This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

+ *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.
+ *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.
+ *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.
+ *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at http://books.google.com/

~~War 19.30~~
KF 475

Harvard College Library

FROM THE BEQUEST OF

JOHN AMORY LOWELL,

(Class of 1815).

This fund is $20,000, and of its income three quarters shall be spent for books and one quarter be added to the principal.

JOURNAL

OF THE

UNITED STATES ARTILLERY

PUBLISHED UNDER DIRECTION OF THE

ARTILLERY BOARD.

VOLUME XX

1903.

FORT MONROE, VA.,
ARTILLERY SCHOOL PRESS,
1904.

KF475 Lowell Fund

COPYRIGHT.
JOURNAL OF THE UNITED STATES ARTILLERY.
1902.

JULY–AUGUST.

Vol. XX. No. 1. Whole No. 62.

1903.

JOURNAL

OF THE

UNITED STATES ARTILLERY

PUBLISHED UNDER SUPERVISION OF THE

ARTILLERY BOARD.

FORT MONROE, VA.:
ARTILLERY SCHOOL PRESS.
1903.

[illegible]

The **JOURNAL OF THE UNITED STATES ARTILLERY** is published, as a bi-monthly, at Fort Monroe, Virginia, under the direction of the Artillery Board.

MANAGER AND EDITOR.

Captain ANDREW HERO, JR., Artillery Corps.

Subscription	$2.50
For countries in the postal union	$3.00
Single numbers	$0.50

All remittances should be made payable to **Journal of the U. S. Artillery.** These and communications relating to the editorial management should be addressed **Editor Journal U. S. Artillery, Fort Monroe, Virginia.**

AGENTS.

NEW YORK — *Dyrsen & Pfeiffer*, successors to *F. W. Christern*, 254, 5th Avenue.

LONDON — *B. F. Stevens & Brown*, 4 Trafalgar Square.

ADVERTISING DEPARTMENT.

All communications in regard to advertising should be addressed to **Mr. Frank St. Clair, Box 799, Norfolk, Va.,** who has complete charge of this department.

NEW GERMAN FIRST-CLASS BATTLESHIP "ZAEHRINGEN," 11,800 TONS; 15,000-I.H.P.; Speed 19.0 Knots.

ARMOR PROTECTION: — Water-line belt K. S. 9 inches amidships, tapering to 4 inches at the extremities; above this belt, 6-inch K. S. side armor extending from fore-turret to the one aft. Turrets for heavy guns, 10-inch K. S.; small turrets, 6-inch K. S.; armored casemates and redoubt, 6-inch K. S.; armored deck, 3-inch.

ARMAMENT: — Four 9.4-inch 40-cal. Q. F. guns; eighteen 5.9-inch, 40-cal. Q. F.; twelve 3.3-inch 30 cal.; twelve 1.4-inch; eight machine guns. Six torpedo tubes: One in stem and two on each broadside, submerged; one above water in the stern.

(The photograph shows the battleship passing through the "Kaiser Wilhelm" Canal.)

— Reproduced from *Ueberall*, No. 37, 1903.

JOURNAL

OF THE

UNITED STATES ARTILLERY.

VOL. XX. No. 1. JULY—AUGUST 1903. WHOLE No. 62.

SEACOAST ORDNANCE: GUN CONSTRUCTION; POWER OF MODERN ORDNANCE IN SEACOAST DEFENSE.

BY MAJOR ROGERS BIRNIE, ORDNANCE DEPARTMENT, U. S. A.

(A lecture delivered at the United States Artillery School, Fort Monroe, Va., May 22, 1903).

The seacoast ordnance which we are now using is a development of the last twenty years very nearly. The first gun of large caliber, an 8-inch breech loading rifle, was undertaken in 1883 and completed at the West Point foundry in 1886, but it was not until 1888 that appropriations were made by Congress, which have since been happily continued, upon a scale to really inaugurate a system of coast defense. Many of you will recall with me the hard fought arguments of that period in bringing public opinion, as represented by Congress, to a decision upon the question of a type of gun construction. We have good proof that the right finally prevailed, and ample cause for congratulation in the consistent fine record of the guns and in observing their number now installed in our principal ports. The installation, as we know, is not all complete, yet there is a power even now, as shown so recently in the imposing and inspiring gun fire at Barrancas, to render a naval attack most hazardous, and the same may be said of the chief ports from Portland, Maine, along the Atlantic coast, the Gulf of Mexico and the Pacific coast to Puget Sound. The zeal and interest of the artillery shown in developing the resources of our coast defense will speedily inspire, if it has not already done so, a feeling of security to the country at large against a naval attack. If there be those amongst you who regret the loss of regimental organization, or suppose from any cause that the artillery may lose prestige, let me say in passing that your influences are all working for good and developing men of intelligence and mark, and the careful observer cannot fail to note the high state of efficiency to which the artillery as a body is progressing.

The built-up forged steel gun claimed and secured its place in 1880 to 1885, when the manufacture of a suitable grade of steel rendered it practicable. Its principles were not new. Lamé and Barlow had demonstrated the law of resistance of a hollow cylinder to interior pressure; Rodman had shown the benefit of initial tension in applying this law to guns cast in one piece, and Treadwell and Blakely extended it to building guns of cylinders or hoops under shrinkage. Our cast-iron smooth-bore guns were not excelled in their day; the manufacture of gun iron, so called, reached a high state of excellence, but did not prove efficient for rifled guns. When the built-up construction was first introduced for large calibers in our service it was applied to gun bodies made of cast iron, hooped with steel. This however endured for a brief experimental period only, and has left no present reminder except in a limited number of 12-inch B.L. Mortars, Model 1886, now in service. The mortars of Model 1890 are made wholly of steel.

The *Proceedings of the Naval Institute*, No. 40, 1887, contains an interesting contribution to the history of the gun, and particularly the quality of steel which should be used. The effort was made to show that the steel which the Army and Navy Ordnance bureau were then advocating was of a grade of so-called high steel with uncertain strength and properties, and that guns should be made of mild steel, with little or no carbon, and having a tensile strength of from 55,000 to 65,000 pounds. The commercial advantage pointed out was that this grade of steel could be readily manufactured in quantity in our own country, and a high price would necessarily be paid for the special steel which the government was demanding. Fortunately at this time we had concluded a very thorough examination of the qualities of steel hoops of domestic manufacture, and had made shrinkage tests which gave a clear idea of the problem of gun construction. What was plainly wanted was a metal possessing a high elastic limit, with good ductility and ultimate strength, to withstand the pressures to which a gun should be subjected without deformation. A gun is essentially an instrument of precision. An ideal gun may be compared to a perfect spring, responding to the pressure of the powder gases and then resuming precisely and invariably its original dimensions. Steel is the best available metal for guns and the best quality is required. The constant demands of the government for maintaining a high standard of quality and to improve it wherever practicable has been of great benefit to the domestic trade. Whereas 15 years since the output of such steel in this country could be counted in pounds, it is now a great industry, and our manufacture of gun steel, including tires and other like products, is not surpassed elsewhere.

The steel used in the tube, jacket and hoops of the gun body is ordinarily made by the open hearth process, with a medium per cent, about 45, of carbon. About 6 per cent. of the ingot is cut off from the bottom and 30 per cent. from the top to exclude porous or unsound metal.* The remainder is forged and finished to rough dimensions and then treated by first annealing, second oil tempering, and third a second annealing.

The most ductile metal is used in the tube and the highest elastic limit is obtained in the hoops, which are comparatively thin and are more thoroughly worked than the larger forgings. The physical qualities prescribed for acceptance of forgings for cannon of 8-inch caliber and upwards are:

	Elastic limit. Pds. per sq. in.	Tensile strength. Pds. per. sq. in.	Elongation after rupture. per cent.	Contraction of area. per cent.
Tube.	46,000	86,000	17	30
Jacket.	48,000	90,000	16	27
Trunnion Hoops.	50,000	90,000	14	20
Cylindrical Hoops.	53,000	93,000	14	20

Nickel steel, or steel containing about 3.5 per cent of nickel, is now required for breech blocks and spindles, with an elastic limit of 70,000 pounds. It is also supplied for the tubes of 5 and 6 inch rapid fire guns of latest model, the prescribed elastic limit being 65,000 pounds. The tube and jacket of the 16-inch gun, recently completed, were made of nickel steel, since the manufacturers would not otherwise guarantee an elastic limit of 50,000 pounds in the metal. The cost of the nickel steel, for the present, acts as a bar to its more extended use. The gain in elastic limit is about 30 per cent over the carbon steel. Progress in the manufacture of steel forgings from year to year is shown in the increased size of forgings produced without deterioration of quality, and whereas the first 8-inch gun was made with hoops about 12 inches long, it is now not uncommon to make the hoops 60 inches long or more.

The formulas applicable to the construction of built-up forged steel guns have been variously discussed and used in different forms, amongst others, by Gadolin, Virgile, Clavarino, Duguet and Pashkievitch abroad, and by Meigs, Ingersoll and Glennon, of the navy, and your commandant, Captain (now Colonel) Story. My own experience led to the use of Clavarino's work, which deals directly with the strains produced in the

*When fluid compression of ingot is used, the amount rejected at top is reduced to about 7 per cent.

metal by all the extraneous forces, and by an evaluation of these strains we are enabled to conserve the primary condition that no part of the gun should be subjected to strain beyond the elastic limit of the metal. By modifying Clavarino's formula in relation to longitudinal stress, a set of relations was secured which produced a most satisfactory agreement in actual construction. The formulas were placed in form to discuss fully the forces engendered in building up a gun with cylinders applied by shrinkage and thus enabled the fidelity of work to be verified not only in the completed gun but also in the various stages of construction, by measuring the bore of tube and the diameters of successive cylinders when applied.

Another valuable attribute of formulas applying directly to the state of rest of the system is the facility afforded for the adjustment of shrinkages in different sections throughout the length of the gun. In making the computations for all parts of a complete gun, the changes in the number of layers and in sectional dimensions from part to part render it necessary to divide the whole length into a number of sections and compute the resistance, shrinkages and strains for each. These sections cannot, however, be considered wholly independent, as that would give rise to a variety of values which would be inconvenient to apply in practice and would cause undesirable inequalities in strains in passing from one section of the gun to another. Whilst not overlooking the primary consideration to preserve wherever practicable, the maximum resistance and, in all cases a sufficient elastic resistance to withstand anticipated pressures, two general rules are to be observed, namely: 1. To apply, as far as practicable, uniform values for the shrinkages in contiguous sections where the shrinkage diameters are the same, or nearly so. 2. To so modulate the curves of compression or contraction of bore in the state of rest that the final curve will present a comparatively smooth contour, conforming in general to the curve of powder pressure and having no abrupt change of ordinates. As it will in general be most necessary to preserve the maximum resistance in the section of the powder chamber, that section should be considered first and the values belonging to it taken to govern others. Under these considerations it frequently becomes necessary for a given section of the gun to assume certain values as, for instance, one or more of the shrinkages, the contraction of bore or other conditions and combine the various equations or transform them to obtain desired results.

Practice has shown a remarkable conformity of results obtained in the actual manufacture of guns with those indicated by the formulas applied in their construction. One of the earlier experiments consisted in building a section of gun with 8-inch bore, composed of four cylinders, shrunk one upon the other. The displacements of diameters and lengths caused by each shrinkage were carefully measured and showed in every instance close agreement with values deduced by the formulas. For example, the anticipated total compression of the 8-inch bore was 0.0129 inch, and its measured compression 0.0131 inch. The anticipated extension of the exterior of the fourth layer or outer hoop (diameter 31.5 inches) was 0.0285 inch and its measured extension 0.0276 inch. These culminating measurements of the series thus showed a difference of less than 2 per cent between the actual and anticipated results.

When a hollow cylinder is subjected to interior pressure the surface of the bore sustains the greatest strain which is exerted to enlarge the bore tangentially. The metal away from the surface of the bore is strained to a less degree depending upon its distance from the axis. Hence, it follows that the elastic strength of a cylinder is measured by an interior pressure that will expand the bore of cylinder to the point where the elastic extensibility of its metal is reached. In the case of a simple cylinder, an increase of thickness of wall beyond about 1.25 calibers adds little to the strength; and, even for an infinite thickness, the elastic resistance is but 0.75 of the elastic limit of the metal. The limit of elastic resistance of a compound tube is twice as great, and, in general, it may be said, that the resistance of a built up gun will be double that of a simple gun of the same dimensions, provided the construction is such as will admit of compressing the bore of the tube to its limit of elastic compressibility in the state of rest. The effect is then to allow the metal at the bore double the range of movement it could have in a simple cylinder. Stated in another way, the tube of the compound cylinder is rendered more resistant by reason of the exterior pressure exerted upon it by the shrinkage of other cylinders around it. Or again, the enveloping cylinders are working at higher tension than they would be if forming part of a simple cylinder, because of the strains in them due to shrinkage. It can be seen indeed that a state of maximum resistance to interior pressure would be induced if the thickness of metal through the wall of the cylinder should be uniformly strained to the elastic limit of the metal. This perfect state is theoretically obtainable only with a cylinder having initial tension introduced by interior cooling and for a particular thickness of wall, that is, 0.65 of a caliber nearly.

The law of resistance in a cylinder with initial tension produced by interior cooling is the same as for a built up cylinder.

In the initial state of a gun or cylinder treated by interior cooling, the interior portion of the wall rests in a state of tangential compression, which is greatest at the surface of the bore, and the exterior portion in a state of tangential extension which is greatest at the outside surface. The strains of compression and extension are in equilibrium—the aggregates of the two being equal quantities. There is a neutral lamina in the wall where the tangential strain is virtually zero, and from this locality the compressions should increase progressively towards the bore and the extensions, likewise towards the outer surface.

