for the first opportunity that may present itself entirely to abandon the wedge system, they assert with no doubtful voice their preference for the French method of breechloading. If some delay has occurred in filling the orders for the Chilian Government, it is due to the fact that with the consent of the Chilian Commission, certain important modifications were made in the plans, in order that the most improved results should be secured. The Chilian cruiser Presidente Pinto is now at Havre, and the installation of her Canet armament is complete. Owing to the prohibition that this armament should be completed on account of the political complications in Chili, the cruiser had, some months ago, to leave French waters without taking her guns on board; but this has nothing to do with any inability on the part of the Forges et Chantiers to supply them, as the guns were at that time ready.

The foregoing observations are sufficient to show that the author of the German article is not always very happy in his criticisms, nor very careful in his deductions. As to the statement that the gun factory of the Forges et Chantiers possesses only quite inferior means of production, every one who has visited these works and the magnificent firing grounds at Hoc, will know precisely what value to set upon this statement. It is unnecessary to insist further upon the means of production possessed by any establishment which has only been in active existence during a few years, and which besides having completed a very large number of coast-defence guns, of field, of mountain, and of siege and garrison guns, has furnished either completely or in part the armament of the following French and foreign ships: The Marceau, Pelayo, Achéron, Styx, Phlégéton, Cocyte, Hydra, Spetzia, Psara, Unébi, Matsushima, Itsukushima, Hashidate, Capitan Prat, Presidente Pinto, Presidente Errazuris, Toussaint-Louverture, Zarragoza, Bouvines, La Touche-Tréville, Jauréguiberry, Gangoute, Georgui, &c. P. M. V.

LY A GERMAN ARTILLERIST.*

In the number for October, 1891, of the *Internationale Revue* a comparison was made between the guns of the Krupp and Canet systems, which was reproduced almost literally in ENGINEERING. A reply followed, as might have been expected; and from its tone we may conclude that it originated from a very well-known French artillerist. The reasons which have induced me to take part in this discussion are of a purely technical nature arising from the great interest of the subject. An additional reason for my participation is afforded by the disclosures which the Commissaire of the French Government made in the Chamber of Deputies on December 9 last, which disclosures are not very flattering to M. Canet's prestige.

My comments upon the reply which appeared in *Le Yacht* have been published in the *Jahrbücher für die Deutsche Armee und Marine*. I shall feel obliged if you will open your columns for those remarks and permit me at the same time to add a few considerations raised by the reply, "Canet *v.* Krupp guns," of the "French Artillerist."

I may say at once that in dealing with my subject I do not intend to make use of the embellishments which the press, inspired by M. Canet, has been pleased to add on this and previous occasions. They compare unfavourably with the straight-forward language of artillerists and are probably intended mainly for readers of little technical training.

My remarks in the *Jahrbücher für die Deutsche Armee und Marine*, in reply to *Le Yacht*, are as follows:

1. The introduction to the comparison published in the *Internationale Revue* points to the *réclames* so complacently inserted in the French journals, that in consequence of a competition be-

* The following article is a rejoinder to the reply of "A French Artillerist," to the German criticism of Canet system of artillery. Both criticism and reply appeared recently in the columns of ENGINEERING.

tween Armstrong, Krupp, and Canet, several governments had given preference to the latter. In support of this inaccurate statement first advanced in *Le Yacht* of May 2, 1891, that journal now asserts that the alleged preference had been awarded, after careful inquiries had been made into the particulars of the ordnance systems mentioned. The orders given by Greece, Japan, and Chili are quoted in exemplification.

What was said in the *Internationale Revue* must be repeated again in this place.

It has been established beyond doubt and cannot be disputed, that the Canet guns were forced upon the Greek Navy by the Comptoir d'Escompte, which at the last moment made the signing of the contract concerning the loan of 99 million drachmas, dependent upon the *conditio sine quâ non* that the guns must be taken from this company, and Mr. Trikupis had to give in. So embarrassed did this statesman feel by these conditions that he withheld the agreement respecting the three ships and their armament for over a year, from the naval authorities, not even permitting it to pass through the control department of the Marine. The destination of the order was, therefore, settled quite apart from "Artillerist" considerations, and comparative experiments never entered into the question.

As regards Chili, it is true that Admiral Latorre, so often mentioned by M. Canet, invited tenders, for arming the ships to be built at the Forges et Chantiers, from Krupp and Armstrong, and then from Creusôt and Canet. The Chilian Government has published the whole of the correspondence. Comparative trials have, however, never been made. We may, therefore, also in this instance fairly question whether it was "artillerist" considerations that decided in favour of Canet. It seems reasonable to assume that for the same cause the guns were ordered from the works which supplied the ships—the Forges et Chantiers. One significant fact tends to prove the correctness of this assumption, and to refute the assertion that Canet guns were selected on account of the superiority of the screw-breech. Almost at the same time, the Chilian Government ordered, at Krupp's establishment, a number of coast-defence guns, and a few months later a large number of field and mountain guns with wedge-breech.

Japan adopted the screw-breech simply because the screwed block is more easily made than a large wedge block. Japan has for some years been trying to make her own guns, and soon discovered that the screw-breech system did not require such large masses of steel as the wedge-block system.

2. The "official adoption" by Russia of the Canet quick-firing guns has to be reduced to the order of *one* quick-firing coast gun, L/35, with carriage and projectiles. This order was made with the distinct understanding that in case of the adoption of the system, Russia would herself manufacture the guns required.

The order proves, therefore, not an "official adoption" of the Canet system, but only that the Russian Government watches and tests everything new in the matter of war material, and further, that Russia intends under all circumstances to have her ordnance made at home. It is remarkable that M. Canet persists in speaking of comparative trials previous to the adoption of the Canet system, although no such trials have been made. The negotiation for the supply of rifles for Russia was also a purely commercial question, and there remains, accordingly, hardly any doubt that the Russian Government was guided by political and financial, and not by technical motives.

3. The *Internationale Revue* stated that the Canet Works were unable to supply in less than one and three-quarter years, the 15 and 12-centimetre (6-in. and 4.8-in.) quick-firing guns for two cruisers ordered by the Chilian Government, which was then obliged to acquire the armament for one of the cruisers, from another firm. The author of the article in *Le Yacht*, in trying to explain this away, falls intentionally into a misunderstanding. It was the Presidente Errazuriz which had actually to leave France without armament. *Le Yacht*, however, speaks of the Presidente Pinto, whose armament should have been completed long before the political complications in Chili which led to the sequestration of the cruiser that was still lying in Havre.

4. *Le Yacht* further advances the opinion that though it may be attractive, and for certain classes of machines (engines for example) permissible, to base a comparison on the value of such engine on the efficiency per pound of weight, still in the case of

artillery, it is not admissible to do so, as was done in the *Internationale Revue.*

Certain guns, it is argued, such as those for service in turrets on board ship, are designedly made heavy to throw the weight towards the breech, and to diminish the diameter of the turret. Similarly in quick-firing guns, in order that the carriages may be easily handled, that the men may not disturb one another, and may be properly protected behind the shield, the weight of the gun is increased towards the breech. On the other hand the weight of garrison and siege guns is diminished by reducing the length, since these guns must be easily transportable. In the former case the efficiency per pound weight of the gun is necessarily diminished. These arguments are intended to explain the greater weight and smaller efficiency of the Canet guns. Such considerations receive their full importance from the constructors of the Krupp works; but they are confined to guns of smaller weight.

The superior efficiency of the Krupp guns is a part which the above arguments do not affect.

5. The journal *Le Yacht* then points out that the author of the article published in the *Internationale Revue* had compared the relatively short Krupp guns with long and heavier Canet guns, since Krupp, it is added, has not built any guns of great length. It is obvious that comparisons can only be made with guns actually in existence, of approximately the same calibre, and which, moreover, have been fully tested. If then the Krupp guns show better ballistic data in spite of a smaller length of bore, this is one more point in their favour.

It may be well here to refute the open and covert insinuations of M. Canet and his supporters in the press; to the effect that M. Canet had, in 1888 and 1889, led the way in constructing very long guns. The initiative is, on the contrary, due to Mr. Krupp, who, towards the end of the seventies, produced guns of 35 calibres in length, and in 1882 submitted some 50 calibres long and 8.7 cent. (3.5 in.) in diameter to public trial. These long bores, even the 35 calibre pieces, were in those days criticised as being dangerous. After some time it was recognised that Krupp was on the right road; and neither England nor France hesitated to follow suit. M. Canet, of whom the world had not then heard, started at once with 45 calibres. Whether or not credit be due here appears doubtful. The Russians, not very prone to extravagance in experimental ballistics, at any rate did not deem it advisable to go in for claptrap performances. When ordering a sample gun, they prescribed a length of 35 calibres, in spite of the corresponding reduction in velocity. The French Minister of Marine is evidently of a different opinion; in presenting his budget in December last, he spoke of initial velocities of 1000 m. and even 1100 m. (3280 ft. and 3610 ft). Krupp has himself supplied 40-calibre guns of the largest size since 1887.

6. The next objection is that results based upon experiments with different kinds of powders, are not comparable. Tests cannot possibly be conducted with the same powders for obvious reasons; and if they were, they would have minor importance only, since the purchaser, as a rule, will acquire both the gun and a suitable powder from the same source. If the efficiency of an ordnance system is to be established, the rounds must be fired with the powder which would be used in a serious engagement.

7. The French writer continues that, besides the utilisation of weight, the properties of the powder, its stability and action upon the metal, must be deciding points. According to him, the powder of French origin had given complete satisfaction, whilst disappointing reports had been heard about the Krupp powder. The firing reports published by the Krupp establishment, and the communications made concerning experiments with smokeless powder, will be a sufficient answer to these remarks.

8. In further continuation of this controversy, *Le Yacht* maintains that rational comparison between two guns should start from the maximum gas pressures in order to ascertain what the weapon would be able to do under normal conditions. The weapon realising the greatest striking energy with the flattest trajectory would be best. Against this it must be objected that there is no basis of normal conditions for shots fired with maximum gas pressures, and that hence any results obtained would only admit of practical conclusions so far as the powder is concerned. The limit of resistance is higher for the barrel of the gun than it would be for the breech and the obturator. The barrel may bear

a maximum gas pressure which would yet not be admissible on account of the breech. As a consequence the gun becomes difficult to charge, as is shown by the eighteenth round of the 32-cent. (12.6-in.) Canet gun, 40 calibres long.

In the case of maximum gas pressure and corresponding very high initial velocities, there arises the difficulty of the proper guiding of the projectiles, on which the accuracy of aim essentially depends. High initial velocity and the consequent flattening of the trajectory, attain practical importance only when they are combined with accuracy. The basis of comparison proposed by *Le Yacht* would thus lead to erroneous conclusions.

This view is shared by the English journal *The Engiueer*, of December 11, 1891, where it is said: "The Elswick firm complains about articles recently published in some journals, in which the efficiencies of English and French guns are compared in an unfair manner. The unfairness consists not in quoting false figures, but of speaking only of initial velocities. When we wish to ascertain whether a gun is a good embodiment of force, we can do no better than adopt Mr. Krupp's method, that is, divide the *vis viva* by the weight of the gun, so as to obtain the *vis viva* per ton or per kilogramme weight of gun."

9. *Le Yacht* concludes by discussing several of the comparative rounds of the *Internationale Revue* on the basis mentioned above. It would lead too far to enter into details. It is noteworthy, however, that the author, in order to illustrate the efficiency of the most recent 32-cent. (12.6-in.) Canet gun, 40 calibres long, elects for comparison a Krupp gun constructed ten yeare ago.

The author does not here remember that it is "serious" artillerists to whose judgment he has appealed. Any artillerist expert will grant that, considering the rapid development of the science of artillery, a comparison made with guns constructed after an interval of ten years, is both unfair and unreasonable.

10. To this rejoinder to *Le Yacht*, I wish to add a few words in reply to the French author of "Canet *v.* Krupp Guns."

The author criticises the data of the *Internationale Revue* in the same way as *Le Yacht* did, starting sometimes from maximum and sometimes from equal gas pressures. The difference in principle between this basis of comparison and that chosen by the *Internationale Revue* has sufficiently been explained under the foregoing paragraphs, 6 and 8. Any further discussion would be superfluous. In what follows I can only touch upon the chief points in the introduction and conclusion of the article "Canet *v.* Krupp Guns."

The introduction says: "It is worthy of note that Mr. Krupp no longer bases the alleged superiority of his guns upon the exceptional quality of the steel with which they are made." It is superfluous to dwell upon the value of this phrase. We should like, however, to point out to the author that he will have little luck with this move. For the very basis of comparison, against which he protests for obvious reasons, the determination of the efficiency per pound weight of gun resulting with approximately equal charges and projectiles of the same weight, establishes the superiority of the Krupp *materiel* in the most striking manner.

There is here an evasion of a matter of fact, and the reference to the alleged mishap to the 40-cent. (16-in.) gun which Krupp supplied to Italy is of a similar nature. The French author does not refrain on this occasion from deviating from the truth, when he states that the inner tubes were displaced and shifted forward. This sensational piece of news is simply an invention.

The author does not at all confine himself to technical matters, in spite of his emphatic reiterations to this effect. He says: "The report of the firing trials is reproduced exactly as they were set down on the firing ground, and in no way subjected to any subsequent corrections, as is done by some makers of ordnance." We will remark that the term "firing ground" needs a slight modification. M. Canet has no firing ground, but only butts, and he is hence not in a position either to determine accuracy of aim, or to try projectiles and fuzes in a decisive way. But it would be of great interest to learn more precisely, by whom such subsequent corrections of ballistic data are made. On one side, at any rate, no case of puffing of this kind has ever been known, as we can declare to the honour of an industry of universal importance.

With regard to the gas pressure of 3300 kilos. (21 tons per square inch) in one of the Canet rounds, the author remarks that though the pressure was evidently too high, it had at any rate, been proved that Canet guns were able to resist this pressure. My answer is that any gun of modern construction can do as much. There is, hence, nothing extraordinary in this performance, which, however, would not be admissible in actual warfare.

Most of the remarks of the "French Artillerist" are hardly relevant to the real issue, and they have only been taken up here to demonstrate that his polemics and petty digressions can hardly be characterised as *sine irâ et studio.*

M. Canet's own words, moreover, reduce the significance of such methods of argument to their intrinsic worth. When recently a foreign visitor to the Forges et Chantiers de la Mediterranée took exception, with praiseworthy thoroughness, to M. Canet's assertions, respecting the high initial velocities attained by himself, and would not rest satisfied with empty words, M. Canet notified that he does not recommend charges which would develop gas pressures of more than 2400 atmospheres (15.74 tons per square inch), because beyond that limit, considerable erosion would occur. Now this pressure of 2400 atmospheres (15.74 tons per square inch) would, in a gun of 45 calibres, produce an initial velocity of 700 metres (2300 ft.) approximately; whilst a velocity of 800 metres (2625 ft.) would require a pressure of about 3000 atmospheres (19.7 tons per square inch).

The "French Artillerist" concludes his remarks with the arguments in the introduction to the article in *Le Yacht.* The statement that the wedge system for closing the breeches of guns is rapidly falling out of favour, has already been dealt with.

The same applies to the assertion that Krupp had followed M. Canet's lead when producing ordnance of great length. We will assume, in favour of the author, that this assertion arises, not from a conscious disregard of the truth, but from ignorance of the actual facts. We can, however, not refrain from pointing out how little the long guns of M. Canet are appreciated even in France. The French author, with greater boldness than prudence, refers to the sitting of the Chamber of Deputies on December 9 of last year. During the discussions, the Director of Artillery, M. Du Pan, said literally, "I should not like to say anything which might be detrimental to the industries of the French nation, and I am, therefore, obliged to speak with great reserve. But it is certain that the Canet guns on the artillery grounds have not justified the expectations placed upon them. The guns have been improved and tested with smokeless powder. The results were very good, but not such as we desired. It is well to say so here, for the newspapers do not always give the full truth. In proof of this I may mention that the eight guns which the Forges et Chantiers de la Mediterranée will supply for the *Bouvines*, are not equal to those which had been made in May, 1891. A drawing has been placed before me. But my experience in these matters—I was for eight years director of the gun foundry in Ruelle—teaches me that far shorter guns than that of 60-calibre which M. Canet submitted, have bent to an extent that they could not be classed for service. Thus I have been obliged to explain to M. Canet: 'If you make your guns after the drawing submitted to me, there will be bending. You must alter them in order to avoid it.'"

The article proceeds with a renewed discussion of the high initial velocities and flatter trajectories of Canet guns.

This point has also been disposed of already. Fully to estimate the value of those advantages, we should need positive data as to the correlation between the guiding of the projectiles, accuracy of aim on the one hand, and the much-praised high initial velocities and flat trajectories on the other; such data are unfortunately missing.

The author then comes to the modern improvements in gun carriages, the impulse for which is said to have been given by M. Canet. Hydraulic brakes with conical brake-rods and central charging appliances for turret guns, are claimed as original inventions by M. Canet. This is not correct in several respects. Hydraulic brakes with conical brake-rods were employed by Krupp as early as 1879, previous therefore to M. Canet, and the central charging appliances originated in England.

In conclusion, the author returns to his old and already refuted dictum, that several States had given preference to the guns of M. Canet on the basis of comparative trials conducted in England, Germany, and France, and he then attempts, as does the article in *Le Yacht*, to palliate by subterfuge, the inferior faculty displayed by the Forges et Chantiers de la Mediterranée in arming the Chilian cruiser.

An independent reader of the two articles might admit that they came from an able pen, but they will hardly be able to inspire a serious artillerist with the convictions possessed, or perhaps only wished for, by "French Artillerist."

[REPRINTED FROM ENGINEERING, BY PERMISSION.]

BY A FRENCH ARTILLERIST.

The recent contribution of Mr. Krupp to ENGINEERING is for the most part a translation of the article that was published a short time since in the German magazine, the *Jahrbücher für die Deutsche Armee und Marine*. As it advanced but few new statements, and certainly brought to light no new facts in replying to the ENGINEERING article, I shall also be replying to that in the *Jahrbücher*.

The German writer assumes that he places himself upon a technical platform; now it will be seen at a glance that he does not reply to any of the arguments thrown into relief by my first answer to Mr. Krupp's strictures. His essay contains only vague affirmations of the class which we in France sometimes call *des potins*. In my original reply I placed myself entirely upon a basis of facts; and this is what I again propose to do in the remarks that follow.

The German author asserts that only very innocent artillerists can be caught by the arguments I set forth in my first reply. The number of such innocent artillerists must certainly be very great, or Mr. Krupp would not feel that there is a real necessity for again attacking the Canet system, and for reproducing many of the same arguments which, it now appears, were not so convincing on the former occasion as he had expected them to be. It is more reasonable to suppose that the really innocent artillerists are those who, for so many years, have been contented to accept everything that came out of Essen; who have taken for granted, and without confirmation, the statements made by the German manufacturers, and who have not even insisted on the right of proving the truth of those statements, nor of thoroughly inspecting the war material ordered at Essen while it was in course of construction. Whatever else may be the value of this discussion, it will have the good effect of awakening new ideas and of bringing to light precise facts; it will help to remove in some measure the veil of mystery that has too long been thrown over the practice of the modern gunmaker; it may very likely dispel some illusions; and at all events it will keep in public notice one of the most interesting and important industries on which the security of nations is supposed so largely to depend.

Le Yacht is not a journal open to pecuniary conviction (*un journal de réclame*); it is the best recognised organ in France for the discussion of marine questions; it, as little as any paper published in Europe, has the habit of stating as facts those things that cannot be absolutely proved. The German publication *Jahrbücher für die Deutsche Armee und Marine*, in its issue of last February takes up the theme of the *Internationale Revue* (see its number for October, 1891), and casts discredit on the statements made in *Le Yacht* of December, 1891. The author, to some extent, plays with the meaning of words, and he entirely distorts the character of certain negotiations. We will reply to him, not by explanation nor by corrections, but in facts. The writer in the *Jahrbücher* accuses *Le Yacht* of maintaining a theme based on falsehood, when pretending that preference had been given to the Canet system in Greece, in Chili, in Japan, and in many other countries, and that this preference was the result of a series of long and careful comparative trials made between guns of French and guns of German construction.

Of course, no one would suppose that these trials had been made with the guns placed side by side in the same polygon; those would be impossible experiments, impossible, at all events, for cannon of large calibre. What actually took place was that various committees, after having studied the proposals submitted by the manufacturers, and after having followed with care and on several occasions, experiments carried out at Essen, at Elswick, and at Havre, reported in favour of the Canet system, because they were convinced that it offered more powerful guns, a better system of breechclosing, carriages and mountings possessing many special advantages, and other points of superiority. It is scarcely probable that the greater number of those countries which, up to the date of this committee, had placed their orders with Krupp, would, out of caprice or for some eqally light motive, undertake so serious a matter as the complete change of their armament.

The German author ascribes the orders for Canet guns given by Chili, to the fact that the ships being constructed by the Société des Forges et Chantiers de la Mediterranée "it appeared more convenient to order the artillery from the same firm." This explanation is absolutely correct, but by advancing it Mr. Krupp condemns himself. It is an old truth, well recognised by technical people, that in the actual development of naval artillery, the ships for which the guns are built are in one sense only floating carriages; the ship and its guns should be made one for the other, and each with special reference to the other. It is in this fact, more, perhaps, than in any other, that lies the undoubted superiority of the two great naval and military establishments, the only two in the world that can deliver a war vessel complete with its armament—that of Armstrong in England, and that of the Forges et Chantiers de la Mediterranée in France. In this important respect, Mr. Krupp finds himself in so unfortunate a position that it would be sufficient to account for a nearly entire cessation of foreign orders for heavy naval guns. It is only reasonable to assume that engineers who are thoroughly *au courant* of the requirements of naval ordnance, are more likely to produce weapons that fill all the necessary requirements. And, perhaps, herein lies the reason why the Krupp establishment designs its naval carriages on the same heavy and inconvenient lines, which may be excusable or even desirable on land, but which are wholly inadmissible on board ship. Such material for the marine is obsolete, and it was simply because the Canet system for naval guns and carriages represented the most advanced type, best adapted for modern warfare, that they were adopted for the three Greek ironclads. The guns proposed by the Krupp factory were less powerful than those of Canet; they occupied more space in the ironclad redoubt, and this involved an increase in the displacement of the vessels, and consequently an increase in their cost. As to the intervention of the Comptoir d'Escompte in the affair of the Greek ships, nothing could be more natural or necessary, whenever it happens that a financial establishment acts as the intermediary between a manufacturing company that requires to be paid in gold, and a Government which prefers, on account of financial questions only, to pay in paper, or on the receipt of certain taxes. But the Essen factory shows bad taste in complaining of the purely financial assistance given by a French banking establishment to a great French industry, when such very different means were employed at Essen. The agents of Mr. Krupp, when these contracts were still in the market, went to Greece, as well as to other countries, in the name of Prince Bismarck, and a certain president of a foreign commission was summoned to Berlin, where Prince Bismarck informed him that if the order for ships and guns which was about to be made, was not given to Germany, that country would not renew the commercial treaties which would shortly lapse. But even this did not avail, and the order was after all given to the Forges et Chantiers de la Mediterranée. Everybody *au courant* of this question knows how much pressure German diplomacy always tries to bring in favour of German manufacturers, especially for orders to be executed for European powers. We may add that there was nothing astonishing in Chili having ordered coast-defense guns as well as field artillery from Mr. Krupp, because the order came from the Minister of War, and contrary to what had been done by the Admiralty Department, the War Department had not nominated any commission to examine for themselves French war material; if this had been done it is not by any means clear that Essen would have obtained the order. As for Japan, it should be mentioned that up to the present time this country has only manufactured a very small number of cast-iron guns, and those of moderate dimensions; all her heavy guns have been ordered either in France or in England, and the screw block is invariably used for closing the breech.

Mr. Krupp always finds excellent diplomatic or financial reasons to explain how it is that almost every country has abandoned the wedge for the screw system; the causes are much simpler than he would have us believe, and they are purely technical. However that might be, one fact is certain; Greece and Chili, Japan and Brazil, Sweden, Servia, &c., to say nothing of England and the United States, are unanimous in their condemnation of the Krupp system of breechclosing. An eminent artillery officer said to the writer a short time since, "There is an irresistible tendency towards the screw system, and a corresponding abandonment of the wedge system." That is the fact. Now this is more significant than appears on the surface, because for those countries which have armed themselves with Krupp breechloading guns, a very serious cost must be incurred in making the desired change for the better. It must be admitted that if French artillerists are, according to Mr. Krupp, wholly of no account, the French diplomatists and financiers are, on the other hand, unusually clever.

Mr. Krupp has been very badly informed on the subject of the orders given to the Forges et Chantiers by Russia. The War Department of that country ordered a 6-in. gun of 50 calibres, and not one of 35 calibres, for coast defense. As to the adoption of the Canet quick-firing guns by the Russian Naval Department, a fact which Mr. Krupp persists in denying, to put an end once for all to further discussion of this point, the writer appends translations of the letters written by Monsieur le Commandant Rimsky-Korsakoff, Russian naval attaché, and by Admiral Popoff, announcing the adoption of the Canet system and the intention of the Russian Government to construct this class of gun in Russia.

Naval Attaché at the Russian Embassy, 6, Rue Marbeuf,
Paris, June 8, 1891.

Sir, I have the honour to inclose you herewith the textual translation of the order from the Minister of the Imperial Russian Navy, which I have just received.

I am happy to inform you, that your systems of quick-firing gun and carriage have been recognised as superior to those of other manufacturers, and I beg you to be good enough to send me, with the least possible delay, the reply asked for by the Minister of the Imperial Navy.

(Signed) COMMANDANT RIMSKY-KORSAKOFF.

Monsieur Canet, Directeur de l'Artillerie,
Société des Forges et Chantiers de la Mediterranée, 3, Rue Vignon.

Ministère de la Marine, Bureau Central de Construction et d'Armement,
May 22—June 2, 1891. No. 4832.

To the Naval Attaché in France.

Sir,—The Technical Committee, after having examined the report of the commission of artillery officers of marine, which was instructed to visit the different establishments, to study the best system of quick-firing gun, has made its selection in that of the Canet type . . .

The General Direction, therefore, requests you to communicate to M. Canet the decision taken by His Excellency the Minister, and if M. Canet consents to send to the Russian Government the detailed drawings and the models of these guns, with the right of allowing them to be manufactured in Russia . . . You will request him to make known in writing his conditions, &c. . . . The Direction requests you to communicate the reply of M. Canet as soon as possible in order that the Direction may make a report to His Excellency the Minister of Marine. (Signed) VICE-ADMIRAL POPOFF.
COLONEL KONOTOKIN.