Suppose the initial tension curve to be such as is required by theory to give a maximum resistance, several consequences may be stated as follows:

1. The point of critical strain will be at the surface of the bore where the compression at rest and the extension under interior pressure will be greater than at any other place, but by condition must not exceed the elastic limit of the metal.

2. To make the resistance to interior pressure a maximum in any cylinder, the state of initial tension should be such that when the pressure acts from within the whole thickness of metal in the wall should be, as nearly as practicable, uniformly strained to the elastic limit of the metal. If this condition of uniform strain is attained it will give the possible maximum resistance for the cylinder.

3. If the limits of elastic extension and compression for the metal are equal, as usually considered, and the compression of bore carried to the limit, there is but one thickness of cylinder, 0.65 caliber nearly, for which a condition of uniform strain in action equal to the elastic limit of the metal can be attained.

4. For cylinders of greater thickness than 0.65 caliber, a state of uniform strain in the wall will be reached under the action of an interior pressure and passed before the elastic limit of the metal is attained, and with increasing pressure this limit will be fully reached only at the surface of the bore, thus determining the limit of pressure. For such cylinders the best condition of resistance will be obtained by utilizing the full limit of compression of the metal in the initial tension.

5. For cylinders of less thickness than 0.65 caliber, a state of uniform strain in action equal to the elastic limit of the metal and, consequently, the possible maximum resistance can be obtained with a compression of bore less than the elastic limit of the metal under compression. The thinner the cylinder the less should be the initial compression imposed. If the full limit of initial compression were given, the elastic limit of the metal would be reached in action at the exterior of the cylinder sooner than at the bore, and the resistance would be diminished. It follows that the possible maximum resistance of such cylinders will be obtained by adjusting the initial compression within limits, and the resistance of cylinders of less thickness than 0.65 caliber, treated by interior cooling, should be directly proportional to the thickness. No other means can be provided, so far as I am aware, for deriving as great resistance from a given weight of metal in a cylinder of given caliber.

The apparent value of utilizing the principle of initial tension, which is but another form of shrinkage, has appealed to me with great force. If successfully applied it economizes weight of metal for the same tangential resistance, and affords a solid gun body free from joints. It also promises cheapness of construction in avoiding the finishing of shrinkage surfaces. A 3-inch gun and a 5-inch rapid fire gun have been constructed on this principle and tested extensively with satisfactory results.

A number of 5-inch tubes have also been made in this way. The outcome of the process in these tubes has not been encouraging for a continuance of this method in view of the trouble experienced and the number of re-treatments necessary to obtain the degree of initial tension desired. I believe, however, that care and experience in manufacture would be able to control this plan of construction and apply it advantageously at least to guns of small and medium caliber. The apparent difficulty that would arise with guns of large caliber is in procuring the whole gun body in one piece of uniform quality. This is, however, also a question of experience and advancement in knowledge of the art, and quite within the limits of future possibility.

This method of construction must not be judged by the results from the 8-inch Gatling gun tested in 1899, which burst at the 15th round after being subjected to powder pressures not exceeding about 41,000 pounds per sq. inch. In the construction of the gun it was attempted to secure initial tension by mandrelling the bore while hot. The gun was made of cast steel, and not forged, and one of the broken fragments of the gun, comprising half of the powder chamber, showed along the ruptured surface three cavities extending from 1 to 4 inches into the body of the metal. The interior of the cavities extended to the surface of the powder chamber, and had been noticed as slight imperfections before firing.

The several attempts to make cast steel guns in one body have resulted in failure, either from imperfections combined with faulty construction as in the Gatling gun, or from deficiency in elastic strength, as in the cast guns of low steel tested by the Navy department under Act of Congress, approved March 3rd, 1897. The Bofors Company, in Sweden, probably alone, of all manufacturers, make guns of cast steel, and of first rate quality. It must be understood, however, that the guns are made with tube, jacket and hoops on the built up principle and the parts are treated after casting to improve their quality in essentially the same manner as forgings at other manufacturers. The Bofors Company has made a specialty of steel castings and its products are held in high repute.

Notwithstanding the greatly increased power of the more recent models of heavy guns in our two services, the Army and Navy, there has been no necessity for adopting a wire gun construction to replace the forgings. My preference has been and still remains for the latter when constructed with the care exercised in our service, believing that it will, in general, afford greater stiffness and strength longitudinally and sufficient strength tangentially, particularly for the larger calibers. Moreover, under the consideration that the tube should not be worked beyond its limit of compression at rest or of extension in action, there is no apparent gain of tangential strength for wire construction in the heavier calibers.

The Crozier 10-inch wire-wound rifle has been subjected to a test of 275 rounds and recommended by the Board for Testing Rifled Cannon, appointed under the Act of Congress, approved July 5th, 1884, as "a suitable gun to be put in the government service." For concise statement of the results of trial, which was entirely successful, and of the merits of the design I cannot do better than quote from the report of the Ordnance Board, page 320, report of the Chief of Ordnance, U. S. Army, 1896. It will be noted that the finding is specifically opposed to the objection regarding lack of stiffness in the chase.

After 275 rounds, "the gun is now so eroded at the commencement of the rifling that, being experimental for other purposes than the effect of erosion, it is not considered judicious to subject it to further firing without lining, unless it be considered that the test for efficiency and stability of the system of construction is at an end, and it is desired to gain knowledge as to the extent to which erosion can be allowed to proceed without danger. The accuracy of the piece, provided projectile bands of increased diameter be used, does not seem to be impaired. Relining is permitted for guns built under contract for the Department after 250 rounds. Impressions of the eroded portion of the bore are forwarded".

"The strength and endurance of the system seem to have been abundantly proven by this test. The design does not indicate as great tranverse stiffness of chase as that of the service guns if it be assumed that the wire affords no assistance in this particular; the results of the test, however, indicate that such an assumption would be erroneous, since, after a careful examination of the gun, no evidence whatever, can be found of a lack of stiffness at any part of the bore. If special attention were given to this feature, it is probable that a still greater stiffness could be given to the chase without materially changing the design".

"No superiority of theoretical tranverse strength over that of the service type of gun is claimed by the inventor for this system".

"The designed powder pressure is placed 5,000 pounds per square inch higher than for the service type for reasons which he states about as follows: In the service gun the elastic limit of the exterior cylinders is reached when that of the tube is; any higher pressure, overstraining the tube, will, therefore, also overstrain the outer parts, which thenceforth will cease to afford the designed support to the tube. In the wire gun the large reserve of strength of the tube's envelope prevents this condition from arising. Nearly the maximum theoretical strength can therefore be utilized with confidence".

"Further alleged advantage is based upon cheapness of construction".

"The following is a comparison of certain elements of this gun and the 10-inch service gun as shown by the tests of the Crozier and the type 10-inch, as far as they have proceeded, that of the type gun being still in progress:

		Service.	Crozier.
Weight	tons.	30	30
Projectile	pounds.	575	575
Charge service, brown powder	pounds.	250	267
Pressure per sq. inch	pounds.	37,000	42,000
Velocity	feet per sec.	1,975	2,100
Muzzle Energy	foot-tons.	15,550	17,560

		Service.	Crozier.
Rounds fired :			
Brown powder	number.	260	275
Smokeless powder	number.	8	
Mean charge :			
Brown powder	pounds.	220	267
Smokeless powder	pounds.	115	---
Mean pressure per sq. inch	pounds.	32,800	40,800
Maximum pressure per sq. inch	pounds.	61,000	46,000
Enlargement along middle length of chamber	inches.	*0.003 to 0.005	0.007 to 0.015

* After 244 rounds.

"It is proper to state that the type gun is not so badly eroded as the Crozier, and it is still in condition to be fired".

The Brown wire-wound gun with segmental tube, is still under consideration by the War department. It is understood that the Board of Ordnance and Fortification has recommended the procurement and trial of a 6-inch gun, which is prescribed to give a muzzle velocity of 3,500 f.s. with 100 pound projectile.

The Bofor's 6-inch R.F. gun, now undergoing test at Sandy Hook, has been fired somewhat over 250 rounds. The gun is built up of parts comprising tube, jacket and breech piece, not forged but made of cast nickel steel specially treated after casting. The projectile weighs 100 pounds, and the standard velocity is 2,624 f.s., to be obtained with a pressure not exceeding 35,000 pounds. The most interesting feature of the gun is the breech mechanism, which is opened and closed by a single movement, and may be operated automatically or by hand. The breech recess is conoidal in shape with a large and convenient opening to the rear for loading, and is fitted with a loading tray that works automatically. The mounting is provided with two sets of sights, one on either side, so that one man can control the direction and another the sighting in elevation for rapid firing. In the trials for rapidity at will, 10 rounds were fired in 103 seconds with the breech operated by hand, and 10 rounds in 94.6 seconds with the breech operated automatically. The automatic arrangement is complete for both opening and closing the block. The opening is effected by the recoil of the gun in its cradle, which, at the same time compresses a spring and a catch holds the block open. On releasing this catch the spring automatically closes the block. This mechanism has worked well throughout. The automatic feature gives only a little increase of rapidity in fire, but has the advantage of saving space for loading and dispenses with the services of one man. Amongst the many labor and time saving devices now attempted to be introduced for the service of guns, which are frequently objectionable, because of delicacy and increased complications, the Bofor's automatic breech opening and closing device appears exceptional for distinctive merit and certainty of operation. To see it in operation one experiences the same sense of relief, to a degree, as in the use of fixed ammunition instead of separate loading in the rapid fire field guns. The cannoneers are saved by so much from violent and rapid exertion, the loading progresses more smoothly, and withal, with increased rapidity.

SERVICE GUNS FOR SEACOAST DEFENSE.

The cannon completed for seacoast defense, most of which are now mounted, comprise about 70 6-pdrs., 194 15-pdrs., 4 4-inch, 44 4.7-inch, 32 5-inch and 127 6-inch R.F. guns; 80 8-inch, 131 10-inch and 105 12-inch seacoast guns; and 376 12-inch mortars, besides 1 16-inch gun. The totals are 471 rapid-fire guns, 317 heavy seacoast guns, and 376 12-inch seacoast mortars, making 1164 in all. These are all of the built-up type and made wholly of steel, except 80 of the 12-inch mortars, which are composed of a cast iron body hooped with steel. Data pertaining to the standard service types with smokeless powder charges are as follows..

TABLE I.

GUN.	Length of bore. CALIBERS.	Projectile. POUNDS.	Muzzle velocity. F.S.	Muzzle energy. FT. TONS.	Estimated perforation of steel. INCHES.
2.24-inch R.F.	50	6	2400	255	——
3-inch R.F.	50	15	2600	703	4.36 K.C.
5-inch R.F., M. 1897.	45	55	2600	2577	7.13 K.C.
6-inch R.F., M. 1897.	45	100	2600	4686	9.25 K.C.
6-inch R.F., M. 1900.	50	100	3000	6239	11.06 K.C.
8-inch B.L.R., M. 1888.	32	300	2300	10528	12.5 K.C.
10-inch B.L.R., M. 1888.	34	575	2300	21086	16.9 K.C.
10-inch B.L.R., M. 1895.	35	575	2300	21086	16.9 K.C.
10-inch B.L.R., M. 1900.	40	575	2560	26120	19.7 K.C.
12-inch B.L.R., M. 1888.	34	1000	2300	36671	21.3 K.C.
12-inch B.L.R., M. 1895.	35	1000	2300	36671	21.3 K.C.
12-inch B.L.R., M. 1900.	40	1000	2560	45420	24.8 K.C.
16-inch B.L.R., M. 1895.	35	2400	2300	88050	32.0 K.C.
12-inch Mortar, M. 1886.	9	800	1200	7986	7.2 K.C.
12-inch Mortar, M. 1886.	9	1000	1050	——	——
12-inch Mortar, M. 1890.	10	800	1325	——	——
12-inch Mortar, M. 1890.	10	1000	1150	9168	7.9 K.C.

K. C. Krupp armor, capped projectile.

A similar table for U. S. Naval guns of recent type, models of 1899, shows.

TABLE II.

GUN.	Length of bore. CALIBERS.	Projectile. POUNDS.	Muzzle velocity. F.S.	Muzzle energy. FT. TONS.	Estimated perforation of steel. INCHES.
3-inch Mark I.	50	13	2800	709	4.4 K.C.
4-inch Mark VII.	50	32	2900	1870	6.4 K.C.
5-inch Mark V.	50	60	2900	3503	8.4 K.C.
6-inch Mark VI.	50	100	2900	5838	10.9 K.C.
7-inch Mark I.	45	165	2900	9646	13.2 K.C.
8-inch Mark V.	45	250	2800	13602	15.0 K.C.
10-inch Mark III.	45	500	2800	27204	20.0 K.C.
12-inch Mark III.	45	850	2800	46246	20.0 K.C.

K. C. Krupp armor, capped projectile.

I will not attempt to describe in detail the construction of the gun as built up of tube, jacket and hoop forgings. The general features are familiar to us all. Each type of gun is assembled with uniform shrinkages, the values of which are based upon the elastic limit of the metal determined from tests of specimens cut from the forgings. The elastic limit for this determination is taken as the lowest fixed for the acceptance of the metal. The resistance of the gun then computed for the typical case will be the least of its kind, and the good effect of the higher elastic qualities in the steel, which will be put into most of the guns, will result in giving a greater resistance without necessitating any change in the prescribed shrinkages. The estimated tangential resistance of the 8, 10 and 12-inch guns, that is, the pressure per sq. inch, which can be supported in the powder chamber without exceeding the elastic limit of the gun, is about 52000 pounds.