The convention was definitely concluded on August 22, 1891. As Russia wished to manufacture the gun herself, she requested the Société des Forges et Chantiers to furnish the department with working and shop drawings, specifications for the reception of steel and other material, plans and model of breech mechanism, full size, templates, &c. As for the turrets and carriages, the Canet system has also been fully adopted, and these are being constructed in the Russian Government factories, with which the Forges et Chantiers have made suitable arrangements. It will thus be seen that there is no question of preliminary arrangements. The letter of Admiral Popoff reduces to their actual nothingness the allegations of Mr. Krupp, who pretends that there was never anything like a competition between the different systems of quick-firing guns; that there were no technical reasons to assist the decision of the Russian Government; and that there was no adoption of the Canet system. And we cordially request Mr. Krupp to pay a visit in a year or two to Russia, and to go on board some of the new Russian ships—such as the Gangoute, the Georgui, the Trois Eveques—and let him satisfy himself if the turrets and the quick-firing armament on these vessels are on the Krupp or on the Canet system.

As regards the new Russian rifle, the writer of the German article wishes it to be believed that negotiations with French makers have only reached the preliminary stage, when it is quite an open secret that these guns are actually in course of manufacture at the Chatellerault factory, the French Government having placed its facilities of production at the disposal of a friendly power. The assertions of Mr. Krupp certainly do no credit to his Secret Intelligence Department. He is equally ill-informed on the subject of the Chilian warships. Chili applied to only one firm for the armament of these ships—the Forges et Chantiers. The Presidente Errazuris left a French port armed with Canet quick-firing guns. The ship was at Buenos Ayres at the commencement of November last, and at Valparaiso on December 22, 1891. According to the report of the officers who went on board when the ship arrived at Chili, "the artillery is admirable." As to the Pinto, this ship is not waiting for its armament, which was placed on board some time since. The trials of this artillery were made in February last, and gave very excellent results; they were described in *Le Yacht* in its issue of March 5 last. From one of her 12-cent. (4.72-in.) guns there were fired (on board, and not in a polygon) ten rounds in 54 seconds. This was done in the presence of the Chilian Commission, presided over by Commandant Valenzuela Day; there were also present Commandant Artigas, Commandant Perez, of the Chilian Navy, Admiral Ménard, of the French Navy, and MM. Clemenceau, de la Ferronays, Menard-Dorian, members of Parliament. The Pinto is now waiting at Havre for her crew, which has not yet arrived from Chili, and until her equipment in this respect is thoroughly complete, she will remain in the French port. Such are the facts, as compared with the legend. We regret that we have been drawn upon this ground, and to have been obliged to apply to non-technical attacks, because doing so of necessity reduces the interest of this discussion, attacks formulated by Mr. Krupp who has this time been rather unfortunately inspired. The ground, however, is now cleared of these points, entirely unworthy of a great establishment which during so many years had either no rivals or affected to despise them.

There is no occasion to discuss indefinitely the question of efficiency. The clear and precise explanation published in *Le Yacht* and in ENGINEERING ought to be sufficient. Efficiency is necessary and indispensable in order to compare two guns placed under conditions of service which are nearly identical. But no really serious artillerist would admit that this should be the one critical point for deciding the value of different guns designed and constructed with totally different ideas, especially if the comparison is made as the *Internationale Revue* has made it, between rounds of 1000 kilos. (6.35 tons per square inch) of pressure, and rounds of 2600 kilos. (16.51 tons per square inch). Whenever a comparison is made between a short and a long gun, the former gives a higher efficiency per ton of metal. But when the comparison is made between Canet and Krupp guns of the same relative powers, and under similar conditions, this comparison is invariably to the advantage of Canet, as the Tables published in ENGINEERING have shown.

It is admitted that Mr. Krupp has not shown sufficient care in the design of his heavy gun mountings, from a naval point of view, and the defective distribution of the weight of the gun must be considered as being the principal cause. Moreover, he has not succeeded, after twenty years of experience, in making his wedge system of breechclosing a success.

The quick-firing Canet guns are manœuvred and loaded with much greater facility than the Krupp guns. The field and siege artillery of Canet is much more easily handled and is lighter than that of Krupp. They are more powerful and can resist much heavier pressures. What more can be desired? and of what possible importance can be the question of efficiency per pound of powder or per hundred-weight of metal? These are details interesting enough for the firing ground, but of no importance in service, and it can be only supposed that the *Internationale Revue* has introduced them with the object of drawing a red herring across the trail as it were, and so diverting attention from the real points at issue. In any engagement victory will remain, not with guns that show the highest efficiency per pound weight of gun, but with those that are the most powerful and the most easily handled. Those are the main objects to be aimed at in the successful construction of artillery.

It is not true that the Krupp guns, although shorter, give better results; the Tables published by ENGINEERING prove that the Canet guns are always the more powerful. Mr. Krupp states that he has designed guns of 8.7-cent. (3.43-in.) calibre, and of 50 calibres in length. Why has he not continued in this line of construction? It is most probably because he quickly found himself face to face with practical difficulties which he did not know how to overcome. At the present time he does not propose to exceed a length of 35 calibres; therefore it is fair to assume that his 50-calibre gun of 8.7-cent. (3.43-in.) calibre is not a success. Remaining always on the firm foundation of facts, it is indisputable that in 1888 M. Canet commenced the manufacture of three guns of 32-cent. (12.6-in.) calibre, and of 40 calibres length, which are actually the most powerful weapons in existence, and which under severe test showed no deflection, whilst the British guns of the Benbow did deflect, and the 11-in. guns on the Krupp system, 35 calibres long, constructed for the coast defence of Russia, bent from 1/8 in. to 1/2 in.; that is if we are to believe the official reports of the Russian artillery officers. The Canet guns of 10-cent., 12-cent., and 15-cent. (3.94-in., 4.72-in., and 5.9-in.) calibre, and 48 calibres in length, and which have given an initial velocity of 880 metres (2888 ft.) per second, have been fired up to a pressure of 4000 kilos. (25.4 tons) per square inch, can be used with safety in regular service up to a velocity of 800 metres (2625 ft.) per second, and do not show the slightest sign of deflection. The Russian Government, contrary to Mr. Krupp's belief, have adopted these long guns, and they have chosen for the normal types for naval purposes, Canet guns of 45, 50, and actually 80 calibres in length. In fact Russia objects so little to this long type, that she has ordered from M. Canet a model coast-defense gun of 6 in. in diameter and 50 calibres in length. In the countries where these very long guns are abused, it is because the manufacturers who have tried to make them have only met with failure. M. Canet has constructed a system following entirely a new order of ideas, based upon theory, experiment, and experience, and he has succeeded where others have failed. That is another fact for Mr. Krupp.

All the trials of which the results have been given in the *Yacht* for the Canet guns, have been obtained with powder of ordinary manufacture, powder which can be relied upon in all respects, and which causes far less erosion in the bore than any black or chocolate powders. The powders manufactured and used in Germany give high velocities and considerable efficiency; but they keep very badly. And this point is one of very great importance when such powders are employed for ammunition on board ship, where the magazines are frequently kept at a high temperature. The polygon results obtained with these powders cannot therefore be admitted as practical. The only reliable data are those obtained with a powder which can be relied upon for its stability and its keeping qualities, and which does not produce any serious erosion in the bore of a gun. The French powders fulfil these conditions.

As regards maximum pressures, Mr. Krupp permits himself to play upon words; in service, pressures of from 2800 to 3000 atmospheres are not permissible. It is the case that guns should not be fired in service with pressures exceeding 2400 to 2600 atmospheres, because above these, difficulties in working the breech mechanisms arise. But is it certain that every Krupp gun can resist such pressures as these? The 11-in. cannon supplied to Russia showed an enlargement of the bore at pressures exceeding 2250 atmospheres. As we have already proved, the Canet guns can resist testing pressures of 3000 and even 4000 atmospheres. Their power is superior to those of Krupp, as has been clearly proved by the data published in ENGINEERING. This is another unkind truth.

As to the basis of comparisons between the different guns selected in the reply of a "French Artillerist," published in ENGINEERING, in which the identical conditions of loading gave pressures practically identical, this comparison was absolutely justifiable. All serious artillerists would admit this, and even the German author does not dare to dispute it. M. Canet is reproached with attaching too much importance to the question of initial velocity. For field artillery this point is one only of relative importance; but it is a very different matter with coast defense and with naval ordnance. Admitting that all conditions are at hand to insure the stability of the projectile upon its line of trajectory, it is the great factor on account of the flatness which it gives to that trajectory, and to the consequent increase of the dangerous zone and the increased precision which results from this, This is so evident that the efforts of all artillerists are directed to increase this velocity by every possible means. At the Elswick gun factory, as at the Krupp works, medium velocities continue to be the rule, because at neither of these establishments are very long guns manufactured. Elswick appears to shrink before this type of weapon, because the outline of the bore is defective, as the not infrequent accidents which guns made by Armstrong have amply demonstrated. But sooner or later both these establishments will be obliged to follow the true path of progress. Mr. Krupp, who has always advocated the use of heavy projectiles, at present is actually diminishing the weight of his shells in a very marked degree; he therefore recognises the high importance of great initial velocity. M. Canet long since realised that the practice of the future must be in the direction of long guns. His system of artillery has been consistently designed with this view, and results have entirely justified his theory, which at the present time does not want imitators.

It is true that the Canet gun of 32 cent. (12.6 in.) cannot be exactly compared with the Krupp 120-ton gun, because such a comparison would be simply disastrous. The only object of the comparison was to prove that with a gun of one-half the weight it is possible to obtain an efficiency equal to that of this monstrous and unwieldy weapon. But if we compare it with the 30.5-cent. (12.01-in) gun which Mr. Krupp parades as the most formidable he has yet been able to produce, the comparison is still more in favour of M. Canet. With the same weight of projectile and with considerably lower pressures, it gives a penetrating power which is much higher. For equal penetration, the pressure in the Krupp gun is 2640 kilos. (16.76 tons) per square inch, and in the Canet gun is 2421 kilos. (15.36 tons) per square inch. The round fired from the German gun, in which this pressure was recorded, cannot be regarded as a normal round. We state this to bring us back to the ground from which Mr. Krupp appears so desirous of withdrawing us.

In order to follow the mode of discussion adopted by the German writer, we may here add a few words in reply to what was said in ENGINEERING, at the conclusion of the translation of the article from the *Jahrbücher*. The paragraphs 6 and 8 (see page 475 *ante*) do not contain any answer to the various points dwelt on by "A French Artillerist," on the question of efficiency; but the basis on which these points rested remains none the less correct and unassailable. If the consideration of efficiency takes precedence of everything else, the wire gun of Mr. Longridge must certainly be adopted, because it combines with great lightness a high degree of transverse strength. But there are many other points to which the serious artillerist has to direct his attention, and which prevent him from following blindly in this path. For example, the want of longitudinal strength and the fact that the breech of a gun ought not to be exposed in practice to strains exceeding 2400 or 2600 atmospheres. In regard to the quality of steel, I can only repeat what has already been said. In France all tests are made by controlling officers who inspect personally the cutting off of the test discs and of the bars; every piece that does not rigidly comply with the specification is absolutely rejected. In the Krupp works everything is shrouded in mystery, and it is on this account that such unpleasant surprises are heard of from time to time at Obukoff in Russia. The metal of some Krupp guns has been tested (not by the makers) and has revealed itself as of very ordinary quality. The Canet guns will resist from 3000 kilos. to 4000 kilos, (19.05 to 25.4 tons) per square inch of pressure, as has been shown in the Tables published in ENGINEERING. This is another fact. Some Krupp guns have developed extensions in the bore at normal pressures. Belgium, which was for a long time a strong partisan of Krupp, complains of this defect at the present time. The *Réforme* of Brussels stated, a short time ago, that some guns delivered from the works at Essen would not resist more than twenty rounds. Failing a disproof of this very damaging statement, its correctness must be accepted, and it should be remembered that Belgium has for a number of years been dependent on Krupp for its armament. In presence of all these facts it seems really unnecessary to pursue this part of the subject; and we ask what the question of efficiency has to do with the quality of metal?

If it were a question of straining every pound of steel up to the margin of destruction, the remark would have some good purpose. But as has been pointed out there are many other considerations involved which lead to the necessity of increasing the weight of large naval guns, if ships are to be armed with practical and efficient weapons.

It is to be regretted that the expression "firing ground" was made use of, since it has offended Mr. Krupp. The Forges et Chantiers possesses, at the Pointe du Hoc, a polygon with six platforms on which guns of all calibres can be mounted for firing. The capacity for mounting and transporting guns up to 100 tons in weight, are thoroughly complete, and velocity trials are made in two sand chambers. The polygon is situated on the sea shore, and firing trials under all conditions and at every angle can be made at fixed and at moving targets. Training and sighting appliances for long-range firing at sea can be thoroughly tested, and in this respect the Hoc polygon is far superior to any land firing ground, where complete results are never attainable. The French naval department employs —for ordinary firing—the firing grounds at Sevran-Livry, and for the establishment of range tables the Polygon at Gavres, near Lorient. All trials of powders are made at Sevran-Livry, which is less efficient than the Hoc, but that does not prevent the French navy from arriving at most satisfactory results.

Morover, tests recently made with a 27-cent. (10.63-in.) coast-defense gun in Japan have shown the accuracy of fire with these large-calibre weapons made by M. Canet. The official report emphasises the fact that the accuracy of firing was superior to that of any guns that had been previously purchased by the Japanese Government. On the occasion referred to rounds were fired at a range of 2400 metres (2624 yards) against a target 10 metres (32.8 ft.) high and 6 metres (19.68 ft.) wide; the trials took place at Hashirimizu. The average errors were:

In height	0.4 m. (1.31 ft.)
In direction	0.5 m. (1.64 ft.)

With a falling angle of 2 deg. 4 min.

This result is excellent, and it should be pointed out that this gun did not give a very flat trajectory. It is a cast-iron weapon lined with a steel tube and giving an initial velocity of 570 metres (1870 ft.) per second. This is a single example selected to show what can be obtained under the most unfavourable conditions. As to the pressure of 3300 kilos. (20.95 tons), all the Canet guns that have been constructed have proved themselves capable of resisting it.

The heavy Krupp guns on the other hand do not appear capable of resisting such high pressures without damage, as has been clearly proved by various facts brought out in the course of this discussion. As regards service charges it is quite natural that M. Canet should have recommended that they should not be larger than would develop a pressure exceeding 2400 atmospheres; this limit is recognised by every one.

Mr. Krupp is of the same opinion; he has repeated many times that 2400 atmospheres should be considered the highest pressures admissible in service. But where he deceives himself is when he asserts that it is necessary to develop a pressure of 3000 atmospheres in order to obtain a velocity of 800 metres (2625 ft.). This velocity can be very easily obtained in service without exceeding 2400 atmospheres, provided that suitable powder is employed. This is fully proved by the results obtained by the Canet guns of 10, 12, and 15 cent. (3.94 in., 4.72 in., and 5.90 in.), and which have been already reported in ENGINEERING. The fact that Mr. Krupp himself mentions several countries where the Canet system has been definitely adopted, shows to what extent and with what rapidity Mr. Krupp is losing ground abroad. He is wholly without justification in taking credit for the manufacture of long guns, since he still confines himself to a length of 35 calibres, while M. Canet has very many of 40, 45, and 50 calibres in the service.

As regards hydraulic brakes, the important *rôle* played by M. Canet is a matter of common knowledge. He was the first to elaborate and to publish a mathematical investigation on this subject, in 1879, in the *Revue d'Artillerie*. At that time he maintained the important principle of orifices of variable dimensions, whilst Mr. Krupp only employed constant orifices, which he has since been compelled to abandon. As to the method of central loading in any position of the gun, the first applications were made on the Achéron, the Cocyte, the Styx, the Phlégéton, and the Marceau, in France, and the Pelayo in Spain, from plans prepared by M. Canet in 1881-1882. Before that time it was necessary always to bring the gun into one fixed position for loading it. Evidence of the truth of this statement is to be found on every type of warship constructed prior to that date.

We will add a word on the recent discussion on the Budget of the French Navy. Mr. Krupp evidently imagined that he was placing M. Canet in a serious dilemma by quoting a part of the speech of General du Pan. But it was only a part of his speech that was quoted, and if the whole sense of the discussion had been reported an impression totally different to that desired by Mr. Krupp would have been given. The Minister of the French Marine said in the course of this same discussion: "The experiments repeatedly made on the guns constructed by the Forges et Chantiers have been highly satisfactory. As the result of these trials, I ordered from the company the quick-firing guns for the Bouvines." General du Pan, whose words were so imperfectly quoted, made a very clear and a very just distinction between the Canet guns of the earlier types and those of the modern practice. "It is certain," said General du Pan, "that the Canet guns in 1889 and 1890 did not fulfil everything that might have been desired, and in saying that I refer to the trials made at the polygon. Since that time they have been greatly improved, and for some time now they have been thoroughly satisfactory." What could be desired clearer than that, and by what right does Mr. Krupp ascribe words to General du Pan which were never in his mind? He added that "The results, although good, were not such as the Marine wished to obtain." The explanation is very simple; the Marine wished to arrive at an initial velocity of 800 metres (2625 ft.) per second. M. Canet pointed out that his guns had not been constructed to give such velocity with the powder placed at his disposal, and that such a result could not be obtained with that powder, which could not be expected to give more than 760 metres (2493 ft.). Mr. Krupp will probably admit that service firing of a large number of rounds, with such a velocity, is amply sufficient to satisfy even the exigencies of a "German Artillerist." With the same gun and another class of powder an average velocity of 800 metres (2625 ft.) and with 2400 kilos.

(15.24 tons) per square inch of pressure was obtained, proving that the want of velocity was solely due to the powder. General du Pan required that the 60-calibred guns, ordered by his department, should be shortened to a length of 55 calibres; this was one of the conditions of the contract to which M. Canet had no objection to raise. Close as possible investigations have shown that after very numerous trials at high pressure, made at the Hoc polygon, there was absolutely no bending in such long guns, and of much larger diameter, so that he continues with perfect confidence the manufacture of guns as long and even longer than this.

It would really seem that the foregoing entirely annihilates the most terrible arguments of Mr. Krupp; for my own part I do not care for that class of discussion, the strength of which depends on mis-quotations, or in quoting parts of a sentence, whose meaning is entirely modified by another part, which is carefully omitted. Moreover, everybody knows that in France the various Government departments do not look with much favour on private industry. In this respect ideas are much broader in England and in Germany. In both of these countries it is well understood how much service can be made of private industry, and of what vital importance it may be to the State at critical times.

We would not wish to terminate this reply without rendering a full measure of public homage to Essen, which for so many years was the first great gun factory of the world. In its time it has armed almost every power, and Germany owes it a debt of gratitude for having so largely contributed to its military glory. It would be very unjust and very ungrateful if, as is stated, the German Government thought of imitating France and patronising a modern establishment designed to come into direct competition with Essen. Such a course could only be explained by the fact that Mr. Krupp obstinately refuses to keep to the front in the march of progress. We leave the "serious artillerists" of whom the author of the article in the *Jahrbücher* paper speaks, to hold to their ideas of efficiency, to short gun, and to wedge breech mechanism. Every country desirous of increasing its military and naval power must find itself compelled to abandon these cherished principles, and to accept others. Artillerists of the younger school devote themselves to questions of the power and the facility of handling guns, and their rapidity of fire. They are charged sometimes with rashness, but they continue to press forward, and it is thus that progress is made and success achieved.

The foregoing reply to the "German Artillerist" was written when we had under our hand the number of the *Internationale Revue* for April last. This publication contains an interesting article on apparatus for handling heavy guns, and especially the Krupp guns of 30.5 cent. (12.01 in.) calibre. We have no intention of discussing the opinions set forth by the author; but the third part of the article has suggested two reflections which seem to give a new authority, and, as it were, a confirmation of what has been said by a "French Artillerist."

1. The table of principle data and the results of firing show 62,450 kilos. (61.46 tons) as the weight of the 30.5-cent. (12.01-in.) Krupp gun, mounted on its hydraulic naval carriage; whilst the weight of the coast-defence gun and of the earlier type of gun supplied to Austria—both of the same length, 35 calibres—only weighed 49,700 kilos. (48.91 tons) and 48,550 kilos. (47.78 tons). Why all this difference? It is true that with the same pressures an increase of about 36 per cent. in the striking energy with the brown powder and of 67 per cent. with the new powders can be obtained. But in rising from 48,550 kilos. (47.78 tons) to 62,450 kilos. (61.46 tons) in the weight of his new naval gun, has not Mr. Krupp been guided by special considerations resulting from the necessities of the Marine? The former guns were fired at pressures of 2725 kilos. (17.44 tons per square inch); the gun of model 1888 gave a maximum velocity of 681 metres (2234 ft.) with 2700 kilos. (17.14 tons per square inch) of pressure. Modifications in the powder charge might have led Mr. Krupp to certain changes in the design, but this would not alone justify an increase in weight of 14 tons, or more than 33 per cent. The weight of 62,450 kilos. (61.46 tons) approximates very closely to that of the 32-cent. (12.60-in.) Canet gun, which is 5 calibres longer and weighs 66 tons; thus

with equal length and calibre, the Canet gun would be the lighter of the two. Clearly, therefore, this consideration of weight should not take precedence of everything else, and ought in fact to disappear in presence of other and much more important requirements for service on board ship. Evidently Mr. Krupp has recognised this necessity. It may be added that the Krupp wedge weighs, according to the weight given in the *Revue*, 1500 kilos. (3307 lb.), which is very considerable, and must certainly hamper, to an extraordinary degree, the manœuvring of the gun, no matter how perfect or complicated the auxiliary mechanism may be.

2. Mr. Krupp has constantly reproached M. Canet for quoting "theatrical rounds" fired from his guns. Mr. Krupp admits that the pressure of 2400 atmospheres should never be exceeded in service; that, too, is the common opinion of all artillerists. Nevertheless, for the gun, 1887 model, three rounds are given, and these rounds were fired with the following pressures: 2945, 2818, and 2700 kilos. (18.70, 17.88, and 17.14 tons) per square inch; so that it would appear that even Mr. Krupp cannot rise superior to the temptation of putting forward "theatrical rounds." In the replies by a "French Artillerist," published in ENGINEERING, it has been shown that the Canet 32-cent. (12.6-in.) gun with a pressure of 2550 kilos. (16.16 tons) per square inch, but little in excess of the normal pressure, gives an initial velocity of 727 metres (2385 ft.), a striking energy of 12,149 metric tons (39,230 foot-tons), and an efficiency of 184.9 metric tons per kilo. (82.55 foot-tons per pound) of metal, instead of 172 tons (76.8 foot-tons) obtained by Mr. Krupp with the pressure of 2700 kilos. (17.14 tons) per square inch. Mr. Krupp states that the 30.5-cent. (12.01-in.) model 1887, is the most recent type of his large calibre guns in actual service.

At the moment of completing this reply particulars of the last results obtained with the latest type of Canet 57-mil. (2.244-in.) quick-firing guns, 80 calibres in length, are available for publication; these results were obtained with trials conducted in May last. With a pressure of 2600 kilos. (16.51 tons) a velocity of 1013 metres per second was obtained; and with 2570 kilos. (16.32 tons), which is within the range of practical work, 1000 metres (3281 ft.) or 1 kilom. per second were recorded. This is the first time that such a velocity has been obtained from any gun, and until now the attainment of such a speed has been considered impossible. The result proves what can be obtained by the use of long guns. With such speeds point blank firing becomes easy, at distances which not long ago were regarded as probable fighting ranges—2000 yards for example; and it suggests something very like a revolution in the armament and fighting tactics of the future.

Can Mr. Krupp record velocities anything like these from the comparatively short guns for which he is so determined an advocate? P. M. V.

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SCHNEIDER AND CO.'S 15-CENTIMETRE (5.9-IN.) QUICK-FIRING GUN.

From time to time reports have been published in the French papers of a new quick-firing gun which, it was claimed, would come into direct and serious competition with the similar weapons designed by Mr. Canet and made by the Forges et Chantiers. Not long since a series of official trials were conducted in France with this new gun, but the results then obtained were not sufficiently promising to justify the advisers of the department to adopt it for service, so for the present at all events the Schneider quick-firing gun must, it seems, be regarded as not having emerged from the experimental stage, although its makers expect it to play an important part in the future. We are glad to have the opportunity of publishing detailed illustrations of this gun, the arrangement of which will be easily understood from the following description. The advantages claimed for it by the designers are as follows:

1. Very high ballistic power.
2. Breech mechanism of simple manipulation, with firing devices arranged for percussion or by electrical contact.
3. Simplicity of construction, and management and strength in the various parts.
4. The use of metallic cartridges.
5. The employment of a simple extracting device.
6. The adoption of a safety apparatus for preventing firing before the complete closing of the breech, and for opening the breech in case of a miss-fire.

The gun is built up of forged, tempered, and annealed steel tubes of the quality that conforms with the specifications of the French marine. The length is 45 calibres or 6.750 metres (23 ft. 3.75 in.), and the weight is 5.5 tons. It includes an inner tube in one piece extending for the whole length of the gun, and into the end of which the breech-block is screwed. An outer tube covering the inner one strengthens the rear as far as the trunnion ring.

A series of outer rings over the latter tube, and some lighter rings extending from the trunnions to the muzzle, complete the structure. The outer tube and the reinforcing rings are all cylindrical, and are made of such dimensions as to secure a shrinkage of 1 millimetre per metre of diameter. The gun, like other quick-firing guns, is designed for the use of metallic cartridges, and for this reason no obturating mechanism is necessary, the cartridge-case being sufficient to check the escape of gases to the rear by its expansion. The chamber is formed to fit the cartridge and also to receive a projectile furnished with centering and rifling rings. The rifling consists of 48 grooves of varying pitch, commencing at 2 deg. and finishing at 7 deg.; the depth of the grooves is 1 mm. and the diameter between the lands is 150 mm.

The breech-closing mechanism is of the Schneider system, in which the breech-block, with an interrupted screw thread of three equal sectors, is employed together with a bronze bracket and a double latch that keeps the bracket solidly fixed either to the gun or to the breech-block.

Manipulation of the breech-block is effected by means of the lever A, Figs. 7, 8, and 9, and a cam *a* is pressed by the spring *b* into the groove C at the back of the breech in order to prevent the breech-block from becoming free (Fig. 11). The extractor consists of a strong rectangular bar B provided in front with a gripping claw and with lateral teeth (Fig. 7). A toothed sector turning on the hinge E gears always with the extractor and has a recess *d* in which the finger F, fixed upon a bracket, can enter. This finger is placed vertically, and has at its upper end a projection which bears constantly on an incline *e* upon the hinge, by means of a spring *g*. The breech being closed, the various parts occupy the positions shown in Figs. 7, 8, and 9. The extractor claw is a little in advance of the base of the metallic cartridge, as will be seen in Fig. 7. By taking the lever A and moving it round one-sixth of a turn, and at the same time by holding the small lever K, the cam *a* that locks the lever A is released. After the breech-block is set free it is drawn towards the aperture by pulling on the lever A and the handle K; the breech-block, guided by the guides *h*, strikes at the end of its movement, the front faces of these guides. The shock resulting from this sets free the double latch, and at the same time the rear point of the latch engages in the breech-block, and the finger F enters the recess in the toothed sector B. By pulling sharply on the lever A the bracket and the breech-block turn round the hinged axis, and at the commencement of the rotation the finger F strikes the toothed sector of the extractor, the shock having the effect of loosening the metallic cartridge-case. As the movement of turning the bracket continues, the finger draws with it the toothed sector and the extractor bar, at the same time the slope *e* on the hinge raises the point *f* of the finger F; and this latter becomes disengaged from the toothed sector and leaves it shortly before the rotation of the bracket is completed; but by this time the extractor has been moved so far that the metallic cartridge-case, which has moved with it, has been withdrawn some inches from the end of the gun; one of the operators then pulls out the case and others put the new cartridge into the gun. The flange of this cartridge engages in the end of the extractor, and moves it forward into the gun in such a way that the extractor bar returns easily to its initial position. The breech is then closed by the ordinary movement; the lever A goes back into its original position shown in Figs. 8 and 9, and the cam *a* enters the recess, locking the breech-block.