Beyond this a permanent set of the bore may be produced, but rupture is prevented by the ductility of the metal, and the guns can support higher pressures. The standard limit of powder pressure for the charge is 38000 pounds per sq. inch, or about 73 per cent of the elastic resistance of the gun.

The actual limit of safe pressure for these guns is probably not less than 70000 pounds to the square inch. But one case of explosive rupture of a gun of this type has occurred at the Sandy Hook Proving Ground aside from experiments with explosives. This was a 10-inch gun, in March 1899, using an experimental smokeless powder which proved to be of brittle nature.

The breech of the gun was destroyed. The two pressure gauges registered 78000 and 79000 pounds per square inch. On another occasion, the breech block of a 5-inch gun was stripped under an estimated pressure of about 70000 pounds. Six-inch R. F. gun No. 1, sustained a pressure of 86000 pounds as registered by the gauge, which resulted in wedging the breech block.

Various calibers of the guns including the 12-inch have been repeatedly subjected to pressures of 50000, and in exceptional cases considerably higher pressures without serious effect.

The type guns of heavy calibre have sustained the following number of rounds for endurance, &c., namely: experimental 8-inch gun No. 1, West Point Foundry, 335 rounds; 8-inch gun No. 1, Watervliet Arsenal, type, 390 rounds; 10-inch gun No. 1, Watervliet Arsenal, type, 281 rounds; 12-inch gun No. 1, Watervliet Arsenal, type, 265 rounds, and the types of 12-inch mortars model 1886 and 1890, respectively, 398 and 399 rounds. Barring erosion, all the guns are intact except the second 8-inch in which longitudinal cracks appeared in the tube at the muzzle after 388 rounds.

The several types of Army guns are apparently well adapted to the requirements of seacoast defense. A model 1900, 5-inch gun with 3000 f.s. muzzle velocity is to be produced and a model 1900 8-inch gun, 40 calibers length of bore, is required to complete the system and bring it up to date in comparison with other standards. Exception will be taken to the 6-pounder gun on rampart mount, intended either for use in the fortification or for defense against landing parties, but practically consigned to the latter purpose only. This mounting is inconvenient, too heavy and cumbersome for the mobility desired, and must be anchored, in any case, for firing. It is generally conceded that the 6-pounder guns would be better placed on pedestal mounts.

The purchase has been ordered of a Vickers-Maxim 1-pounder automatic gun (the "pom pom") with mountain equipment, the object being in part to test its availability for landing defense. The mountain wheel carriage, with gun complete, weighs only about 900 pounds. The shell power of the gun is sufficient to destroy boats and its fire is very rapid. It appears that this combination should fulfill the requirements of this service.

The increase of power of the 12-inch model 1900 rifle, using smokeless powder, over the 12-inch model 1888, using brown powder, is strikingly shown by a comparison of the muzzle energies. The model 1888 rifle gave 28426 foot-tons while the model 1900 gives 45420 foot-tons or an increase of about 60 per cent. The range of the new 12-inch rifle at 10 degrees elevation is about 13360 yards.

The 16-inch rifle is justly regarded as a magnificent piece of work. Special credit is due Major Charles S. Smith of the Ordnance Department who designed the gun, the Bethlehem Steel Company that produced the forgings, to those in charge of the work at the gun factory, particularly Captain Hobbs of the Ordnance Department who directed the critical operation of shrinking on the jacket, and to the DuPont Powder works who produced a first lot of powder that almost exactly fulfilled the estimated results. The piece has been fired 8 rounds with charges of DuPont nitro-cellulose powder, lot 1, 1902, for 16-inch rifle, varying in weight from 450 to 640 pounds. Round No. 6, charge 640 pounds and projectile 2400 pounds, gave 2345 f.s. muzzle velocity with 38545 pounds pressure, and muzzle energy 91500 foot-tons. Colonel Ingall's estimate of the maximum range of this piece is 20.9 miles and the maximum ordinate of the trajectory, 30516 feet or above 5.75 miles. The gun is at present mounted upon a proof carriage. It is intended to be subsequently tried upon a disappearing carriage of new design prepared by General Buffington and being constructed at Watertown Arsenal. Guns of this caliber were demanded by the Endicott Board, in 1885, and this gun has been produced as a type for such further manufacture as may be required. In view of the present developed power of the 12-inch rifle, particularly with a high explosive charge in the projectile, as compared with the resistance of ship armor, it would appear that 16-inch guns are not essential to the defense of the coast.

A notable illustration of the power of the 12-inch rifle was given in the competitive tests with the 18-inch Gathmann gun, at Sandy Hook, in November 1901. A Carnegie-Krupp face hardened steel plate 16 by 7.5 feet by 11.5 inches thick was mounted with backing to represent a section of the side of a battleship. The plate and backing were completely destroyed by three rounds with armor piercing projectiles charged with high explosive fired for normal impact but with reduced velocities corresponding respectively to ranges of 4400, 4400 and 1880 yards. It was very conclusively shown by these trials that penetration is required to render high explosive projectiles effective against strong armor. The 12-inch projectiles contained, respectively, about 20, 23, and 60 pounds of explosive. The 18-inch Gathmann projectiles which were fired at a similar plate were fragile shell each containing about 500 pounds of wet gun cotton yet they produced no appreciable indentation upon the surface of the plate.

In this connection attention should be invited to the following extract from the report of the Fort Wadsworth board on fire control, September 3, 1901, as published in the *Journal of the United States Artillery* No. 55, May-June, 1902, page 299. The report states:

"Not only has it been demonstrated that an high explosive of great power can readily be fired from powder guns, and that these explosives may be fired through armor plates of considerable thickness; but also that armor plates of 12-inches thickness can be entirely destroyed by the explosion of a charge upon their face, without any penetration."

In support of this the Board further states:

A "12-inch torpedo shell loaded with 125 pounds of explosive *D* was fired against a 12-inch plate of hardened steel, with a remaining velocity equal to that which it would have had at a range of 3500 yards. The charge exploded on the face of the plate without penetration and the plate was utterly destroyed."

These quotations refer to round 265, May 8, 1901, from 12-inch B. L. rifle No. 1. A summary of the trials is published in the Report of the Chief of Ordnance, U. S. Army, 1901, appendix 46. The effect of the torpedo shell was certainly very destructive but the deductions of the Fort Wadsworth board therefrom are much too sweeping. First, because the plate fired at was a weak fragment of a larger plate and the backing was also weak and, second, the plate *was* partially penetrated. A basin shaped depression 3.5 inches deep was formed at the point of impact where the plate was broken. What the effect of this shell would have been against the strong Gathmann targets is uncertain. It would have been greater no doubt than that of the Gathmann shell because the torpedo shell is much stronger and was capable of penetrating nearly one-third through the fragment of 12-inch plate. However, all the high explosive tests confirm the opinion that the greater the penetration the better the effect. And the conclusion was reached that a 12-inch A. P. shell, capped, and holding 60 pounds of explosive is to be much preferred for the attack of heavy armor over a torpedo shell holding more than double the amount of explosive.

I do not concur with the views of the Wadsworth board as to the utility of firing the torpedo shell from high power guns. These are relatively weak shell not adapted for penetrating armor, but rather for vertical fire to produce an explosion upon deck, or damage the hull if falling alongside. Moreover although this shell has been fired safely and indeed is regularly tested for acceptance under a powder pressure equal to the standard for the 12-inch gun, yet it is hardly so strong a shell as desired for firing regularly from this gun, particularly when charged with high explosive, in view of the very serious consequences that would follow from an explosion in the bore. The torpedo shell

I think should be reserved for mortars and will find its best application at ranges between 2000 and about 4500 yards within which limits the D. P. shell is deficient in deck penetration.

The projectiles provided for war service with the sea coast guns, other than shrapnel up to 6-inch caliber, are steel A. P. shell and shot. The relative value of these for armor penetration, without an explosive charge, is indicated by the tests which they must undergo for acceptance. The shell must penetrate a plate about three-fifths caliber and the shot a plate one caliber thick without breaking up when fired with a striking velocity just sufficient for perforation. Taking the 12-inch for example: the test velocity of the A. P. shot against a 12-inch face hardened plate is 1475 f.s. and that of the A. P. shell against a 7-inch nickel steel plate is 900 f.s. Now, even with a muzzle velocity of 2000 f.s. these test velocities correspond to a range of 5600 yards for the shot and *considerably over* 12000 yards for the shell. The addition of the high explosive charge adds very materially to these figures.

It has apparently made the shell equal to breaking through one caliber thickness by exploding in the plate. The value of the shell for penetration has also been enhanced by providing it with a soft steel cap like that heretofore used on the shot. These shell, it may be said, take the place, in our service, of the common shell (a term so often used elsewhere.) Their cost is not materially greater than the ordinary common steel shell, while their effectiveness is of a high order. The quantity of high explosive contained in the shell (64 pounds for the 12-inch) combined with its very much greater penetrative power, renders it more effective than the torpedo shell from high power guns, and and makes another reason for not using the latter in these guns. Improvements are now being made in the armor piercing shell which increase their perforative power; also, if the shell has a striking velocity considerably higher than needed for perforation, it may be carried intact through the plate and burst well within the ship as desired for the most effective work. The superior penetrative power (without breaking up) of the A. P. shot, however, makes it the most effective projectile for use within the limits where heavy armor can be certainly perforated. This projectile, it will be understood, is really a thick walled shell, and carries an effective bursting charge of high explosive.

In general terms it would appear that the tactics should prescribe the use of A.P. shell against other than the heavily armored ships at all ranges; and, as regards the latter, a larger proportion of the shell should be used at long ranges, and a larger proportion of the shot within the armor piercing zone, or say 4 shells to 1 shot from extreme ranges to about 6000 yards, and 3 shot to 2 shell within 6000 yards. This would seem a fair proportion in considering also that every round may not be expected to strike and penetrate to the "vitals," so called, of the ship, but may more often hit the upper works and guns in casemate above the protective deck, which, in most vessels so far built, are not protected by heavy armor on the broadside. Or if the vessel is end on, a projectile passing above the turrets or bulkheads may produce the same or even greater effect upon parts above the protective deck than from the broadside position.

The use of the terms "deck piercing zone," "intermediate zone" and "armor piercing zone," in gun fire, do not seem to me to be necessary or appropriate. And, in fact, does not the armor piercing zone properly extend to the limit of fire, or say 12000 yards for the 12-inch gun. As already stated, the A.P. shell has sufficient remaining velocity to perforate 7 inches of armor beyond 12000 yards, and the high explosive charge increases its effectiveness; it also increases the effectiveness of the A.P. shot. It will, of course, be noted that these remarks refer to normal impact, but on the other hand normal impact may be secured against the turrets, bulkheads or armored sides of a ship at any range. Hence it would appear that armor piercing shell and shot should be used against the battleships at all ranges from the extreme to the shortest.

It is a matter of great interest to the artillerist, but not vital, I think, to the question of fire direction, to know in how much oblique impact detracts from the perforative power of projectiles both on heavy armor and on deck armor. At long ranges the gunner cannot choose what part of the ship to hit, but will be fortunate to secure a hit in any part; at short ranges where this can be controlled, the shot would be naturally directed to secure normal impact, at a turret or bulkhead if the ship be coming nearly head on or at the broadside if that be nearly perpendicular to the line of fire. The general knowledge that oblique impact weakens the fire leads to its avoidance as much as possible.

The perforative power of a projectile decreases with the angle of impact (angle made by the trajectory with the face of the plate or tangent plane) from that which it has on normal impact. The laws governing the loss of this power so far as I am aware, have not been formulated. If the angle is great enough for the point of the projectile to take hold, the projectile tends to take a normal position for penetration and also to crack the plate. The question has two phases. One in the case of thick armor where the plate is about a match for the projectile at normal impact, and the other the case of deck armor where the plate is largely overmatched and where a slight angle of impact can let the projectile break through the plate.

For thick armor, experiment has shown that the point of an uncapped shell will enter the plate at about 45 degrees angle, and a capped projectile at a somewhat smaller angle. This will not, however, always occur, and there is, at the best, a great loss of perforative power as compared with normal impact. The loss of power, where the projectile takes hold at all, is probably not in proportion to the thickness in the direction of the line of fire, but may be approximately estimated by this rule. For angles of impact of 60, 50, 55, 40 and 35 degrees, the thickness of plate on the line of impact is increased over the normal thickness respectively 15, 30, 41, 55 and 75 per cent. It is probably not good practice to fall below an angle of 60 degrees, or 30 degrees from the normal, that is to say, if a vessel's broadside presents a less angle than this it would be best to fire at her turrets or bulkhead.

Thin armor, like deck armor, can be broken through by relatively heavy projectiles with slight angle of impact. The practice of the Navy Bureau of Ordnance in tests of deck plates for acceptance has established the following as about the limit of good nickel steel plates, the poorer quality of plate cracking or tearing open and allowing the projectile or fragments to pass through, viz:

The plate is set up at an angle of 9 degrees with the line of fire, then,

A 1-inch plate will sustain the impact of a 4-inch 33-pound projectile with 1912 f.s. striking velocity.

A 1.5-inch plate will sustain 1775 f.s., a 2-inch plate, 1850 f.s.

A 2.5-inch, 1950 f.s., and a 3-inch plate, 2000 f.s., all with a 6-inch 100-pound projectile.

From these results it will be seen that 8, 10 and 12-inch projectiles can readily perforate the same plates if striking at an angle of 7 degrees or greater. The effect in this case is produced rather by a side blow of the projectile acting to dish the plate and not by the point of the projectile taking hold. At the instance of the Board to revise Coast Artillery Drill Regulations here, experiments are shortly to be made at Sandy Hook with 8, 10 and 12-inch projectiles fired at representative deck plates, at various angles of inclination, to determine the least angle at which these projectiles will be effective on the plates.

In connection with the employment of mortar fire, I take opportunity to congratulate the members of the Fort Preble board upon the work accomplished and the establishment of a standard of excellence that will always bear emulation. What I regret is that the board should have fixed upon 3,000 yards as the minimum limit of useful range. That limit is undoubtedly too great, and I feel confident in saying that it will hereafter be decreased to 2000 yards, and we will not, either in maneuvers or actual conflict, have the spectacle of vessels enjoying a safe anchorage 2,000 yards or more from a 12-inch mortar battery and within its field of fire.

In firings at Sandy Hook, Sept. 24, 1902, nine rounds were fired with 1000 pound shell, having the cavity closely packed with sand and sawdust to give full weight. Using a charge of powder to give 560 f.s. velocity, elevations varying by 1 degree from 60 up to 70 degrees (except 63 and 69) were employed. The ranges were consistent, varying from 2582 yards at 60° to 1805 yards at 70°, and all the projectiles fell point on with base inclined about 10° to the front except the one at 68°, which fell upon its side. Even admitting that an occasional projectile may be erratic within these ranges, there is no reason to doubt that such fire would be most hazardous to vessels, or that it would effectually prevent their occupying such a position.

At Barrancas last month the mortars were fired at a fixed angle of elevation which seemed to me a method wholly inconsistent with the thorough, well considered and well executed plans which otherwise marked that installation for fire direction. I do not propose to discuss the system of fire control and direction for guns, only remarking in general that it would seem wise to devote great attention in drill and practice to that alternative which will require the direction to be exercised at the batteries themselves with the least possible reliance upon distant communications by electric wires. That the emergency will arise at times in conflict when some important feature of the distant control system will fail, can hardly be doubted, and while giving every attention to the perfecting of this system, let it be thoroughly understood what will be done and let the batteries be organized and drilled to meet emergencies arising from failure of the means of distant communication.

Major Whistler has very kindly allowed me to read his communication of March 3, 1902, proposing a system of mortar fire with a constant elevation of 45 degrees, and incidentally a resource to other angles of elevation up to 60 degrees to cover the whole field of fire within limits of range. The heart of the system is however to use a fixed angle only, and 45 degrees is preferred. The principal arguments in favor of this system have been stated as follows:

1. The variation of range obtainable by changing the elevation for a given charge of powder is exceedingly small when compared with the entire field of fire and entirely inadequate for predicted fire at a moving target.

2. The tumbling of projectiles at elevations above 52 or 53 degrees practically eliminates these high angles from the problem of fire direction at moving targets.

3. When a mortar is fired at 45 degrees the change in range due to an error in elevation is very small. A change of about 10 yards in range only will be effected by the following variations in elevation, namely: 18 minutes at 1,000 yards, 24 minutes at 6,000 yards and 42 minutes at 3,000 yards. It is therefore manifest that a slight error in laying the mortar at 45 degrees has practically no effect on the range. This elevation (secured as will be understood by a pointer or mark on the trunnion and without the use of a spirit level) admits of rapid work in laying, as it is not necessary to waste time in alternately elevating and depressing so as to lay exactly on the degree mark, a variation of 10 or 20 minutes would make no material difference.

In pursuance of this method the harbor is charted with circles 900 yards apart; powder charges are provided which will reach each one of these circles at 45° elevation, and the target is to be fired at when it crosses any one of the 45° circles. The spaces between circles, or rather the difference of their radii, is regulated by the consideration that about 2 minutes will be occupied by a vessel travelling over the shortest distance or on a radius, and time will be afforded to fire on a vessel so travelling at the crossing of each circle. If the target travels diagonally to the radius the time will evidently be increased, depending upon the course of the target, and it may of course be indefinitely prolonged if the target moves in a circle between two of the 45° circles. However in case of a restricted field of fire, or in harbors where the lay of the channel is such that the target would not enter on a line normal to the range circles the distance between these circles would be changed to suit local conditions and special powder charges prepared accordingly.

The lack of elasticity in this system and particularly the loss of fire and waste of time involved in waiting for a target to cross the given lines, or the still further waiting for it to reach another dead line, in case of failure of the pieces for any reason to fire at the first crossing, would appear sufficient reasons in themselves alone to class the system as one of relatively small merit in general. Its relative merit in this respect would be confined to restricted localities and conditions of channel where the range circles may be considered essentially the same as salvo points for gun fire, but even then there can be no special merit, on the whole, claimed for a 45° fire over a higher angle, but rather the reverse when we include the question of deck penetration.

In the choice of 45 degrees for a fixed firing angle the governing reason appears to have been the large variation which can be allowed in laying for elevation without appreciably affecting the range, but this reason lacks importance because the allowable variation at 45 degrees is greater than needed for accurate work. The question is rather how much error in range will be caused by variations in laying, within limits of practice, at high-angles of elevation. We will find that at 60 degrees elevation an error of 1 minute in laying of elevation gives about the following errors in range, viz: 3 yards at 9000, 2.5 yards at 7000, 2 yards at 5000 and 1.66 yards at 3000 yards range. This shows that errors in elevation are not a serious objection to the use of high angles, and moreover the errors in range dependent upon elevation is not so important as that due to variations in the muzzle velocity, and a variation in the muzzle velocity will affect the range somewhat more at 45 degrees than at higher angles.

A third objection to the 45 degree angle is the loss of deck piercing power, which is especially serious at the shorter ranges, due in part to a less striking velocity than at higher angles but chiefly to the angle of impact. It must be noted that this is not the same case of deck penetration as previously considered for high power guns, but it resembles the attack of thick armor where the projectile meets its match in the plate for normal impact. The angle of fall for 45° elevation is about 50° and it appears that 4000 yards would be about the inferior limit for perforation of a 2.5 inch nickel steel deck plate with the 1000 pound projectile. If 70° elevation be used the limit would be reduced nearly to 2000 yards.

A fourth objection is the difficulty of covering the zone between 2000 and 3000 yards. A velocity of 560 f. s. gives a range about 3000 yards with 1000 pound projectile at 45° elevation and about 2000 yards at 70° elevation. To attain a range of 2000 yards with 45° elevation would require a very light and inefficient charge.

There has been serious complaint, and with reason, against the present method of giving elevations to the 12-inch mortar, where the quadrant is held upon the breech and elevation is given by cannoneers at the elevating wheels. This is unquestionable a tedious and very cumbersome method. The ordnance department is now having made for trial, four different instruments to replace the use of the quadrant on the breech. Two of these are essentially quadrants placed on the rimbase of the mortar in view of the operator at the elevating wheel. They comprise a fixed bracket on the piece with degree graduation, and a removable level made on the same principle as the present quadrant arm to set for the reading in minutes. The spirit level, it will be remarked, is the only instrument that will give true elevations independent of variations in the positions of the top carriage on counter recoil.

The third instrument was designed after suggestions made by Major Whistler, Artillery Corps. It comprises an arc fastened on the rimbase of the carriage, with a movable scale plate having an attached level, and a pointer on the piece. The special feature of this device is that any necessary leveling can be done while loading is in progress, and finally the piece is elevated to an even degree mark only for firing. Whether the spirit level on this instrument must be made removable or not will depend upon firing tests.

The fourth was suggested by Lieut. Rorebeck, Artillery Corps, after trials made with an improvised pattern at Fort Monroe, This comprises essentially a graduated wheel on the elevating shaft and an index bracket on the top carriage.

After the trials at Fort Preble, the Artillery Committee of the Board of Ordnance and Fortification made certain recommendations in pursuance of which a scheme of mortar firing is now being carried out at Sandy Hook. The principal features of this scheme are:

1. Firings at elevations between 45 and 70 degrees except with the full charge where the angle is limited to 65 degrees to save strain upon the carriage.

2. Determining the least number of zones and corresponding powder charges required to cover the field of range, by using the 1000 pound projectile from about 2000 yards to the limit of range of this projectile, about 11300 yards, and using the 800 pound projectile with full powder charge only to give an outer zone

IFICATION 1901.

ning about 3.25% of nickel.
ed and then annealed.
line of fire.

6 INCH

3-inch steel shields, fa
5-inch A. P. shot, d

Round No.	Projectile.	
	Cal.	Wght.
	In.	lbs.
1	3	13
2	3	13
3	3	13
4	3	13
5	3	13
1	5	50
2	3	13
3	3	13
4	3	13
5	5	50

Remarks.

ust show no opening.
he limit of good nickel steel
e poorer quality of plate
or tearing open and allow-
projectile or fragments to
igh.

y 22, 1903.
. P. shell, uncapped.

d. Projectile glanced, leav-
n plate 4 inches deep and 2
s crossing the score.
d. Dish 5 in. but no cracks.

pped A. P. shot.

ably passed through, plate
two, halves ot well defined
le on each part; line of pen-
ormal to surface of plate.

capped, against Carnegie
inches, inclined 45°.

d about one half through
e plate into two pieces
through point of impact.

pped projectiles (2 cals. radius)

ngle for capped projectiles, the

overlapping the 1000 pound projectile and extending to the extreme range, about 12230 yards, or 7 miles nearly.

The carrying out of this project involves the replacement of the present cast iron racers and top carriages by pieces made of steel, and measures to this end have been taken for modifying the carriages in service.

Firings that have been under this plan have determined five zones as required for the 1000 pound projectile, approximately as follows:

Velocity.	Range. 70°		Range. 45°	Width of zone.	Overlap.
F.S.	YDS.		YDS.	YDS.	YDS.
560	1900		3095	1195	—
650	2685		4215	1530	410
800	3670		6030	2360	545
1000	5660		8780	3120	370
1150	8150	(65°)	11300	3150	630

The field from 2685 to 11300 yards range is covered by four zones, the remaining zone (inner) reduces the range to 1900 yards. It would seem, however, that this may be regarded as a special zone for which charges should be supplied, but which, in actual service, will not often require to be utilized. These wide zones dispose of the objection heretofore made that the variation in range obtainable by changing the elevation for a given charge of powder is small and inadequate for predicted fire at a moving target, whatever force that objection may have with angles limited between 45 and 60 degrees, for it will be observed that the latter limits were not exceeded in the Fort Preble trials.

PROJECTILES, FUZES AND PRIMERS.

By Captain BEVERLY W. DUNN, Ordnance Department, U. S. A.

(A lecture delivered at the United States Artillery School, Fort Monroe, Va., May 29, 1903).

I shall attempt in this lecture to give you, according to my information, an outline sketch of the present development of projectiles, fuzes and primers in our service. While we cannot acquire too much professional knowledge and while it appears especially desirable that an artilleryman should be familiar with the best methods of designing and constructing the material he uses, it is of greater importance to the service that he should first become thoroughly familiar with the best method of using his tools to secure their maximum efficiency.

PROJECTILES FOR SEACOAST GUNS.

The principal function of the projectile is to carry its charge intact to the enemy's most vulnerable point, and its relative efficiency will be in a measure proportional to its carrying capacity. Given the obstructions to be penetrated, we can furnish the most efficient design for the projectile. In order that its charge may be a maximum it must have only the mass required to reach its destination without material deformation. Since the stress on any cross section is the product of the mass supported by that section and the acceleration communicated to it, and since the maximum rate of change in velocity while passing through an armor plate is much greater than that due to maximum powder pressure, it is evident that the thickness of wall must be greater at the front than at the rear, and that the mass of the base plug must be a minimum. The hardness of metal in the point is limited by the condition that the projectile must not crack spontaneously from internal strains. Surface cracks of the armor plate are permissible and generally indicate superior treatment for hardness. It is principally in this matter of surface hardness that the plate retains an inherent advantage over the projectile. I have never seen a perfectly satisfactory explanation of the assistance the projectile derives from its soft cap in neutralizing this advantage. My own observation and experience have suggested that it is due principally to the softening effect on the plate of the great heat produced by the molecular flow of the soft metal. I do not know of any accurate method of calculating the maximum stress exerted on the projectile by the plate's resistance. In designing detonating fuze stocks, I have assumed the retardation to be uniform, the work done to correspond to the velocity required to penetrate, and the path to be the thickness of the plate. This gives approximately correct results for the fuze stock, but would not give equally correct results for the maximum stress on the projectile. We have defined the most efficient projectile as one carrying a maximum charge to its destination. Our projectiles should vary in strength then directly with the resistance of the enemy's protection and with the range. As this rule would cause too great a variety of types, a compromise is necessary, and all compromises generate discussions and differences of opinion. We have tried to cover the field by one extreme type, the A. P. shot, and one mean, the A. P. shell. For our mortars we have the mean in the D. P. shell and the opposite extreme in the torpedo shell. These are some of the tools furnished you, and yours is the task to decide how best to use them. When these types were adopted, the shot, which contains only the cavity required in manufacture to give it a maximum of strength for penetration, was to be fired without bursting charge since it could not be broken up by black powder—the only explosive charge then available—and since black powder could not in any event penetrate thick armor without exploding prematurely. The A. P. shell was to contain black powder and the torpedo shell a high explosive. These conditions are now materially changed as a result of the adoption of high explosive charges for all projectiles. The following suggestions are made largely for the purpose of stimulating your interest and provoking your thought and criticism. Three very different targets, calling for different types of projectiles, are offered by a battleship: (1) vital machinery and heavy guns back of thick armor; (2) upper works and rapid fire guns and mounts, and (3) personnel. For (1) the 12-inch A. P. shot, or the strongest projectile that can be supplied, must be used. Is the present relative efficiency of the 12-inch A. P. shell for (2) and (3) sufficiently greater than that of the A. P. shot for the same purpose to justify the use, or even the existence, of the shell?