When the breech is closed the small block J, actuated by the spring I placed on the back of the gun, locks the lever and prevents any further movement. At the side of the block is a small spring finger *m*. When the gun is fired, recoil takes place suddenly, the small block by its inertia enters a recess in the gun and releases the lever, the spring finger on which, engaged in the small recess, is so arranged as to prevent any further movement; it is then possible to manipulate the lever and to open the breech. On the other hand, if the gun hangs fire no recoil takes place, and the block remains in its normal position over the lever, which cannot be manipulated by the operator until the block is pressed by hand and the lever released.

The gun can be fired either by percussion or by electricity, the former method is represented in Figs. 11 and 12, and the latter in Figs. 7, 8, and 9. In each case the operation is entirely under the control of the man serving the gun, and firing is absolutely impossible unless the breech is completely closed. The apparatus for firing with percussion fuzes consists essentially of a striker actuated by the coiled spring of the lock and the trigger controlling this lock. The striker N and its actuating spring *n* are placed in the axis of the breech-block, the needle *i* of the striker moves in a hole in the block, and in its normal position is flush with the forward face of the breech-block; this position is maintained by the collar of the spring *o* and by the returning spring *p*.

At the rear end of the striker is the groove P, in which works the spring detent Q mounted on the lever R. The axis of this lever can be rotated by the T-shaped head that engages in a grooved path formed at the back of the gun. It is controlled by the lever S, to which is attached one end of the firing cord, the other end being held by the man serving the gun. The spiral spring mounted on a key and the flat spring attached to the firing lever, restore all the various parts to their normal positions. By this arrangement the operator by drawing on the cord sets the striker by means of the lever R; the spring detent Q becomes free of the striker when this lever is drawn sufficiently far back, and under the action of the spring *n* the needle of the striker is thrown forward against the percussion fuze placed in the center of the base of the metallic cartridge-case. In the event of a miss-fire the operator can re-set the striker by pulling a second time on the firing cord. It will be remarked that the lever R is mounted on the main lever of the breech-block, and that the controlling key is fixed to the breech of the gun; firing therefore can only take place when the main lever of the breech is in its proper position, that is to say, when the breech is completely closed.

When firing by electricity is preferred, the striker and spring device are replaced by an insulated needle, which by means of a coiled spring is made to project slightly from the forward face of the breech-block. The main lever carrying the firing lever and the detent is replaced by another, to which is attached an insulated conductor, and when the breech is closed the needle V is in contact with the central part of the electric fuze placed in the base of the cartridge-case. Electrical contact is made by the terminal X attached to the rear of the gun, Fig. 8, and with which contact is made at the moment when the breech is locked, by an insulated conductor on the main lever, and which then connects with the needle V. One of the wires from the battery is attached to the terminal X; the other wire is in contact with the gun and its mounting, and so long as the breech is not completely closed the contact with the conductor of the main lever does not take place, the circuit remains open, and the gun cannot be fired. The operation is completed by means of a circuit-closer operated at will by the man serving the gun. In order to avoid miss-fire all the contacts are made of silver.

The ammunition is contained in the metallic cartridge-case (Fig. 13), the percussion and electric fuze being carried in the base of the case. The charge is fired by means of a small priming of black powder. The projectile is forced into the open end of the cartridge-case for a sufficient distance to insure firm contact. The projectiles employed weigh 40 kilogrammes, and are of three kinds—ordinary cast-iron shell, chrome steel shell, and mitraille shell. All of these projectiles are fitted with red copper bands to take the rifling. The belt, moreover, marks the limit of depth at which the end of the projectile is placed in the cartridge-case.

The *personnel* necessary for working the gun is as follows:

1. One pointer.
2. One man who opens and closes the breech.
3. One man for feeding.
4. One man for withdrawing the empty cartridge-case.

When the target aimed at is a rapidly moving one, No. 1 fires the gun, but for quick firing at a fixed target or at a slowly moving object the work devolves on No. 2. The maximum rapidity of firing without pointing is about 10 rounds per minute.

The carriage (Figs. 3 to 6) upon which this gun is mounted is of the central-pivot type with small recoil and automatic return.

It can be placed equally well on board ship or mounted on a coast battery. The carriage consists essentially of an oscillating cradle A, of two slides with brake cylinders B, of the frame C and D, and of the under carriage E. It is also furnished with a steel shield. The total weight of this carriage without the shield is about 4.7 tons; the weight of the shield is 2.5 tons, so that the weight of the carriage complete is about 7.2 tons.

The carriage has been designed with the intention of fulfilling the following conditions:

1. To reduce the amount of recoil to the lowest possible limits, and to insure a rapid and automatic return so as to secure rapid firing.

2. To do away with the effect of percussion in all positions of the gun by making it recoil on its axial line, and by opposing the direct action of the brake.

3. To distribute the effects of firing over a large surface in order to reduce the strains on the various parts.

4. To allow the man pointing the gun to effect this manœuvre rapidly both for elevation and direction, while at the same time he can fire the gun himself, although he has nothing to do with loading it.

The carriage is of a very strong and simple construction, and does not require any preparatory manipulation for putting it in service. The gun is maintained constantly in firing position by springs, the brake cylinders are always full of liquid; the joints in this part of the mechanism are few in number, and so designed as to remain quite tight; under these conditions the gun is always ready for firing. It is mounted as upon ordinary carriages, the trunnions resting on the usual bearings and being held in place in the usual way, as shown in the illustrations.

The body of the carriage is of cast steel; the cradle is formed of two parts bolted together in the middle and provided with trunnions that rest in bearings on the sides of the frame, and which carry the weight of the gun, the slides and the cradle. The latter is formed of a strong casting of the shape shown in Figs. 3 and 5; on the upper faces are bronze strips (Fig. 5) that serve as slides for the brake guides. The forward and rear ends of each of the girders are raised in such a way as to furnish points of attachment for the piston-rods of the brake. The central rib (Fig. 3) provides the means of connecting the two sides of the cradle, at the same time giving it great rigidity. The lateral trunnions I, which are cast with the cradle, are fitted with bronze rings.

The two brake cylinders, which are absolutely similar, are placed symmetrically on each side of the gun, and are operated in identically the same manner. On each of these is mounted with great accuracy the trunnion of the gun; consequently the cylinders follow all the recoil and forward movements of the gun. The trunnions are kept in place by a strap as shown in the drawings. Two half collars in forged steel connect the two cylinders in front and at the back, and at the same time check any displacement of the gun around its trunnions. The cylinders F F^1 are of forged steel of precisely the same internal diameter and of the same length; the rear ends of these cylinders are in communication with each other by means of the passages *b b*. These pistons are shown at G G; their rods H H^1 are bolted as already mentioned to the raised ends of the cradle.

When the gun, after having been fired, forces back the cylinders, the pistons G G remain immovable; the liquid, which is in front of each of these pistons is forced to the other side through the grooves cut within the cylinders; these grooves have a variable section determined in such a manner as to give a constant resistance during the whole length of the recoil, which has a maximum length of 253 mm. (9.8 in.). During the recoil the partial vacuum, which would be formed in the front part of the cylinders by their movements along the piston-rods H, is compensated by an equal quantity of liquid forced through the passages *c c* by the piston-rods H^1 as the cylinders move forward upon them. In this manner the brake cylinders are always kept full, the loss in one being compensated by the excess in the other; this arrangement thus forms a constant volume brake, and a regular recoil without shock is secured. This system of coupled hydraulic brakes, with four cylinders. divides the effect of the recoil over four points of the frame by means of the four piston-rods, two of which work in compression and two in tension. This division of the strains due to firing considerably diminishes the length of recoil; at the same the dimensions of the brake are very small.

Fig. 5 shows the arrangement for bringing the gun back into the firing position automatically by means of a power-storing device formed of two sets of direct acting springs. Beneath each of the brake cylinders and at the forward end is a projection that serves as an abutment for the springs *r r*, mounted on the rod K. This rod is formed with a head at the forward end that bears on the projection made in the side of the bracket; a thread is cut on a considerable portion of the rod at the rear end, and by this means sufficient initial compression can be given to the springs to keep the brake cylinders and the gun fixed at the maximum angle of elevation. The compression nut K is guided in the groove at the rear part of the side of the cradle. Spiral springs are employed, ten in each groop; they are separated by discs which prevent them from getting foul of each other. At the moment of recoil, these springs are compressed by the movement of the brake cylinders, and when recoil ceases, the energy thus stored up is utilised in bringing back the gun and the cylinders to their initial position. This return movement is regulated by the brake which works in a manner inverse to that set up by the recoil, and any resulting shock is almost entirely absorbed by the buffers M placed at the forward part of the carriage. These buffers, made of discs of leather alternating with discs of iron, are mounted on the rods K, between two circular plates of heavier section at each end.

The bedplate D, to which the sides of the frame C are solidly bolted, is formed of a circular cast-steel plate. In the centre is a recess which receives the pivot of the under carriage, and round which is made the rolling path for twenty-four conical rollers (Fig. 3) which bear on a suitable surface in the bottom of the under carriage, and turn freely, but their distance apart and their radial position are maintained by two concentric rings in which the spindles of the rollers take their bearings. A large catch in front and two smaller ones at the back, fixed to the bedplate, and engaging in the back of the under carriage prevent the frame from lifting during the recoil. One of the rear catches carries the locking-bolt O intended to keep the frame in any desired position when the gun is not in service. The covering plate S surrounds the bedplate and under carriage, and shields the roller paths and conical rollers.

The maximum elevation of the gun is 23 deg. (from -5 deg. to $+18$ deg.). This is obtained by turning the cradle of the carriage around its trunnions. The movement is controlled by means of the hand-wheel P that operates the shaft *p* mounted on the left side of the frame. This shaft turns the screw T and the helicoidal wheel *t* and the pinion U that gears with the toothed sector V fixed in the left side of the cradle. It should be pointed out that the mechanism for turning the gun in elevation is attached to those parts of the carriage which do not recoil, consequently the man training the gun is not obliged to release the hand-wheel at the moment of firing. The gun can be turned through its maximum amplitude in twelve seconds.

Training in direction through the complete circle is effected by means of the hand-wheel P^1 working the endless screw p^1. This latter operates the helicoidal wheel t^1 and the vertical pinion U^1 that gears with the toothed ring fixed round the saddle. The gun can be turned round the complete circle in 110 seconds.

The under carriage, the pivot of which is fitted with bronze rings, is fixed to the frame by means of twenty-four bolts, and is arranged to receive the steel toothed ring just referred to.

The men serving the gun are protected behind a shield of steel 30 mm. (1.18 in.) thick; though this thickness may be increased to 35 mm. (1.38 in.) if desired. It will be noticed that all the plates of which the shield is composed are flat, the quality of the metal therefore is not endangered by heating and bending in the course of construction. The shield is attached to the bedplate in front and on each side by means of strong angle brackets; it has no connection at all with the sides of the frame, and can therefore be subjected to considerable damage by firing without affecting the working of the gun. The handwheels controlling the training mechanism are placed on the same side as the sights. In action the shoulder-piece X fixed in the same side on the frame assists the man in training the gun, and who, while operating the training wheels is thus able to follow more easily the displacements of the target and to keep the gun upon it. The general

dimensions and other particulars are contained in the following Table:

Total length of gun	6750 mm.	23 ft. 3.75 in.
" " in calibres	45	
Weight of gun, including breech-block .	5580 kilos.	12,276 lb.
Weight of projectile	40 "	88 "
Powder charge, P.B.	24 "	52.8 "
" B.N. smokeless	16 "	35.2 "
Weight of empty cartridge-case. . . .	14 "	30.8 "
Total weight of loaded cartridge with powder, P.B.	78 "	171.6 "
Total weight of loaded cartridge with powder, B.N.	70 "	154.0 "
Total length of cartridge with shell . . .	1640 mm.	64.47 in.
Initial velocity with P.B. powder . . .	713 m.	2338 ft.
Initial velocity with smokeless powder .	820 m.	2690 ft.
Ratio of weight of gun and weight of projectile $\frac{P}{p}$	139.5	
Striking force of projectile $= \frac{Pv^2}{2g}$		
with powder P.B.	1085 metric tons.	
Ditto B.N.	1070 "	
Thickness of iron plate that can be pierced with initial velocity of 820 metres	399 mm.	15.71 in.
Weight of carriage without shield . .	4700 kilos.	10,340 lb.
Weight of 30-mm. shield	2500 "	5,500 "
Amplitude of horizontal training . . .	360 deg.	
Time required for training the gun round the complete circle	110 seconds.	
Amplitude of training in elevation . .	from −5 to +18 deg.	
Time required for maximum elevation .	12 seconds.	
Height of trunnion above the ground .	1 metre	39.37 in.
Maximum recoil	250 mm.	9.84 "

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QUICK-FIRING GUNS.

We have been requested by MM. Schneider and Co., of Creusôt, to publish the following comparative criticism of their own system of quick-firing guns, and those of Krupp, Armstrong, and Canet. Our readers are familiar with the details of all these guns and lately (see page 509, *ante*) we published very complete illustrations and particulars of the Schneider 15-cent. gun which was recently officially tried in France. The following investigation by MM. Schneider refers in each case to guns of 15-cent. calibre.

In comparing the four types of quick-firing guns, those of Armstrong, Canet, Krupp, and Schneider, it is pointed out that in each the mounting is central-pivoted, and is provided with a steel shield, and that metallic cartridges are employed, but apart from these general points of resemblance, that the differences are so marked as to divide the guns into two distinct classes, in one of which Krupp stands alone, while Armstrong, Canet, and Schneider are grouped in the second category. The distinctive features are: For Krupp, the wedge breech closure and a gravity return carriage, such carriage being of an ordinary type with inclined sides, and for Armstrong, Canet, and Schneider a screw breech-block, an oscillating cradle on which the gun can recoil on the line of its axis, an hydraulic brake (like Krupp), but instead of a gravity return, the gun is brought into firing position by using the stored-up energy of recoil. Of course, although possessing these several features in common, the English and French guns are all distinct in design and nature of detail, and in each case the object aimed at, that of fulfilling the official conditions prescribed by the British and French Marine, is arrived at, more or less perfectly, by different means.

Probably official restrictions have been more severe in France than in England; certainly they have helped largely to develop the definite model of the Canet gun, and the same influence will affect the development of the Schneider gun.

The Krupp 15-Cent. Quick-Firing Gun.—Apart from the method of extracting the empty cartridge, and an automatic safety arrangement, there does not appear, either in the Krupp quick-firing gun or its mounting, any development of special design or modification of detail for the conditions of rapid firing. The wedge block is heavy, bulky, and difficult to manoeuvre. These are defects that have caused the general abandonment of the wedge for ordinary guns, even with many countries that had adopted the system, and it is evident that the drawbacks are much less serious in any other type of gun than that for quick firing, where rapidity and ease of manipulation are, after security and efficiency, of first necessity.*

The gravity return type of carriage does not admit of the direction of recoil coinciding with the axis of the gun, and involves a long recoil to gradually absorb shocks that would be otherwise excessive. The gravity return system is not well adapted for board ship, where the rolling may tend to check the movement of the gun into firing positions, or, on the other hand, may unduly accelerate it; this tendency has to be controlled by a supplementary brake to hold the gun fast, or to regulate its movement on the slides. The sights shifting with the gun render it necessary to train after each round. All these inconveniencies, and others of less importance, are characteristic of the Krupp mode of mounting, so that neither gun nor carriage, as hitherto designed, are adapted to the special requirements of quick-firing. The carriage especially is not at all adapted to withtsand the heavy strain of recoil due to the higher initial velocities required, and which must be absorbed by the brakes without excessive strain either to the mount or the deck of the ship. Means are wanting for rapid sighting and training, the gun does not return

* [We believe that Mr. Krupp is now constructing quick-firing guns with some sort of threaded breechblock. so that the foregoing strictures will no doubt cease to have an application.—ED. E.]

to firing position quickly, and requires to be held there by special means when in a sea-way.*

The Armstrong, Canet, and Schneider Systems of Breech Mechanism.—As has already been said, these three systems have one feature in common—that of the use of a cylindrical breech-closing block with interrupted threads. The manipulation of this type of breech-closing involves: (1) To open the breech; a turning movement to set free the block, a second to withdraw it to the rear, and a third to throw it on one side in order to leave the breech clear for the introduction of the projectile. (2) To close the breech previous to firing the gun, these three movements have to be repeated in an inverse order. It has been sought in the Armstrong and Canet systems to effect a saving of time in these operations. In the first-named system one of the movements, that of withdrawing the block, has been suppressed; in the Canet system the three motions follow each other uninterruptedly by a successive transformation of the power produced in one and the same plane by a lever which is operated by hand. It is not apparent that the economy claimed by these two constructors, supposing it to exist at all, is appreciable, because experience has shown that the Canet gun has not given any greater rapidity than that obtained with the Schneider gun, in which each of the three ordinary movements of the block are effected without any effort to render them continuous, and the Schneider gun has been proved to be far superior to that of the Armstrong in point of rapidity. It will be understood, moreover, *à priori* that the necessity of the three movements being admitted, their production by a continuous effort does not present much, if any real advantage; in the Canet gun, if any useful economy in time is effected, it is practically insignificant, for it is evident that no economy can be obtained in each movement considered separately, because each movement is always executed in every system with the greatest possible rapidity. Therefore it is only in the change from one movement to another that any economy in time can be effected, and this, if it exists, must be infinitely small. It should

* [It must be remembered that these criticisms do not apply to the later types of Krupp quick-firing guns.—ED. E.]

also be observed that the continuously applied effort must vary in its intensity, because the resistance to be overcome is variable, according to whether the block is to be set free in the breech, or withdrawn, or thrown to the side. In the Armstrong system the withdrawing movement of the breech-block from its seat is suppressed by making the block conical in front and cylindrical towards the rear; the contour of these two portions is such that when the block is set free, the movement of turning it to the side can be at once commenced. It is evident from this arrangement that the total pressure on the breech, that is to say, the end pressure, is distributed unequally between the threads of the cylindrical part of the block and those of the cone. The latter, which is considerably inclined to the axis, is much less strained than the former, and it is probable that the threads of the cylindrical portion have in practice to resist the whole of the strains. This is evidently a very bad arrangement for preserving the threads of the screw block in good condition, and consequently there is no guarantee that the mechanism of the gun can be kept in working order. In other words, the alleged economy in time obtained by suppressing one movement, is gained at the expense of safety.

We may now proceed to analyse the breechloading mechanism of the Canet system. As regards the transition from one to the other of the three movements of the screw under the single and continuous action which is effected always in the same plane and in the same direction, we have granted all that can be reasonably admitted about the reduction in time obtained by these movements, but the fact is that only two of them can be considered, because the third and last, that of opening the breech, presents no specialty. When at the end of the second movement the whole system is made rigid, the third movement is effected in the ordinary way, that is to say, by turning the bracket around its axis. Whether the operator manipulates the breech by means of the Canet lever, or whether he does it with an ordinary lever and handle, is precisely the same thing. The convenience is neither greater nor less in one system than in the other; indeed, if there is any difference, it appears to us this latter method is more convenient, because the operator has an instinctive tendency to use his left hand, which is free, by placing it on some projection of the block in order to aid his right hand, and the handle naturally presents itself for this purpose. We are, therefore, limited to the examination of the two first movements for opening the breech, and, inversely, with the two last in the case of closing it. The plane in which the effort is exerted is horizontal, that in which it is transmitted to the block is vertical. Two segments of bevel pinions serve as intermediaries. The arrangement is very simple, but if we consider the effort of transmission it is much to be feared that an excessive strain is set up in the gearing and that sooner or later this must suffer damage. When the block is set free it has to be withdrawn to the rear, and during the whole of this movement the direction of the path it follows is oblique in relation to the tangential effort created at the end of the actuating lever. These are undesirable conditions, because the oblique strains and their reactions lead always to an excessive friction and wear. Finally it may be remarked that in order to facilitate the whole of these movements in the Canet gun, a dimunition in the amplitude of the turning motion is necessary; the threaded and unthreaded segments extend alternately around one-eighth of the circumference instead of one-sixth; and one-eighth of a turn is therefore sufficient to set free the block. This arrangement has the inconvenience of reducing the useful bearing surface. The extremities of the threads not having the same resistance as the middle, and the ends of the threaded sections being repeated in eight parts instead of six, the number of these weakened parts is increased in this proportion. It will be seen from the foregoing that there is reason to fear that the alleged economy, which is very problematical if not wholly imaginary, and certainly useless under practical conditions, is secured at the expense of delicate mechanism. It is freely admitted that there is considerable beauty and attraction in the arrangement, which fails, however, to give confidence as to duration and to continued good work.

There is a more or less marked tendency on the part of all gunmakers to devote themselves to securing extreme rapidity of fire, in excess of what can even be obtained in practice, for reasons quite independent of perfection in breech mechanism.

These reasons, such as heating the gun, the necessity of training at each round in the case of a shifting target, fatigue of operators, the necessity of economising ammunition, &c., lead the most experienced artillerists to concur that a rate of three or four rounds a minute will be amply sufficient, assuming that both adversaries use smokeless powder. In the design of the Schneider gun the main object in view has not been a reduction of the time required for operating the breech, although, as has been already stated, this can be done as quickly as with the Canet gun. The threaded and smooth segments of the block each occupy one-sixth of the circumference alternately, and the three movements are effected in tne ordinary manner. There is no danger of delays arising from any hesitations in operating the gun on the part of the men manœuvring it. The main lever is sufficiently long to enable the work to be done without any excessive exertion, and the arrangement is such as to greatly facilitate the various movements, particularly those of setting free the breech-block and extracting the cartridge, which latter is done when the block is swung round on the bracket.

The arrangement of this bracket is somewhat different to that adapted to ordinary guns. It is placed on the left side, because, as in the Canet gun, the block is swung to the left. The block when in the gun rests on the extractor bar, to which reference will be made later, and which slides in a groove cut in the smooth segment at the underside of the block. The block is guided into the gun by the bracket which is locked to the breech during the period of extraction. In this way the block is always kept accurately centered, and under conditions that insure as great, if not a greater, guarantee of safety than the Canet bracket, that seems somewhat too light for security.

Extracting Devices.—After a round has been fired the empty cartridge-case must be removed from the chamber. Two phases have to be considered in this operation; first, the loosening of the case that has been expanded by the explosion, against the sides of the chamber, and, second, its ejection to the rear with such force that the case may project far enough beyond the breech for the men serving the gun to take hold of it and complete its removal. Whatever type of extracting device is employed it must possess at the extremity claws that pass the breech-block and over the rim of the cartridge. One or two such gripping claws may be employed with the extractor, and it is preferable that they should remain always in front of the rim, rather than they be forced over the rim at the moment of closing the breech. The extractor may be attached to the block, or be independent of it. We may now examine the varieties of extracting devices in each of the three types of guns under consideration. In the Armstrong system there is only one claw, which always remains in front of the rim. This claw is at the end of a round bar traversing the left side of the gun obliquely at the bottom of the breech-block. If the bar is turned the cartridge is loosened and the ejection takes place, but this is insufficient: as the ejection is very limited, and the case must be withdrawn by hand, aided with a special tool, before it can be seized by the men working the gun and entirely removed. The extracting mechanism in the Canet system comprises two claws that do not always remain in front of the rim. They are placed in diametrically opposite recesses in the breech-block, and in the same recesses are operating springs. The extractor, therefore, forms a part of the breech-block and turns with it through an eighth of a revolution in the operations of unlocking and locking the block. When the gun is fired and the withdrawal of the block is commenced, the claws following the movement of the block retire with it, bringing with them the empty cartridge; but there is is a danger, if the case is jammed in the chamber, of the extractor claws passing over the rim and failing to act. It should also be borne in mind that when the movement of swinging back the block commences, the claw which is farthest from the hinge of the bracket quits its hold of the cartridge, while the other claw is compressed upon it and withdraws it obliquely from the chamber. When the breech is closed the claws spring over the cartridge rim, and again assume the necessary position for service. This arrangement is a very delicate one, and presents some danger of not working properly; moreover, the cartridge not being sufficiently withdrawn, does not offer a sufficient hold to the men whose duty it is to complete the ejection.

In the Schneider gun the extractor device is independent of the breech-block, and the claw is always in front of the cartridge rim. Instead of being slight, the body of the extractor is formed of a strong bar, on one face of which a rack is cut, into which gears a toothed sector, which is turned by the movement of the bracket. The empty cartridge to be extracted rests on this bar, the claw loosens it from the chamber by impact, and in its backward movement the bar drags the cartridge so far out that the attendant can remove it without difficulty. The extractor becomes free at the end of its stroke as soon as the breech is opened, and when a new cartridge is placed in the gun it carries with it the extractor bar, on which it rests. As the bar slides in a piece that forms a loading table, it is always well guided, and the cartridge being supported continuously is introduced with ease into the chamber. All these parts are extremely simple, and cannot be damaged by any ordinary usage.

We may now examine into what will take place with the three systems of extraction—those of Armstrong, Canet, and Schneider—when, the gun being loaded and the breech closed, it is desired either to open the breech simply, or to open it and extract the loaded cartridge. The first case may happen if the fuze has to be charged after a miss-fire; the second is likely to arise only during, or at the conclusion of, firing trials.

In the Armstrong and Canet gun it is impossible to open the breech without operating the extractor; in the former system, however, a device may doubtless be added to disengage the extractor from the breech. In the Schneider system, as it is always possible to throw the extractor out of gear, it remains undisturbed when the breech is opened and the fuze renewed. In both the Canet and Schneider guns, which are fitted with a safety device, this latter must of course be disengaged previously. The Schneider system is the only one that fulfills the necessary conditions in the first case assumed, that of opening the breech to renew a fuze.