The fragmentation of the shot by its high explosive charge is practically equal to that of the shell.

The explosive charge of the shell is about three times that of the shot, and it must be conceded that its fragments are dispersed with a higher velocity. If both projectiles could be placed in the turret or in the boiler room we should choose the shell, but would not the shot do well enough, and would it not be very agreeable to you to use but one projectile in your 12-inch guns, and thus reduce by one, at least, the things you have to think about in the heat of action? A shot striking the upper works would do less damage than the shell, but a shell striking thick armor might do none at all. It is only by reaching her vitals that a ship can be quickly disabled and possibly sunk by a single shot. Should not every round fired from a heavy gun have this end in view? A recent plate test shows something of the relative destructive effects of the two projectiles when fired against heavy armor at about 4000 yards range. The exhibit is considered somewhat more favorable for the shell than can be claimed with certainty. Instead of penetrating a Krupp plate 1 calibre thick it would be more correct to say that after partial penetration with the assistance of its soft cap it broke through from the accelerating push given by its high explosive charge. If the plate had not been already weakened by the two preceding shots, it is a question whether the shell would have broken through. In one other test, a 12-inch A. P. shell, without a cap, failed to break through a 12-inch Krupp plate, and for acceptance these shell are required only to penetrate 7 inches of tempered nickel steel. The strong tendency of the high explosive charge to push the heavy head of the projectile through the plate is a well established fact.

A cross section of a modern battleship emphasizes the fact that it is desirable to do more than just get through the plate, for the coal bunkers must also be traversed before the vitals of the ship can be reached. It is difficult to pursue this discussion without encroaching on general territory, but one further suggestion seems desirable. If the 12-inch rifle and one type of projectile should appeal to you as the most efficient combination to use against the protected parts of a battleship, and the 6-inch, aided by smaller rapid fire guns, should appear satisfactory for the necessary damage to the superstructure and personnel, and to the material unprotected by heavy armor, why would it not be advisable to eliminate the intermediate calibres from our principal seacoast defences? Do we not need heavy projectiles for armor belts and turrets and the largest possible number of 6-inch and smaller projectiles for everything else?

With a given limit to the number of emplacements and men, would it not be better to have every heavy shot fired capable of reaching, if well directed, the vitals of any hostile ship that could be brought into range? Another very strong reason for using the shot exclusively is that no matter how safe and excellent our material in design, or how careful our construction and supervision, an occasional premature explosion must be regarded as among the possibilities. Fortunately we have not yet had occasion to test this matter with our large projectiles, but I am of the opinion that a 12-inch shot, with its small charge, would not rupture explosively a 12-inch rifle, and the moral effect of such a catastrophe will probably not have to be reckoned with with this projectile. A 12-inch shell would be much more liable to do so. On one occasion in test firing a defective torpedo shell loaded with nitro-gelatine wholly destroyed the gun. On the other hand if you get your fire control system so perfect and your personnel so thoroughly trained that you do not fear confusion in the heat of action, then you use torpedo shell at long ranges, A. P. shell at intermediate and shot for short. The chance to reduce the 12-inch mortar projectiles to a single type is not so favorable. The proper target for this piece is the same as that for the 12-inch rifle, namely: the vitals of a ship; but there are two paths, one through the protective deck for the D. P. shell, and the alternative one through the water to the hull, for the torpedo shell. The latter projectile should be most effective when it strikes in the water and explodes within ten feet of the hull. It will probably be stopped by the protective deck when it strikes the ship, but the moral as well the material effect of detonating on this deck a mass of nearly 150 pounds of high explosive would be very great. The size of the target is materially increased for this shell, due to its effectiveness when striking in the water near the ship. Experiments should be conducted to determine more accurately its destructive effect as a function of the distance of the point of detonation from the ship. Another point in regard to water impact of mortar shell needs investigation. At all angles of fall less than 90 degrees there must be an upward deflection, and the shell approaches a horizontal direction in passing through the water. At an angle of fall of say 45 degrees and for a given range, is the shell deflected to a horizontal course at a depth less than the draught of a battleship? If so, a promising method of attacking a ship with delay action fuzes or fuzes insensitive to water impact would be to strike short and thus reach the hull.

In any event there is no room to doubt that a "short" is more desirable than an "over," and an artillery gunner should be trained to shoot low rather than high. It is sometimes proposed to use shrapnel with rapid fire seacoast guns for 6-inch and lower calibres, but I fail to see any advantage in doing so. Generally the use of delay action fuzes will cause those shell that strike short of the target to explode in the air. At ricochet ranges and with high explosive charges shrapnel effects may be expected from these shell. For use against landing or mine field parties, the high explosive shell should also be more effective than shrapnel when we consider the inherent inaccuracies and uncertainties of the best time fuzes, inaccuracies that necessarily produce errors of range proportional to remaining velocities.

SIEGE PROJECTILES.

The breaching of stone walls and earth parapets and long range action against personnel may be considered the legitimate functions of siege projectiles arranged in the order of importance. The present 7-inch howitzer, common steel shell, weighing 105 pounds, carries a charge of 8½ pounds and is strong enough to puncture, without material deformation, three inches of ship steel. Under various conditions we have conducted competitive tests of this projectile with a maximum capacity shell of the same weight, carrying 16½ pounds of high explosive, and with the single exception of mining earth and sand parapets, the stronger projectile has shown itself to be superior. I will give some views showing comparative dimensions and fragmentation tests of these projectiles and their breaching effect on sand parapets. The necessity for a delay action in the fuze to give penetration before explosion is as pronounced here as for armor piercing projectiles. This delay action opens a possibly new field for high explosive siege and field shell at ricochet ranges. Troops in well constructed ditches are practically immune to injury by front fire, with the single exception of fortunate bursts from mortar shrapnel. By striking in front, however, with a high explosive shell, and a delay action fuze, it is possible to secure a burst over the ditch and a vertical path for the fragments. A delay action has the disadvantage, however, that for long range firing against personnel the shell will bury themselves in soft ground and explode harmlessly. The use of high explosives in siege projectiles will tend towards reduction in calibre and increase in mobility. Many obstructions can now be destroyed with a 5-inch or less, where, under old conditions, a 7-inch calibre would have been necessary. The combination of rapid fire from stable carriages and high explosive charges has directed special attention to the question of calibre of siege guns. To take a high power 6-inch gun into the field as a part of the regular equipment would be on a par, in my opinion, with using our 16-inch rifle to attack an armored cruiser. Our largest gun should be only just large enough to neutralize our enemy's strongest probable protection, permanent works not considered. The strongest walls of the buildings he might occupy and his temporary earth works are normal targets. Extreme range is of greatest importance in protracted siege operations and bombardment for moral effect. Our heavy 7-inch howitzer can attain a range of about 8800 yards with its extreme elevation, but it would not be wise to expend a limited supply of ammunition in firing at that range. It is my opinion that curved fire will finally be discarded. The vertically projected fragments from ricochet shell promise to do more effectively by direct fire what has heretofore required curved fire.

FIELD PROJECTILES.

The shrapnel will continue to be the principal projectile for attack of troops in the open. It has been occasionally suggested that high explosive shell with time fuzes might be substituted for them with advantage, but this has little to recommend it. With a time fuze, which, by construction, starts to burn almost as soon as the projectile begins to move, there is always the chance of a premature explosion. Time fuzes cannot be made to burn accurately, and at medium ranges for any group of, say 10 projectiles, with identical fuze settings, the points of burst will probably be distributed over a range of from 200 to 300 yards.

The shrapnel bullets will be effective at a range of 300 yards beyond the point of burst, their cone of dispersion being about 12 to 14 degrees. The high explosive shell fragments will radiate in all directions from the point of burst, and granting that the shell will give twice as many effective fragments as the shrapnel the density of its hits on any unit surface within the shrapnel cone will be to that of the shrapnel about as 1 to 132; in other words, the chance in favor of hitting a man directly in front of the point of burst with the shrapnel is 132 times as great as with the high explosive shell. This is the reason for the extremely local effect constantly reported for the high explosive shell when used against troops in the open. With each improvement effected in the time fuze, the weakest feature at present, the value of the shrapnel will increase. The 15 pound field shell, in future, will be made of steel and contain about 2 pounds of high explosive. It will give from 500 to 600 effective fragments, where the old 3.2-inch 13½ pound cast iron shell, loaded with black powder, gave from 25 to 40. It will be as effective for breaching purposes as the 5-inch siege black-powder shell. Satisfactory tests have been made to determine its breaching action in brick walls and its effects against troops in ditches by overhead bursts. A great deal of energy has been expended, especially in recent years, in efforts to improve the field shrapnel. Our present type for the 3.2-inch guns has been in use for about 12 years. It is of the head charge separator design, and contains about 160 lead balls of 170 grains weight. The separators are used principally to prevent deformation of the lead balls on discharge, and they furnish effective fragments at short distances from the point of burst. In this design the strength of the case has to be accurately adjusted. If too weak it will be upset and deformed in the gun, and if too strong it will not be opened thoroughly by the bursting charge, and some of its fragments will not be released. It is not well adapted to use with fixed ammunition. The remaining velocity is slightly reduced by the bursting charge, and the cone of dispersion is large with consequent low density of fragments striking a unit area directly in front. A wide cone of dispersion would be advantageous for front attack on a line of skirmishers if perfectly accurate time fuzes were available. With fuzes as they are, a small angle is better since the number of high and low fragments lost is reduced. The efficiency of the shrapnel design is well measured by the ratio of the weight of the balls, the only really effective fragments, to the total weight of the projectile. I introduced some years ago the head charge, hexagonal case, steel jacketed ball design, and increased this ratio from about 30% to over 46%. The jackets perform the function of the separators in preventing deformation of the balls on discharge, and they also secure better penetration. The hexagonal section prevents relative rotation of the case around the balls and furnishes natural lines of weakness for the head charge to open the case at the point of burst. Before this model could be introduced into service the advantages of the base charge became so evident that my design was changed. The principal advantages of the base charge are the smaller cone of dispersion and the increased velocity given the balls by it, the shrapnel case being utilized as a short gun. This increase in velocity is from 200 to 300 f.s. In this design inconsistent conditions do not affect the case. It is required to be strong both in the gun and in flight. In foreign models a powder chamber in the base is secured by a strong diaphragm resting on a solid shoulder forged in the case. The balls rest on this diaphragm and are embedded in a resisting matrix such as resin to prevent their upsetting on discharge. In my experiments I found it very difficult to secure a diaphragm of reasonable weight that would not be deformed by the pressure of about 30 tons required to communicate acceleration to the balls, and I finally conceived a rather bold, but now known to be safe, solution which is as follows. In other models the diaphragm is used to shield the powder from pressure, and the boldness consists in making the powder take all the pressure, omitting the shoulder entirely and reducing the thick and heavy diaphragm to a thin steel plate used merely to distribute the pressure and confine the gases. Safety is secured by subjecting the powder to an assembling pressure of about 60 tons, which enables it to stand the service pressure of 30 to 35 tons without the relative movement of the grains over each other, which, in loose powder, would generate by friction the heat necessary to explode the charge in the gun. Several distinct improvements in design flow from this arrangement. The weight of metal in the omitted diapragm and its supporting shoulder is saved, the forging of the case simplified, the weight available for balls and the efficiency ratio of the shrapnel increased, and a progressive action of the base charge, similiar to that in modern gun powder secured. With the change from head to base charge, the advantage of the hexagonal case disappears, since tangential strength instead of weakness is now desirable. The almost certain use of shields on field gun carriages will also render the steel jacketed balls obsolete. Solid and hardened steel balls will be required to penetrate these shields and they will very materially increase the cost of the shrapnel.

The last improvement in shrapnel design to which I will call your attention is in the method of packing the balls to secure the maximum efficiency ratio. Instead of using balls of uniform size it is possible, by the use of different sizes, to materially decrease the vacant spaces in the packed balls and even to reduce the central tube connecting the fuze and base charge to effective fragments. The efficiency ratio of this design is about 53 per cent, which is about the limit for this order. It is suggested that, just as the small arm rifle is a machine built around the projectile that we wish to transfer to a distant point, so the shrapnel case is built around the ball possessing the mass which experience has shown to be necessary, and the field gun is built around the shrapnel case. The starting point of the system is the shrapnel ball, and I suggest that, with this given, the proper calibre of the field gun follows as a consequence.

PERCUSSION FUZES.

A percussion fuze is a small affair, relatively, but its importance cannot be overrated, and all artillery officers should be thoroughly familiar with its design, and the proper methods of handling and using it. All percussion fuzes carry an interior mass called a plunger, whose forward movement, when the shell is retarded, causes the firing pin to strike a percussion primer and explode it. Before firing, the fuze must be in a "safe" or "unarmed" condition in which the pin cannot reach the primer, and during the flight of the projectile it must be in the "ready" or "armed" position. Either or both of the forces exerted on the plunger to give it the longitudinal and angular accelerations communicated to the projectile may be utilized to transform the plunger from the "safe" to the "ready" position. Powder pressure may also be used to act on an interior fastening for the plunger by deforming the metal in the base of the fuze.

The centrifugal force is preferred in our service, since it is the most difficult to duplicate by any rough treatment incident to handling and transportation. When a 3.2-inch shell is dropped, base down, on a solid iron foundation, from a height of 30 feet, the force exerted by the blow on the fuze plunger is about equal to that exerted on it in the same direction when the projectile is fired with full charge. It would not be possible, however, to rotate the projectile at the rate of 15,000 R.P.M., without a special machine to do it, and the gun is about the only machine available for this purpose.