All three guns are capable of fulfilling the second condition, that of extracting the loaded cartridge. Only as the Armstrong projectile is separate from the cartridge, the shell must be removed by means of a rod passed down the muzzle. In the Canet gun, if from any cause the cartridge is wedged in the chamber, the claws which do not appear sufficiently strong may easily become bent, and prevent the breech from being opened. None of the difficulties inherent in the other extracting devices are found in that of the Schneider gun. Of course, if the projectile has to be driven forcibly into the chamber, it is probable that the extractor would fail to start it, and recourse must be had to a rammer from the muzzle. But such a condition is independent of the extractor, and would certainly never occur in actual warfare.

The most important details of that class of ordnance designed for rapid firing are those of the breech mechanism and of extracting the cartridge cases. These, however, include certain other devices, very interesting in themselves, but which do not include questions of principle, and therefore there is not any occasion to consider these in the present criticism of the four types of quick-firing guns under consideration—those of Armstrong, Canet, Krupp, and Schneider. Moreover, it generally appears that some of these supplementary devices may, with certain variations, be applied to other types of guns than those for which they were specially designed. Such devices are those for firing the charges, whether by electricity or by percussion, and English and French guns are alike equipped with both means, either of which can be used at will; other devices are the safety apparatus to prevent accidentally unlocking the block; safety devices for preventing premature discharge of the cartridges before the complete closing of the breech; contrivances for preventing the breech being opened before the round has been fired, &c. A special advantage possessed by the Schneider system, however, may be mentioned, which other guns of the same class do not possess; in case of a miss-fire, the percussion striker can be reset simply by pulling on the firing rod.

Armstrong, Canet and Schneider Carriages.—MM. Schneider and Co. point out that all these carriages are of the central pivot type; their special characteristic is to allow the gun to recoil in the line of its axis, and to store up the power that is generated, in such a way as to bring the gun back into firing position automatically. All three of these constructors have especially devoted their ingenuity to reduce the effect of shock on the carriage and of strain upon the deck of the ship on which the gun is mounted; at the same time rendering it unnecessary to point the gun for each discharge. In order to fulfill these conditions the three carriages present arrangements which are in reality only variations of the same principle, namely, the use of an intermediate frame between the gun and the main frame, which supports the trunnions, and in which the gun recoils upon suitable guides. The three arrangements appear equally well adapted to the solution of the problem, and the differences between them really refer only to the connection between the gun and the carriage, and the greater or less facility offered for displacing and remounting. Both in the Armstrong and in the Canet mounting the devices adopted appear well suited for the purpose. The arrangement of the Schneider carriage is open to improvement, as in the actual construction the operation would be somewhat longer, but the present is only a temporary device and has been altered in carriages already subjected to trial.

In the new arrangement the upper part of the cradle is done away with, and the gun can be removed with great facility. Each of the three carriages is fitted with the hydraulic brake operated by variable openings and constant resistance. In the Armstrong carriage there are two cylinders, on the right and left and below the gun; they are carried on the oscillating sleeve. In the Canet mounting there is only one brake cylinder, also placed below the gun on a supplementary piece which does not exist in the other two mountings, and which is intermediary between the gun and the oscillating frame. In the Schneider system there are four brake cylinders coupled in pairs on each side of the gun, so as to form really only two cylinders from a constructive point of view. These cylinders are placed in recesses in the slides and in the plane of the recoil; the arrangement possesses the special advantage not existing in the two other systems, that there is no tendency to set up any reverse strains that tend to produce an oscillating movement in the chase of the gun at the moment of firing.

In the Canet and Schneider carriages the cylinders move and the pistons remain stationary; the contrary system is adopted in the Armstrong carriage. The displacement of the liquid in the cylinders is determined by arrangements already adopted by the various constructors in other systems of carriages. Thus in the Canet system a central counter rod is adopted, and in the Schneider carriage a well-known system of coupled cylinders. Both these systems have been thoroughly proved in practice, and adverse criticism can only be directed at certain points of detail, which may be more or less important according to the special object desired to be obtained. As regards delicacy and complication the Armstrong and Canet carriages are certainly less satisfactory than that of Schneider, which is constructed without a single valve or spring. In this system, as well as in that of Armstrong, if the gun is not in use the liquid in the brake is not under pressure. In the Canet carriage, on the other hand, the liquid is always under a certain pressure, which of necessity causes a difficulty in keeping tight joints, and gives more trouble to maintain the apparatus in working order. That this is so is proved by the addition of the pump to the apparatus, to maintain the desired pressure in the cylinders, such an auxiliary being unnecessary in the Schneider arrangement. In the Canet system the regenerating Belleville springs act upon the brake in order to bring the gun back into firing position, and a means of regulating the action of the brake and the spring is therefore necessary This is not the case with the Schneider brake, as the regulating springs are so arranged as to be entirely independent of the brake. The regulating device is only necessary to secure the initial tension required in the springs to bring the gun back into firing position when it is elevated to its maximum angle. It should also be remarked that the regenerating springs in the Schneider system have the same range of movement as that of the recoil, whilst in the Canet system this range is much smaller, the result being that there is less certainty of the gun being brought back into firing position. In the Armstrong carriage the regenerator, which is inclosed in a cylindrical casing in the gun, is not visible, but it appears to act somewhat like the same organ in the Schneider mounting, and to be equally independent of the brake. The constancy of the volume of liquid which flows through the Schneider brake prevents all shock, and the return into battery, while more rapid than in the other mountings, does not exceed a desirable limit, since no trouble has arisen from this cause during the various experiments which have been made. In the Schneider system the arrangement of brakes comprising four cylinders has the effect of dividing up the strains due to recoil, and of distributing them over four points of the cradle, by means of the four piston-rods, which is an extremely favourable condition. Moreover, by means of this distribution of strains it has been rendered possible to reduce the diameter of the cylinders and the length of recoil; in other words, the brake acts with greater energy. With the brake having one or two cylinders the diameter has to be increased to reduce the recoil, and this reduction is naturally less with one than with two cylinders. It is for this reason that with similar mounting the length of recoil in the Canet gun is 40 cent.; in that of Armstrong 33 cent., and in the Schneider only 32.5 cent. Reduction in the length of recoil permits the size of the carriage in the direction parallel to the gun, to be also reduced, and at the same time it does not increase strains thrown upon the deck of the ship, provided that the mounting is designed with the base of large diameter, and that the height of the trunnions above the ground is comparatively small. Of course, this part of the problem is of less importance in carriages for coast defence. For naval purposes the Schneider carriage appears to be admirably adapted. . Its base is greater than either those of Armstrong or Canet, and the centre of the trunnions is only 1 metre above the ground, whilst it is 15 cent. more for the Canet carriage, and still greater in that of Armstrong. It may be mentioned in passing, that further experiments to elucidate the exact value of these points are to be desired. As to the weight of the various carriages there is no doubt that the advantage lies with Schneider; his mounting is 600 kilos. less than that of Canet, and 950 kilos. less than that of Armstrong. The respective weights of the three carriages, not including the shields, are about 4700 kilos., 5300 kilos., and 5600 kilos.

As regards the space at the rear of the gun, the small dimensions of the brake cylinders, and the way in which they are placed, secure certain advantages in the Schneider system; the man training the gun has a larger free space for manœuvring, and the cylinders are completely sheltered by the shield. In the Armstrong and Canet systems this security is equally well afforded, because the brakes are placed beneath the gun. Facility for training, both in direction and elevation, conduces largely to rapidity in fire. To secure this, the English and French builders place the controlling wheels under the hand of the man training the gun, that is to say, on the left. The operator brings the gun to bear upon the target by moving these wheels, and the same man fires the gun. As to the best relative positions of the two handwheels it appears difficult to lay down any absolute rules, as it appears to be largely a question of habit and personal preference. In the Canet and Schneider arrangement one man trains the gun and fires it. In the Armstrong carriage the gear for training in direction is duplicated on the right-hand side, which suggests the necessity of an assistant to train the gun; the two men stand each on a small footplate and thus move round with the carriage. This arrangement is somewhat complicated and does not appear to have any special advantages; in the other systems the men stand upon the ground, which is a more certain platform; in the Schneider arrangement the steadiness is still further secured by the action of the shoulder-plate attached to the carriage, against which the operator leans to obtain greater stability.

In the Canet mounting an arrangement was introduced by which only one handwheel was necessary for training in both directions, a special intermediate gearing being necessary to secure this result, and as this was liable to lead to error the arrangement has been abandoned. Electrical agency has also been introduced for the same purpose; it is probable that if either of the other two constructors were required to do so they would scheme devices equally efficient; as, however, at present, there does not appear to be any special advantage in using electricity for this purpose, there is no good reason for discussing the subject.

The other parts of the three carriages under consideration do not call for much remark; it may be mentioned that in two of them, those of Armstrong and Canet, the carriage rotates on a series of balls resting on bed-plates. There is also introduced a set of Belleville springs for throwing the greater part of the weight of the mounting on the centre of the underframe when the gun is not being fired.

This arrangement does not appear to insure any greater freedom in movement of the carriage, and the compression of the springs when the gun is fired, producing some displacement of the gun, may readily interfere with precision in firing. In the Schneider mounting a ring of live rollers is employed for training in direction. The arrangement of all these parts is very simple, and, indeed, the arrangements for completely revolving the three mountings, as well as for turning them through the comparatively small angles generally necessary for training in direction, can be affected in about the same time with each carriage.

Ammunition.—The four guns under consideration are arranged for the reception of metallic cartridges. In the Krupp, Canet, and Schneider systems the projectile is inserted in the case of the cartridges, so that the gun is loaded in one operation; in the Armstrong system the projectile is independent of the cartridge, and there are two operations for loading as in ordinary guns. The saving of time which might be obtained in this latter system by the suppression of one of the movements of the breech-block is certainly lost afterwards in loading. For the Krupp, Canet, aud Armstrong guns the cartridge case is stamped out in a single piece, in the Schneider system the base of the cartridge is fastened to the body of the case. The selection of metal for the case and the best manner of fastening it to the body have been made the subject of numerous experiments at Creusôt, where the problem appears now to have been perfectly solved, and is the result of a great deal of interesting information on the manufacture of cartridges of large dimensions. This manufacture has been greatly simplified, and the strength of the base has been carefully tested for each cartridge, which evidently cannot be done where the cases are made of one piece.

Comparative Efficiency of Quick-Firing Guns.—If we compare the power of the four systems under consideration, it may be stated *a priori* that the Krupp gun has to stand by itself, although it approximates somewhat that of Armstrong.

This is brought out in a striking manner by the following Table, in which are given the weights of the projectiles and the initial velocities, as well as the striking energies of each type:

——	Weight in Kilogrammes.	Velocities in Metres.	In Metric Tons.
Krupp	34.5	742	18,994
Armstrong . .	45.36	650	19,164
Canet.	40	750 to 760	25,651 for $V_c = 753$
Schneider. . .	40	809	29,451

The velocities given above for the three guns—Armstrong, Canet, and Schneider—are those which have been officially reported in France by the recent Artillery Commission. The Schneider gun having the greatest efficiency, it has been taken as a unit, and that of the other guns has been made proportional in the following list, which shows:

Schneider 100
Canet 89
Armstrong 65
Krupp 64

This superiority in the energy of the Schneider gun has been necessarily obtained by the use of a heavier charge, but this charge may be assumed as normal, being 12.8 kilos. for Schneider, and 9.750 kilos., of the same powder, for Canet; these two figures are almost in the same proportion as the velocities obtained; the working pressures, it may be mentioned, remain within practical limits not exceeding 2500 atmospheres, which the Schneider gun, carriage, and cartridge can sustain without any danger.

COMPARATIVE DIMENSIONS AND EFFICIENCIES OF ARMSTRONG, KRUPP, CANET, AND SCHNEIDER QUICK-FIRING GUNS.

——	Calibre.		Total Length of Gun.		Length of Gun in Calibres.	Total Weight of Gun with Breechpiece.		Weight of Carriage Exclusive of Shield.	
	mm.	in.	mm.	in.		kilos	lb.	kilos.	lb.
Armstrong	152	6	6324	249.0	40	6452	14,222	5640	12,434
Krupp	149.1	5.87	5220	205.6	35	4770	10,516	3696	8,147
Canet	150	5.90	6750	265.7	45	5740	12,654	5280	11,640
Schneider	150	5.90	6750	265.7	45	5580	12,300	4700	10,362

——	Weight of Shield.		Maximum Recoil.		Limiting Angle for Pointing Gun.	Weight of Shell.		Weight of Charge of Smokeless Powder.	
	kilos.	lb.	mm.	in.	deg. m.	kilos.	lb.	kilos.	lb.
Armstrong	5385	11,870	330	12.99	—7	45.36	100	6.804	15
Krupp	830	1,829	550	21.66	. .	34.50	76.05	7.55	16.64
Canet	980	2,160	400	15.75	—6 +20 20	40.00	88.18	9.750	21.49
Schneider	2500	5,511	250	9.84	—5 +18	40.00	88.18	12.80	28.21

——	Muzzle Velocity.		Pressure.		Number of Aimed Shots.	Number of Unaimed Shots.	Height of Axis of Trunnions above Base.	
	m.	ft.	atm.	tons per sq. in.	per min.	per min.	mm.	in.
Armstrong	671 to 732	2200 to 2400	2000 to 2200	13.1 to 14.4	2	7	1150	45.2
Krupp	742	2434	2435	15.98	?	7	1092	42.9
Canet	750 to 760	2460 to 2493	2400	15.75	4	8	1150	45.2
Schneider	809	2654	2500	16.40	4	8	1000	39.4

The above Table contains the summary of the principal data of the four systems considered in this article, as well as the results obtained in various experiments carried out in the presence of a French artillery commission, at least so far as concerns the

Armstrong, Canet, and Schneider guns. According to statements made public by the various constructors, results, especially as regards the velocities, much more striking than those given here, have been obtained; but these results have always been reported in a confused and incomplete manner; sometimes the weight of the projectile and the nature of the powder employed are not stated, sometimes the calibre of the gun itself is forgotten. Thus we have heard a great deal of a velocity of 880 metres obtained with the 15-centimetre quick-firing gun, and with B.N.G. nitro-glycerine powder, which is quite unsuitable for active service; it has been recorded that the velocity of 1013 metres was made by the Canet gun of 57 millimetre calibre, but the fact was omitted that this gun had the unpractical length of 80 calibres.