Up to about 1894 we used, in our service, what was known as the Hotchkiss fuze. The firing pin and upper portion of the plunger were covered by a lead sleeve, cast or pressed over it, which, on discharge, was forced to the rear, exposing the firing pin. Experience showed that continued jolting, incident to transportation in the field, caused a creeping action of the sleeve, which was cumulative, and finally resulted in arming the fuze while in the limber chest. The unfortunate accident in the streets of Chicago, where a light battery ammunition chest was exploded while passing over a cobble stone pavement, was due to this cause.

The split ring fuze, the invention of Mr. Wm. Dungan, a foreman at Frankford Arsenal, was then introduced into service. There was no creeping action with this ring. When partially forced out of its seat by an accidental blow it always recovered its initial position.

The difficult case in land service is to provide a fuze that will will arm in mortar or howitzer fire, with reduced charges, and still be safe in transportation and handling. In the split ring fuze it was necessary, to secure bursts of mortar shell, to reduce the resistance of the ring to such a point that dropping the fuze about 17 inches on an iron plate, base down, would arm it. Such a fuze could not be transported assembled in a loaded projectile, and it was therefore issued to the service packed separately, in tow, in tin boxes. In addition to this precaution, a safety wire, passing through the fuze body and plunger, was used in later models to keep the plunger safe until the operation of loading. It was one of these low arming fuzes, without a safety wire, that caused the premature explosion of a 7-inch howitzer at Fort Riley, in 1901, during the act of ramming the projectile. The fuze was probably armed either during transportation or in opening the tin box containing it.

To secure the rapid fire now required, fuzes must be transported assembled in the loaded projectile, and must be safe for transportation in that condition. Furthermore, the projectiles must be loaded with high explosive charges, and contain detonating fuzes. It is thus seen that the conditions affecting the fuze design have become very much more stringent.

I began, some years ago, to develop a centrifugal acting fuze, and I have here to show you a few only of the experimental models tried, including the latest form, which will probably be adopted. Normally the firing pin points 90° away from the primer, and is brought in line with it only when the two halves of the plunger are moved outward by centrifugal force against the action of the safety spring. As soon as this force ceases to act, the plunger returns to its safe position. In one of the experimental models through which the development passed, a fuze exploded prematurely at Frankford arsenal, but the cause of this was completely established and corrected. The severest tests of the model that will be adopted have failed to disclose any unsafe features.

In testing and criticizing any fuze design, it is well to examine its features in the following order :

It ought not to be possible to arm it except by duplicating the gun conditions. Even when rough treatment in the shop is carried to an extreme, the only permissible effect should be to so deform the plunger that it would fail to arm under any conditions, and thus become doubly safe. In shop tests, fuzes are dropped, base, side and point down, in specially arranged holders, from 4 to 8 inches, on solid iron plates, from 30 to 40 times per minute, and for several hours in each position. They are also dropped from a height of 50 feet on stone or concrete, and jumbled for hours in a rectangular box rotated about one of its diagonals.

The heavier the plunger, the more certain the fuze to explode on impact, and the ratio of the weight of the plunger to the total weight of the fuze measures the economical efficiency of the design. In many designs, the plunger is restrained in its unarmed position by masses that do not move forward with the plunger on impact. Such an arrangement violates this principle.

The efficiency of the fuzes in action is measured by the percentage of explosions secured under the most unfavorable conditions, such as graze, impacts on water, and in the shop tests by the drop required to explode the fuze after it is armed. For our fuzes, this drop is not allowed to exceed one inch for each 2000 grains weight of plunger. The results of this test depend, of course, largely upon the sensitiveness of the primer. The lighter the projectile and the higher its impact velocity, the less will be the weight of plunger required in the fuze. Our field fuze plunger weighs about 250, the siege and armor piercing fuze plunger about 700, and the 12-inch mortar fuze plunger about 1800 grains.

For fuzes arming by longitudinal pressures, it is customary to adjust the strength of the split ring, or similar restraining device, to about ¾ of the force calculated as available by multiplying the mass of the sleeve or arming part of the plunger by the maximum acceleration of the projectile for the smallest service charge. In centrifugal acting fuzes, we require the field and armor piercing plungers to arm at 3000, the siege, except 7-inch mortar, at 2000, and the mortar fuze plungers at 1300 R. P. M. These rates are many times the rate of revolution that any of these fuzes would receive in rolling in their proper projectile down the longest ramp in service, and it does not appear that accidental rotation could be given them in any other way.

The following are some of the specially meritorious features of the design we expect to adopt for service :

It is self-contained ; does not depend for its safety upon any attachment to the fuze body, which might be broken or injured by accidental blows ; and all of its parts move forward on impact, adding, by their masses, to the strength of the blow delivered to the primer.

The revolving pin is better than a covered pin, and the fuze has to be completely armed, and its rate of revolution maintained, to keep the pin in line with the primer. Even if the fuze should, in some unaccountable way, become armed, it would recover itself as soon as its rate of rotation was reduced below its adjustment.

The three point support of the firing pin is important, in that by it the pressure of the pin on the primer tends to keep the plunger open and the pin upright. Except for this feature, a grazing impact of the projectile might cause the plunger halves to close, folding down the firing pin, and thus producing a failure of the fuze to function. Our composition for both percussion and friction primers consists of chlorate of potash, sulphur and sulphide of antimony, mixed in equivalent portions, about 3 parts of sulphide to one of sulphur, and just enough chlorate for the oxygen needed. Potassium chloride and oxide of antimony are solid products of the reaction, which become heated to incandescence, and assist materially in carrying the heat to the charge to be ignited. The ignition of the primer composition is due to heat caused by the compression of a small particle between the point of the firing pin and the anvil. About 12 per cent by weight of glass crystals are added to the composition, to increase frictional heat, and about 2 per cent of shellac dissolved in alcohol, to give body and solidity to the pellet. Gum is sometimes used instead of shellac, but the latter is preferred. As some of the energy of the blow of the firing pin is required to penetrate the brass primer shield, and the composition pellet, it is evident that the thinner these are the more sensitive the primer will be. It is possible to make them so thin that a primer will occasionally explode during flight of the projectile, due to atmospheric retardation.

In the Navy a regular percussion cap is used, which requires from the plunger a blow commensurate with that of the firing pin in the small arm, and the Navy fuzes are also much smaller than ours for the same projectile. This combination is probably the cause of the reported failure of a large percentage of their shell to explode during their bombardment of Santiago.

The model also shows our device for securing a short delay action, which averages about .02 of a second, but can be adjusted by the length of the small column of compressed powder. The small vent provided for the gases to expand into the vacant space around the plunger is the secret of this device. Without it the short column of compressed powder would burn without appreciable delay.

TIME FUZES.

Nothing is more difficult to make in the fuze line than an accurate time fuze. There are two methods for preparing the slow burning column of powder upon which the fuze depends, giving rise respectively to the lead drawn time train and the horse-shoe shaped column of compressed powder. The latter type has gradually displaced the former, and may now be regarded as standard. Variations in the incorporation of the ingredients of the powder used, and in the density of this powder secured at different points of the time train, are responsible for many of the irregularities of burning in flight. Chemical action between the oxidizing agent in the powder and its metal envelope is hard to prevent in the course of long storage. The use of aluminum for this envelope had to be abandoned on this account.

A feature of time fuzes not generally known is their tendency to be extinguished in flight when fired with high velocities. Our present 15-second fuze cannot be depended upon to burn at all when the initial velocity exceeds 2200 f.s., and the corresponding limit for our more sluggishly burning 28-second fuze is about 1400 f.s.

The refrigerating effect of the rapid rush of air by the fuze seems to be responsible for these results. When the fuze is not extinguished, its rate of burning, as determined at rest, is affected in an irregular manner, the velocity and the time of flight, as well as barometric pressure entering as causes. The minor mechanical features of the time fuze are readily controlled. Our artillery officers have often complained that our fuzes did not admit of a smaller sub-division than 1/6 of a second. This does not seem to be of much importance, if we admit that no two fuzes fired under the same conditions, and with the same setting, can be depended on to agree within $\frac{2}{8}$ of a second. I have tested a large number of fuzes, and have found, as a general rule, that when 10 consecutive fuzes are fired with identical settings as high as 8 to 10 seconds, the extreme differences in times of burning will exceed one second.

When one of our fuzes is once punched, the necessity for using it for that or a shorter setting is a well recognized defect.

With modern rapid fire field artillery it is quite essential that a battery commander should be able, before going into action, to set all of his fuzes at zero, and thus have them available for use as canister without the loss of time required to set them after an emergency has arisen.

I worked, at odd times, for more than a year, on a modification of our lead train fuzes, and succeeded in developing a perfectly satisfactory device for igniting automatically a lead tube time train, and setting it and resetting it to any fraction of a second desired. The inaccuracies of this form of time train, however, especially after the fuzes have been in store for several years, caused me to abandon the model.

The best time fuzes now obtainable are made by Krupp and the Ehrhardt Co., in Germany. The Ordnance Department has ordered a supply from Ehrhardt, and is going to manufacture this model at Frankford arsenal. It is of the usual double tier horse shoe type. We shall put into it our own percussion and concussion plungers and primers, and pay the Ehrhardt Co., if necessary, for their experience in manufacturing the time train.

A successful clock-work fuze will probably be developed, and when that happens the effectiveness of field artillery projectiles, both shell and shrapnel, will be increased at least 50 per cent. Another immediate consequence of a perfectly safe and accurate time fuze would be a complete abandoment of curved fire for field and siege artillery.

The increased range of our new field gun will require a longer burning fuze, about 21 seconds for the extreme range of 6500 yards. It is said that the English were handicapped in their long range artillery duels in South Africa by the 15 second limit to their time fuzes, which limited their extreme shrapnel range to about 4500 yards.

PRIMERS.

You are doubtless thoroughly familiar with the construction and action of ordinary small arm and cannon percussion primers. As a general rule the explosive composition in these primers contains fulminate of mercury, chlorate of potash, sulphide of antimony or mealed powder, and glass crystals, with gum or shellac for a matrix. We have abandoned, in our service, the use of fulminate, and principally because of the danger in handling it during manufacture. In the primer firing mechanism the strength of the blow is not as limited as it is in the percussion fuze, and hence the usual plan is to assemble the composition and anvil in a brass or copper tube, the base of which is indented by the blow of the firing pin and the composition pressed thereby against the anvil. The cup acts also as a gas check and the

the thickness of it regulates the blow required to explode the primer. A Board of Ordnance officers has been at work lately on regulations to govern the strength of main springs and the resistance of primers. Some percussion mechanisms in service, notably the Armstrong, give excessive blows to the primer, while others, such as the 6-pdr., Driggs-Seabury, give very weak ones. As originally constructed, the Armstrong firing pins, when set for electric firing moved up to contact with force sufficient to fire a sensitive percussion primer. They have been modified to prevent this, and the resistance of our primers for these guns has been increased. Until a few years ago the primers used with our seacoast guns were the screw thread friction and the electric primer of same dimensions. With the improvement in gun carriages and the method of handling projectiles and charges, the time required to remove and replace these primers became greater than any other operation of loading.

It may seem a simple thing to design a primer, but [the number of drawings of different models on file at Frankford would fill quite a large folio. After passing through the stages of simple percussion, simple electric, combination, percussion and electric, and simple friction, we have finally reached the present service model of combination electric and friction primers shown by the models here. The body is machined from Tobin bronze, the shape not being well adapted to manufacture by drawing. The friction composition previously described is assembled by heavy pressure instead of by the use of a matrix, and it performs the additional function of an insulator. The serrated teeth are on a piece separate from the wire so that in case a primer fails to fire by friction, the accidental pushing back of the wire, by dropping the primer for example, will not cause it to fire unexpectedly. The electric elements are clearly shown in the sectional views. The current comes in through the primer wire and passes through the platinum bridge to the primer body, and thence to the gun and the return wire. About one-half of an ampere will fire the primer, but in adjusting a firing circuit, it is well to allow three-quarters of an ampere. It is important in wiring the primer circuit, especially where the current is taken from the power mains, to put the firing switches in the branch leading from the source of power to the firing mechanism and not in the return circuit from the gun. Each primer is tested at Frankford, and when they fail to fire electrically in service the trouble should first be sought, where it usually lies, in the source of power, or in the wiring. In firing this primer by friction it is important to remember that in all friction primers the quicker the serrated teeth are forced through the composition the greater will be the frictional heat, and hence the greater will be the chance of firing the primer. The teeth can be forced through any such primer without firing it if the motion be made very slow. When attempts were made to use a long lanyard with a hand striker on it, the force of the blow from the striker was not always enough to pull the teeth entirely through, and frequent failures resulted. In other cases the teeth were pulled through slowly, due largely to the slack in the long lanyard, the primer failed, and not knowing this, an additional amount of strength was applied, possibly one or two additional men put on the lanyard, and all with unsatisfactory results, as might be expected.

A quick, strong pull from one man should be used, and if the primer fails to fire replace it by another. The use of the combination primer has become quite general, but the usual combination elsewhere is percussion and electric. The objection to this, from our standpoint, is the danger involved in the necessity for the firing pin to move forward against the percussion primer to establish electric contact. If a cocking instead of a continuous pull percussion mechanism is used, another danger is introduced, when, for some reason, it is decided after cocking the mechanism to resort to electric firing instead. The recent accident on the Massachusetts was due to the use of such a primer.