It would be out of place to refer in detail to these results, because this investigation has been limited to guns of 15 centimetres, and it appears prudent to reserve further investigation of these marvellously high results claimed, until experiments shall have established their existence beyond doubt.

TABLE OF ERRATA, VOL. I.

Page 24, line 3—For Ferdinand read Fernand.
Page 26, line 2—For apparatus arranged read adopted apparatus.
Page 43, line 2—For $\int_0^{\alpha} \frac{dy}{\cos^{\frac{3}{2}}}$ read $\int_0^{\alpha} \frac{dy}{\cos^3 y}$.
Page 57, head line—For cass read cast.
Page 76, line 8—For indication read inclination.
Page 78, lines 27 and 28.—For mass-units read units.
Page 104, line 16—For refering read referring-
Page 105, Note—For plate read plates (the reference is to armor plates).
Page 111, line 3—For days' read day's.
Page 147, line 17—For ingenuous read ingenious.
Page 152, line 7—For Il read If.
Page 159, line 13—For annottated read annotated.
Page 163, line 14—For N. S. I. read M. S. I.
Page 197, line 17—For alloted read allotted.
Page 252, head line—For Artllery read Artillery.
Page 291, line 13—For "to separate the free states," read "to separate from the free states."
Page 292, par. 4 line 1—For struck read stuck.
Page 293, par. 5 line 2—Insert hyphen in place of dash.
Page 294, par. 1 line 5—Introduce colon instead of semi-colon.
Page 294, par. 3 line 5—Instead of He passed read He was passed.
Page 295, fourth line from bottom—Insert comma between "was" and "the."
Page 296, par. 2 line 2—Introduce "by the Mexicans" after "La Angostura."
Page 296, par. 2 line 6—For Aqua Nueva read Agua Nueva.
Page 296, par. 2 line 12—For or read nor.
Page 297, par. 2 line 3—Use brackets [ ] instead of parentheses ( ), so as to read the consequences [would be] fatal.
Page 298, par 6.—For papagayo read papagallo. For Joaquin read Joachim. For Cuahutitlan read Cuauhtitlan. For ventosa read ventoso.
Page 319, line 9—Arminia read Armenia.
Page 321, line 19 For naval read moral.
Page 321, line 33—For sections read sectors.
Page 322, line 36—For the read this. For adjuncts read adjunct.
Page 323, line 3—For and read as.
Page 326, line 9—For his read their.
Page 324, line 10—For condition read conditions.
Page 334, line 26—For but read by.
Page 337, lines 10 and 11—For the power developed read this power.
Page 338, line 24—For and read of.
Page 348, line 32—For have read has.
Page 379, head line—For Aeavy read Heavy.

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George W. VanDeusen.
John W. Ruckman.
Charles F. Parker.

2nd Lieut. Charles T. Menoher.
T. Bentley Mott.
Oscar I. Straub.
George W. Burr.
William Lassiter.
William J. Snow.

SECOND ARTILLERY.

Colonel John Mendenhall.†

Lieut. Colonel Royal T. Frank.

Major William Sinclair.
Frank G. Smith.

Captain Carle A Woodruff.
John H. Calef.
William P. Vose.
Frank C. Grugan,
George Mitchell.
John C. Scantling.
George S. Grimes.

Louis V. Caziarc.
Robert M. Rogers.
Eph'm T. Richmond.
James E. Eastman.

1st Lieut. Alexander D. Schenck.
Edwin S. Curtis.
Medorem Crawford, jr.
Sebree Smith.
Henry A. Reed.
Edgar S. Dudley.
George F. E. Harrison.
Wright P. Edgerton.
Lotus Niles.
William A. Simpson.
Victor H. Bridgman.
Erasmus M. Weaver, jr.
Hamilton Rowan.
Edwin St. J. Greble.
George F. Barney.
Louis Ostheim.
Isaac N. Lewis.
Cornélis DeW. Willcox.
Arthur F. Curtis.
John A. Towers.

2nd Lieut. Ernest Hinds.
Herman C. Schumm.
Moses G. Zalinski.
George Montgomery.
Daniel W. Ketcham.
Le Roy S. Lyon. (41)

THIRD ARTILLERY.

Colonel La Rhett L. Livingston.

Major Wallace F. Randolph.

Captain John L. Tiernon.
James Chester.
Frank W. Hess.
William A. Kobbé.
Edward C. Knower.
Ramsay D. Potts.

1st Lieut. Charles Humphreys.
Sedgwick Pratt.
Henry C. Danes.
Edward Davis.
Joseph M. Califf.
Charles W. Hobbs.
John D. C. Hoskins.
John R. Williams.
Henry H. Ludlow.
Charles B. Satterlee.
Charles W. Foster.

Wilbur Loveridge.†
Charles A. Bennett.
Edward A. Millar.
Henry C. Davis.
Elisha S. Benton.
John D. Barrette.
E. W. Hubbard.
John K. Cree.

2nd Lieut. George O. Squier.
Edgar Russel.
Peyton C. March.
Archibald Campbell.
John P. Hains.
George Le R. Irwin.
Colden L'H. Ruggles.
Henry D. Todd, jr.
James Hamilton,
Frank G. Mauldin.
William S. McNair. (38)

FOURTH ARTILLERY.

Colonel Henry W. Closson.

Lieut. Colonel Richard H. Jackson.†
Alex. C. M. Pennington.

Major Henry C. Hasbrouck.
Jacob B. Rawles.

Captain Edward Field.
John P. Story.
George G. Greenough.
Frederick Fuger.
Richard P. Strong.
Constantine Chase.
Sydney W. Taylor.

1st Lieut. Harry R. Anderson.
John A. Lundeen.
Albert S. Cummins.
Charles D. Parkhurst.
George L. Anderson.
Clarence Deems.
Walter S. Alexander.
Frederick S. Strong.
Charles L. Phillips.
Clarence P. Townsley.
Adelbert Cronkhite.
Stephen M. Foote.
John C. W. Brooks.
William P. Stone.
Samuel D. Sturgis.
Harry L. Hawthorne.
Lucien G. Berry.
John E. McMahon.

2nd Lieut. George F. Landers.
Alfred M. Hunter.
Charles D. Palmer.
John T. Martin.
William L. Kenly, jr.
Walter A. Bethel.
Morris K. Barroll.
Thomas B. Lamoreux. (38)

FIFTH ARTILLERY.

Lieut. Colonel Francis L. Guenther.

Major Marcus P. Miller.

Captain Charles Morris.
Joshua A. Fessenden.
Samuel M. Mills.
Edmund L. Zalinski.
Benjamin K. Roberts.
Anthony W. Vogdes.
Frank Thorp.
Elbridge R. Hills.

1st Lieut. Henry J. Reilly.
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2nd Lieut. Charles C. Gallup.
Edmund M. Blake.
Sidney S. Jordan.
Edward F. McGlachlin, jr.
William C. Davis.
George G. Gatley. (29)

U. S. NAVY.

Captain W. H. Brownson.

NATIONAL GUARD.

Governor Levi K. Fuller, Vermont.

General F. A. Faries, Louisiana.

Colonel E. C. Brush, Commanding 1st Regiment Light Art. of Ohio.

Captain H. A. Leslie, Commanding Battery "C," 1st Regiment of Ohio.
Alfred E. Hunt, Commanding Battery "B," Penna.
W. H. Beanham, Commanding Battery "B," La. Arty.
R. Prosper Landry, Commanding Battery "A," Ascension Artillery, Louisiana.

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The Hotchkiss Ordnance Company, Limited, Paris, France.
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* Future support withdrawn.
† Deceased.

FINANCIAL STATEMENT, 1892.

The following statement shows money received and expended by the treasurer, in virtue of power conferred upon him by the directing committee at its first regular meeting in January, 1892.

The funds used in the development and publication of the JOURNAL and accounted for below, have been supplied from two sources:

1. Regular yearly subscriptions amounting to . . . . $553.25.
2. Sale of single copies . . . . $ 24.75.

Total receipts . . . . $578.00.

Owing to the nature and necessities of the work, the expenditures have been due to many causes, which are set forth below.

The total amount expended to this date, including all regular payments up to January 1st, 1893 is $430.43. The balance $147.57 is still on hand to be drawn upon as the future may require. This amount will suffice to pay all necessary expenses connected with the publication of No. 1, Vol. II (Whole No. 6), and will carry the work along continuously until next year's income shall be available.

This is an important consideration, and has been kept constantly in view. Moreover as the JOURNAL increases in size and circulation, heavier expenses will, most probably, have to be met in the early part of the coming year. The amount now on hand will satisfy such expenses without embarrassment in case they arise.

Therefore, from a financial point of view, the condition of the enterprise for the coming year appears quite encouraging, and the JOURNAL should, in consequence, continue to widen its sphere of influence and usefulness, and move steadily onward in the course begun.

These few words and the following accounts are respectfully submitted for the information of the supporters and friends of the JOURNAL.

JOHN W. RUCKMAN,
1st Lieutenant U. S. Artillery,
Treasurer.

Fort Monroe, Virginia,
December 15th, 1892.

RECEIPTS.

	$ c.	$ c.
JANUARY—Subscriptions	72 60	
		72 60
FEBRUARY—Subscriptions	145 00	
		145 00
MARCH—Subscriptions	37 75	
Sales of No. 1	75	
		38 50
APRIL—Subscriptions	127 90	
Sales of No. 2.	1 50	
		129 40
MAY—Subscriptions	37 50	
		37 50
JUNE—Subscriptions	5 00	
		5 00
JULY—Subscriptions	24 00	
		24 00
AUGUST—Subscriptions	15 00	
Sales of No. 3	18 75	
		33 75
SEPTEMBER—Subscriptions	10 00	
Sales of No. 1	75	
		10 75
OCTOBER—Subscription	25 00	
Sales of No. 2	75	
Sales of No. 4	1 50	
		27 25
NOVEMBER—Subscription	23 50	
		23 50
DECEMBER 1st to 15th—Subscriptions	30 00	
Sales of No. 4	75	
		30 75
Total	578 00	578 00

EXPENDITURES.

	$ c.	$ c.
JANUARY—Paid cash for copyright and expressage	1 40	
Cash for lithographic plates for No. 1	14 45	15 85
FEBRUARY—Paid cash for printing	25 00	
" " " making drawings	1 50	
" " " postage, stamps, etc.	11 00	
" " " envelopes	10 20	47 70
MARCH—Paid cash for stationery and stamps	10 00	
" " " copyright	3 00	
" " " lithographic plates No. 2	11 29	24 29
APRIL—Paid Cash for printing	10 00	
" " " red paper	5 50	
" " " postage, stamps and incidentals	8 00	23 50
MAY—Paid cash for printing	11 25	11 25
JULY—Paid cash for printing	31 50	
" " " paper for half tone photographs	11 00	
" " " lithographic plates	33 54	
" " " for hal-fotne-photographic plates	26 00	
" " " postage, stamps, etc.	17 00	119 04
AUGUST—Paid cash for printing	3 50	3 50
SEPTEMBER—Paid cash for printing	12 75	
" " " stamps	5 00	
" " " lithographic plates	12 33	
" " " red paper	11 00	
" " " printing paper	28 13	69 21
OCTOBER—Paid cash for printing	21 25	
" " " postage and stamps	18 00	39 25
NOVEMBER—Paid cash for printing	27 50	
" " " special type symbols	8 19	
" " " stamps	7 50	43 19
DECEMBER 1st to 15th—Paid cash for duty, expressage and charges on foreign parcel	10 50	
Paid cash for lithographic plates	10 30	
" " " printing	12 50	
" " " expressage	35	33 65
Total	430 43	430 43
Cash received	578 00	578 00
Cash on hand	147 57	147 57
On deposit in Bank of Hampton, Va.	142 92	
In hands of Treasurer	4 65	147 57

ARTICLES OF EXPENSE.

COPYRIGHT	4 00	4 00
ILLUSTRATIONS—Lithographic plates No. 1	14 45	
" " No. 2	11 29	
" " No. 3	33 54	
Half-tone photographic plates No. 3	26 00	
Lithographic plates No. 4	12 33	
" " No. 5	10 30	107 91
PRINTING—Salary of regular compositor	107 75	
Pay of irregular compositors	49 00	156 75
PAPER—Printing	28 13	
Red (for covers)	16 50	
Half-tone photographs	11 00	55 63
Reproduction of drawings	2 50	2 50
Envelopes	10 20	10 20
Duties, expressage and charges on foreign parcel	10 50	10 50
Special type symbols	8 19	8 19
Stationery	6 35	6 35
Domestic postage	6 24	6 24
Expressage and freight	4 80	4 80
Stamps and foreign postage	52 23	52 23
Binding	2 00	2 00
Paper fasteners	2 00	2 00
Rubber stamps, registry, etc.	1 13	1 13
Total	430 43	430 43

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FORT MONROE, VIRGINIA.

The *Journal of the U. S. Artillery* is for the present published as a quarterly, by authority of the Staff of the School. It is temporarily edited by the following committee, appointed by the Staff:

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1st Lieutenant J. W. Ruckman, 1st Artillery, Treasurer.
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