A perfectly satisfactory firing mechanism for our combination primer has not yet been put into service, but it is believed that one designed by Captain Horney and now undergoing test will prove satisfactory. For our siege guns a simple friction primer with the electric element omitted is used. The percussion and electric primers supplied for the Armstrong guns are shown by the illustration.

DETONATING FUZES.

You are familiar with the great difference between ordinary explosion and detonation, and the necessity for a good detonating fuze in order to utilize the energy of a high explosive charge. This difference is well shown by fragmentation illustrations. It is difficult to explain why the same compound will, on one occasion, burn slowly, leaving a large part of the shell charge unconsumed, and under nearly identical circumstances be thoroughly detonated. It evidently depends entirely upon the way the decomposition is started, and there is reason to believe that it is all a question of maximum temperature. We can detonate picric acid by dropping small quantities of it into a red hot tube, and if the temperature of the tube could be raised sufficiently high we could probably detonate all explosive compounds in the same way. The expansion of gases, due to combustion, lowers the temperature very rapidly, and the rate at which all combustion takes place is a function of the resultant maximum temperature. The detonator is so rapid in its own decomposition, that when confined in a large charge it is equivalent in the above illustration to raising the tube to the required temperature. If the mass of the explosive charge is sufficiently great an ordinary combustion will become more and more rapid as the temperature rises, until finally the decomposition of the remaining portion of the mass will become so rapid as to be called a detonation. This has happened in explosive works where large masses of gun cotton, picric acid, and even finely granulated smokeless powders have first become ignited and then detonated. On the other hand, it is known that, with long thin charges, the phenomena of detonation may cease, leaving a portion of the explosive unconsumed. The surface of combustion has a great influence on the rate of decomposition for ordinary combustion and it also effects detonation. It is much easier to detonate a given charge in the granular than in the solid state. Increase the granulation of any charge of smokeless powder, keeping the mass the same, and we can pass gradually from explosion to detonation. When in this way detonation, or something very near it, has been reached we can put the same granulation with the same density of loading in a smaller and similar gun, and find ourselves still in the territory of explosion. Here again it is the temperature as affected by the mass of the explosive, and we have, on a small scale, the powder mill data obtained with a smaller mass because of its confinement. A 15-pdr. R.F. gun was ruptured explosively at the proving grounds some years ago, in testing for saluting purposes, a blank charge of 3 lb. 14 ozs., of a powder which gave perfectly regular results as a propelling charge in a 3.2-inch gun.

Innumerable instances could be given to show that detonation is but a rapid combustion, as the general law of continuity in physical phenomenon. Reasoning on this basis, my first attempt to develop a detonating fuze was to force hot gases deficient in oxygen into a hollow cylinder of chlorate of potash placed in a hollow cylinder of gun cotton. The complete oxidation of the gases by the chlorate was relied on to furnish the high temperature required to start the detonation of the gun cotton. It was a crude attempt but it taught me several important facts. Unless the moisture of the gun cotton was limited to one per cent. detonation was not secured, and with the moisture so low the cotton itself was entirely too sensitive to stand the shock of impact on plates of even medium thickness.

I would like to be at liberty to trace for you the different steps that led from this beginning to our present service detonating fuze. All that I can do under existing regulations of the War Department is to enumerate some of the salient facts and conditions that had to be dealt with. The shock to which any material is subjected in being forced through a hard faced armor plate equal in thickness to the calibre of the projectile is beyond our mental conception. Nothing but the most insensitive material for the shell charge will stand it, and unfortunately for the fuze problem the more insensitive the charge to the shock of impact the more difficult it is to detonate it and more powerful the fuze required. Naturally the more powerful the fuze the greater its sensitiveness to shock, as the fuze material cannot be as insensitive as the shell charge, since it must detonate readily when ignited by the percussion primer. What was gained in one direction was thus lost in another. Finally, when satisfactory shell and fuze charges were found, an equally difficult and a more time consuming problem was encountered in ascertaining the proper dimensions and material of a fuze stock. In model after model that part of the stock projecting beyond the inner face of the base plug was torn away by the high retardations due to impact. The illustration* shows one form of a high grade nickel steel stock, which has passed the required tests. These tests emphasize one rather comforting fact, and that is that any explosive material which passes the plate test has a large factor of safety for standing the shock of discharge. For a while the danger of premature explosions in the gun due to leakage of gas through the fuze thread seemed to prohibit the use of high explosives with base fuzes. The use of point fuzes would so weaken our projectiles where they most need strength that the penetration of hard and thick plates would cease to be possible. This difficulty was finally solved by the adoption of what is now the service form base cover. It completely seals all joints, and by abandoning cast projectiles of all kinds and using the safe centrifugal fuze plunger previously described, we feel that we have taken all possible precautions against disaster. Even if an accident should sometimes occur, as it may from some oversight in the manufacture of material, the advantages due to the use of

* Not reproduced.—ED.

high explosives and detonating fuzes are so great that the disaster would have to be tolerated. The employment of black powder has been the cause of much loss of life, and all our experience teaches that with proper precautions our present projectiles can be handled with greater safety than the old ones. This experience has not been gained without sacrifice by the Ordnance Department. I lost a most valuable assistant in the experimental development of our detonating fuze, and neither the Ordnance Corps nor the Army at large has ever lost a life more valuable for sterling qualities of mind and heart, more promising from his past achievements, than was the life of Sidney E. Stuart.

ORGANIZATION OF THE BATTERIES OF RAPID-FIRE FIELD ARTILLERY.

By Captain T. BENTLEY MOTT, Artillery Corps.

Military Attaché, American Embassy, Paris, France.

The manufacture of the new controlled-recoil field gun for our service having begun, it seems important to study at once the organization best suited to the new material. Our gun being about the type and power of the French 75 mm. piece, the French arrangement of four guns and twelve caissons, evolved after much study and experiment, deserves our most careful examination. The French are admitted to have taken and kept the lead in the matter of field gun construction, and while types equal to theirs exist, they exist yet as types only, and no other army is fully armed and exercised with a thoroughly up to date material. But what is equally interesting to us just now is the fact that with a radical boldness unusual in military matters, the French have also built up from first principles an organization for their batteries which makes no attempt to cling to the old solely because it is old, but which creates a new grouping of guns and a new way of employing them based upon the unusual qualities the weapons possess.

After five years of exhaustive trial French artillerymen seem wholly satisfied with their gun, the prescribed method of firing it, and the battery organization to which it gave rise; but this satisfaction would not be so valuable an indication to us in approaching the same problem if it were not supported by competent foreign critics having no reason for flattering the French. Such are surely the Germans, and an expression of opinion supported by arguments from such men as Generals von Alten and Rohne are of inestimable value to us. For this reason I have translated the following extracts from their books, which *La France Militaire* published on May 14, in the belief that these ideas will aid in determining the organization most proper to our new material.

"Last winter General von Alten published a book called *Neue Kanonen*,* in which he supported with great ability the inclination already observed in other German writers to urge a reduction of

* See *Journal U. S. Artillery*, March-April, 1903.

the field and horse batteries to 4 pieces, especially in view of the expected adoption by Germany of a controlled-recoil system similar to the French. One of General von Alten's chief arguments is that the number of pieces assigned to a German army corps is so great that frequently it would be impossible to use them all to advantage and he supports this belief by many examples taken from the batteries of 1870-71. If the batteries were reduced to four pieces there would still be 96 guns to the Army corps, and he considers this a number which could not be profitably exceeded. If the total number of carriages is kept at the present figure it should be done by raising the number of caissons at the expense of the guns, and thus increasing the number of rounds per piece carried by the batteries.

General von Alten also asserts his belief that the field howitzer is more cumbersome than useful, and he would like to see it disappear from the infantry divisions, which at present have one group of these pieces (three batteries) assigned to each of them.

General von Alten being in the Infantry General Staff, approached this question from the point of view of tactics; it is interesting to know that the same conclusions are arrived at by General Rohne, who has a high reputation throughout the world for his competence in technical artillery matters. The following remarks are taken from or based upon an article by him in the April number of the "*Jahrbücher für die deutsche Armee und Marine*".

General Rohne considers that the new batteries of four pieces on controlled-recoil carriages can fire faster than a battery of 6 pieces on the old carriage with trail spade, as long as the latter continue to use their habitual system of successive fire by piece. At present, individual fire by piece, the target being divided and a proportional share assigned to each piece, is only prescribed for distances under 1,500 metres, but the reasons which make this necessary with the old material do not exist for the new controlled-recoil system. It must then be admitted that the new battery of 4 pieces will be technically superior to the old battery of 6.

As for the organization of the personnel, if the same number of men be kept for the new battery as for the old, a similar gain in efficiency will result. With the present 6-gun battery we have 100 men and 60 horses. This gives us just enough horses on a war footing for the 6 pieces. whereas with the 4-gun battery the same number of horses would enable us to send out two caissons in addition to the 4 pieces, and thus take into campaign a "batterie de tir," having greater suppleness and higher maneuvering qualities. (The term "batterie de tir" in the new French organization applies to the 4 guns with their respective caissons and two additional caissons which are first brought into action, the rest of the battery being kept more to the rear and under cover).

Now consider the number of pieces per 1000 men. Under Frederick II. this number was 2 or 3 per 1000 at the beginning of the campaign and rose to 4 and 5 per 1000 at the end, due to the greater losses which the infantry always sustained as compared with the artillery. In 1870 the number of pieces at the beginning of the campaign was, in the German army, about 3.5 per 1000. Later it was carried to 4.8 per 1000, and finally in 1896 to 5.76 per 1000 as a normal figure. This makes the columns longer and more cumbrous, encumbers the camps, cantonments and the field of battle, while of course raising the number of horses to be fed as well as bought. When we come to consider the horses needed for the caissons and other carriages in the battery the number still further increases. In the time of Frederick the number of carriages outside the guns was very small, but in 1870 it was about 3.3 per 1000 men, and with the adoption of the material of 1873 it reached 4.5 per 1000 men, and later, with the adoption of the explosive shell, the figure became 4.75 per 1000. With the adoption of the material of the model of 1896 the proportion grew greater still. Thus, counting only the pieces and the other battery carriages, we have a present proportion of something like 11.5 carriages for every 1000 men, and if we count in the light ammunition columns, this proportion rises to 15.5 per 1000 men.

If now we remember that at the end of the campaign of 1871 the Germans had a proportion (due to the losses in the infantry) of 6.4 pieces and 12.8 carriages for every 1000 men, it may be said that to-day under similar circumstances we would have 15 guns and 40 carriages for every 1000 men; this means that the artillery columns of an army corps would be double the length of the infantry columns. This seems monstrous to General Rohne, who is an artilleryman and therefore more likely to be indulgent than critical in such a matter.

We must now consider the number of rounds per piece. General Rohne shows that the Germans have in a battery only one-half the number of rounds per gun as compared with the French, and he considers this the most dangerous condition when the rapidity of modern fire is considered. This is another argument in favor of the battery of 4 pieces which, while keeping the same number of carriages per battery, has two guns less, two caissons more and each piece provided with double the number of rouuds as compared with the present German system.

General von Alten agrees with General Rohne in believing it dangerous to have on the field of battle more guns than be actually used. For this reason he, too, would like to see the German batteries reduced to 4 pieces, which would still give each army corps 96 guns instead of 144, which number General Rohne as well as General von Alten believes quite sufficient. He says: 'We could have, and we should have' organized our batteries into 4 pieces when we adopted the material of 1896; with the controlled-recoil carriage this modification in the organization of the artillery becomes absolutely indispensable''.

As for the horse artillery, there is every interest, both from the point of view of organization and of mobility, to constitute it in batteries of 4 pieces, but without increasing the number of caissons per piece. The horse artillery is called upon chiefly for actions of short duration, where the consumption of munitions is nothing like so great as in an infantry battle. The number of guns and caissons in a division of cavalry should therefore remain the same, the division being given three batteries of 4 pieces each.

As a final argument General Rohne points out that the adoption of batteries of 4 pieces on modern controlled-recoil carriages, is not only a military necessity but would diminish by one-third the present expense of maintaining the artillery. Such an economy, he says, is not a thing to be disdained in the present embarrassed situation of the German finances.

As the above will show, after having for a long time criticized us for the adoption of a controlled-recoil field carriage and the ensuing 4-gun battery, the Germans are beginning to recognize that the solution which we adopted for both these questions some five years ago was entirely correct.''

FRENCH RAPID-FIRE FIELD ARTILLERY.

ITS MATERIAL, FIRING METHODS, AND MANNER OF EMPLOYMENT.

COMPILED BY CAPTAIN ANDREW HERO, JR., ARTILLERY CORPS.

III.

METHODS OF FIRING.

The new firing methods break with the past more completely than ever would have been imagined. While the former manual always prescribed a precise and minute regulation of fire with the view of obtaining the maximum effect possible with the minimum ammunition, today it is sought particularly, and correctly so, to obtain sufficient results as quickly as possible.

The French have succeeded in deriving all the possible consequences from the adoption of a rapid-fire gun for their field artillery. Thanks to the increase in ammunition supply (a battery having now 40% more ammunition, one piece having 2½ more projectiles than formerly)* a battery can expend a great amount of ammunition, without having to fear finding its supply exhausted, and thus all the superiority of the material can be fully developed.

Great stress is laid on rapidity of ranging, or of regulation of fire, extreme *precision* is no longer sought, but *accuracy* is none the less required; the aim is to succeed in commencing effective fire before the enemy does, to find quickly a given target and then overwhelm it with sudden blows.

Projectiles Employed.—Of the twelve caissons, two caisson bodies carry high explosive shells (*i. e.*, 144 are carried per battery), the remainder carry shrapnel, "obus a balles." The shrapnel have combination fuzes, time and percussion, of great accuracy, the high explosive shell percussion fuze only. No case shot are carried.

Natures of Fire.—The firing may be: 1, without sweeping; 2, with sweeping.

1. Under these heads, there are prescribed the firing with a single elevation and progressive fire. Firing with a single eleva-

* Each caisson body carries 72 rounds and each limber 24 rounds; 4 guns and 12 caissons would then have 1248 rounds or 312 rounds per piece.

tion comprises a certain number of rounds fired successively with rapidity without separate command of the chief of piece and as soon as the layer has given the signal "ready". For example, at the command *By 4, Corrector* ...., (or *Percussion fire*), *Range* ...., the fuzes are properly cut, the firer sets the range disk at the range indicated, and 4 shots are fired without interruption and without further command.

Progressive fire is always with time fuze. It consists of firing two rounds at four successive elevations, varying by 100 metres, commencing at the shortest range. The chief of piece commands, *Progressive fire, Corrector* ...., and then he gives successively the four ranges, being careful to announce the new elevation immediately after the discharge of the second shot at any one elevation. For example, *Progressive fire, Corrector 20*:

2300.—Two rounds are fired with time fuze at 2,300 metres;
2400.— " " " " " " " " 2,400 metres;
2500.— " " " " " " " " 2,500 metres;
2600.— " " " " " " " " 2,600 metres.

The corrector remains at 20.

2. Sweeping is employed when the breadth of the objective is too great to allow the objective to be entirely covered without a change in direction of aim. In this case, three rounds are fired at the same elevation but varying in direction after each round by a quantity corresponding to three turns of the traversing handwheel, *i. e.*, by 6 millièmes. Fire with sweeping is always with time fuze.

To fire with a single elevation; at the command, for example, *By 3, Sweep, Corrector* ...., *Range* ...., the firing is executed as previously explained, except that the layer stops laying in direction after the first round, gives three turns of the traversing handwheel after this shot, and three turns again after the second shot. The third round having been fired, the layer brings the vertical ligne de foi back on the point of aim.

Progressive fire is executed at the command, *Progressive fire, Sweep, Corrector* ....; followed by the indication of the four elevations, given at the proper moment. For the first range, the layer acts as just explained but he does not bring the vertical ligne de foi back on the point of aim. For each new elevation the direction is changed, so that he turns the traversing handwheel to the left for the first and third elevations and to the right for the second and fourth. For example, *Progressive fire, Sweep, Corrector 19:*

2300.		1 round with time fuze is fired.
	3 turns to the left.	1 " " " " " "
	3 " " " "	1 " " " " " "
2400.		1 round with time fuze is fired.
	3 turns to the right.	1 " " " " " "
	3 " " " "	1 " " " " " "
2500.		1 round with time fuze is fired.
	3 turns to the left.	1 " " " " " "
	3 " " " "	1 " " " " " "
2600.		1 round with time fuze is fired.
	3 turns to the right.	1 " " " " " "
	3 " " " "	1 " " " " " "

OPENING AND CONDUCT OF FIRE.

Firing is generally executed with all the pieces of the battery; nevertheless, in certain cases, it may be executed by only a single section or even by a single piece.

By a salvo is meant a succession of shots from the battery fired with the same elevation, in a determined order, at the rate of a single shot for each piece. By a "rafale" is meant all the shots of a battery fired with the same elevation, without any determined order, at the rate of more than one shot per gun. All firing comprises generally a ranging fire followed by a fire for effect. According to circumstances, three different kinds of fire are employed in the fire for effect: first, progressive fire; second, fire with a single elevation; third, fire by salvos or by "rafales" at the command of the captain.

The ranging fire serves to determine the elements of the fire for effect which is intended to bring about or to complete the disorganization or destruction of the objective. Preparation for firing having been made, the captain gives his commands, which are repeated by the chiefs of section. The chiefs of piece successively direct the fire of their pieces, starting from the flank indicated, and in such a manner that the interval between two successive shots of the salvo shall be two or three seconds. One salvo having been fired, the captain gives his commands for the following salvo. The corrections of firing are then made by salvo. If the ranging fire is made with a single piece two shots are fired at each elevation.

The fire for effect is with percussion shell and with a single elevation when its object is to destroy an obstacle or material. If it is directed against troops, it is almost always with time fuze; it is made over a depth varying with the circumstances. In percussion fire, shrapnel or explosive shell are used. The latter is principally employed to demolish material and in the preparation for the attack of villages and woods. In the fire with time fuzes, shrapnel is employed.

For progressive fire, the captain commands, *Progressive fire, Corrector*......... (or *Sweep, Corrector*........ ,) *Range* ...., which are repeated by the chiefs of section. The firing begins at these commands, and each piece fires without reference to neighboring pieces. The chiefs of piece announce only the successive elevations to be employed.

For firing with a single elevation, the captain commands, (so many) *rounds per piece* *, *Corrector*.......... , *Range* .... ,or *By 3 ; Sweep, Corrector* .... , *Range*.......... . For percussion fire, he would give the necessary command after designating the number of rounds per piece, in this case usually 2, 4 or 6. The chiefs of section repeat the commands, (so many) *rounds per piece*, under the form *By*.......... , for example *By* 2. The pieces fire without any reference to one another.

The firing by salvos or by "rafales" † at the command of the captain is usually with time fuzes. It consists of a series of firings with a single elevation with or without sweeping, the captain having the option of varying the successive elevations by 100 to 100 metres or by 50 to 50 metres. The "rafale" without sweeping is always at the rate of two shots per piece. For each salvo or "rafale" the captain gives the commands for firing with a single elevation as above; at the same time he does not give the corrector again unless there is reason for changing it.

EXECUTION OF FIRE.

Duties of Officers.—The chief of group does not generally interfere in the execution of firing. His duties are limited to controlling the effects of fire, to rectifying manifest errors in ranging, indicated by observation of the fire for effect, and to making sure that there has been no error committed in the selection of the objective or in the distribution of the fire. The captain is charged with the regulation of the firing of his own battery. He himself directly controls the regulating of the range and of the height of burst. In the case of indirect fire, when he alone sees the objective, he regulates likewise the direction of the fire. The chiefs of section see to the execution of the orders of the battery commander, preserve order and require promptness and accuracy in the service of their pieces. They regulate the fire in direction except in the case of indirect fire.

* Usually 2 or 4.

† "Rafales" corresponds to "fire with counted cartridges." After getting the range, 4 "rafales" are fired, that is each piece fires 4 shots at will, but for correspondingly numbered shots, all 4 guns have the same range or elevation. It may be called a progressive volley. An Austrian writer uses the expressive term "Feuersturm".

General Principles Relative to the Execution of Fire.—Ranging fire is executed, as a rule, with the same kind of projectile as is to be used in the fire for effect which is to follow it. The elements of the fire for effect are:

1. The deflection allowance suited for each piece.

2. For time fuze fire, the corrector giving the type height of burst.

3. The elevation or range.

The following operations are then necessary:

1. Regulation of fire for direction.

2. Regulation of fire for the height of burst in time fuze fire.

3. Regulation of fire for range.

This triple adjustment is obtained by observation of shots. The regulation in range and in direction can be obtained by the aid of percussion shots or by the aid of low-bursting time fuze shots. The observation of time fuze shots is generally easier because it is independent of accidents of and the nature and condition of the ground ; moreover, when the fire for effect is to be with time fuzes, time is thus gained by the simultaneous regulation of the height of burst and of the other elements. Whenever there is no danger of the accumulation of smoke interfering with the observation of shots, it is advantageous to execute this ranging fire by salvos from the battery distributed over the whole front of the objective. By this method, the fire is regulated for direction, for range, and also for the height of burst all at the same time. Moreover when ranging is executed by means of time fuze shots, regulating the height of burst is more rapid and accurate, and effects, more or less great, may be secured on the objective itself during the execution of the ranging fire. At the start a few more rounds are consumed, but in the long run economy of ammunition and time both result. The regulation of fire in this manner is not imperative, and, in certain cases, where the observation is easy, the captain can perfectly well do his ranging with fire by section or by piece, especially in percussion fire against obstacles; but generally the fire by salvo of four guns gives the best results, wastes the least ammunition and saves time.

RULES FOR FIRING.

Regulation in Direction.—The chiefs of section regulate the direction of fire for each one of their pieces by correcting by the whole of the observed deviation. Nevertheless, against a fixed objective, when, after a correction in one direction they are led to order the same correction in an inverse direction they reduce the second by one-half.

Regulation of the Height of Burst.—The object of this is to determine the proper corrector so that the height of burst of the salvo equals the hauteur-type for the fire for effect, or $\frac{1}{1000}$ (1 millième) when ranging by time fuze fire. The regulation is made by modifying the corrector according to the mean height of the last observed salvo.

The following rules apply for obtaining heights of bursts of $\frac{1}{1000}$ or $\frac{3}{1000}$ of the range: After a salvo whose average point of burst is very high*, diminish the corrector by 6 or 4 divisions; after a salvo whose average point of burst is high, diminish the corrector by 4 or 2 divisions; after a salvo at the proper height of burst, diminish the corrector by 2 or 0 divisions; after a percussion shell salvo, increase the corrector by 4 divisions. If, after a change in the corrector, the new salvo leads to an equal or superior correction in a contrary sense, an intermediate corrector is adopted. It is not necessary to consider salvos or volleys where the height of burst is very irregular, for that is due to an error in cutting the fuze, in laying, or in angle of site. When the regulation of the height of burst has been obtained at $\frac{1}{1000}$ (1 millième), we pass to the type height (hauteur-type) by increasing the corrector by 2 divisions.

Regulation in Range.—All regulation of fire in range consists, generally, of the determination of two elevations, the one for the short range, the other for the long range, bracketing the objective.† In certain cases the inferior limit of this bracket can alone be determined. When observation of fire is possible with respect to the objective itself, the captain, starting with the initial elevation chosen, proceeds by successive jumps, all having the same amplitude, so as to obtain at first two ranges bracketing the target. The jump, and consequently this first bracketing of the objective, is generally 400 metres. It can be reduced to 200 metres in case of easy and reliable observation, by the indications furnished by previous firing, by the fire of another battery, or by range finding measurements. The limits of this first bracket (in ranging, to get the target between a short and an over) are then contracted according to the nature of the fire the

* Heights of burst are estimated from the foot of the objective, if the latter is not sheltered by entrenchments, or in rear of a crest; if such be the case, they are estimated from the summit of the covering crest. A burst is called ***very high*** when it is greater than two hauteurs-types; ***high***, when it is greater than one hauteur-type; ***low***, when it is less than one hauteur-type. The height of burst of a salvo of time fuze shots is estimated by the mean height of the several points of burst.

† A salvo is called ***short*** or ***long***, according as the majority of the observed shots are short or long. A ***bracketing salvo*** is one which comprises 2 short shots and 2 long shots. A bracketing salvo in percussion fire is to be considered as corresponding to the most probable range of the objective.

captain proposes to execute. The definite bracket thus obtained is called the "fork." To decide upon the sense of an elevation corresponding to the limit of the fork, it is necessary to have observed with this setting of the range disk, at least two shots of the character desired in the same salvo or in two ranging salvos. If the object is in movement or liable to be displaced, the bracket is considered effective only if the last salvo corresponded to the limit toward which it moves, or, for lack of indications upon the direction of its movement, to the short limit. If the salvo is with percussion fire, the regulation should be considered finished when in the course of ranging an inclosing salvo is obtained. If with time fuzes, the amplitude of the jump can always be reduced to 100 metres.

In consequence of the invisibility of the objective, it may be necessary to observe the fire with respect to objects or the relief of the ground either in front or in rear of the objective. The captain proceeds generally in the same manner with respect to these auxiliary ranging points employing, according to the conditions of observation, either time fuze or percussion fire.

Progressive fire comprises in general the searching of a fork of 200 metres' extent. The starting elevation is that of the short limit of the fork decreased by 100 metres. It ought to be employed only when a more narrow fork has been found.

Fire with a single elevation comprises the searching of a fork of 50 metres' extent. The starting elevation is the short limit when the fork has been obtained with low time fuze shots. If the fork has been determined with percussion shots, the mean elevation is adopted unless a salvo may have enclosed the objective, when the elevation for this salvo is kept.

Fire by salvos or by "rafales" at the command of the captain is suitable for every fork greater than 50 metres. The starting elevation is the range of one of the two limits of the fork. When it is necessary to have recourse to auxiliary ranging points the amplitude of the fork varies according to circumstances, but it ought never to be less than 100 metres. If there is urgency the captain may even content himself with a single "short" elevation or an "over" elevation, according as the range point is in front or in rear of the objective. When it is possible to determine only one of the limits of the fork, this limit is taken as the starting elevation for firing by salvos or by "rafales" at the command of the captain. The amplitude of this fire is limited by fixing the extent of the zone to be swept.

SALVO OF CONTROL.—After the ranging is completed, a salvo fired from all the pieces that are to participate in the fire for effect is called a salvo of contrôl or verifying salvo. It has for its object the verification of the elements of the fire for effect, or, in the fire against obstacles, improvement of the sighting if there is reason for it, This salvo is fired with the starting elevation of the fire for effect, and with low-bursting time-fuze shots or with percussion shell according as the fire for effect is to be with time or percussion fuze. In progressive fire the short limit of the fork is taken. The salvo can be repeated when it has brought about important modifications in direction or in elevation. When it is long the regulation in range is resumed by reducing, as needed, the amplitude of the "jump." The salvo of control should not be executed either against troops near by or when the last ranging salvo has established the fact that the elevation and direction are good. In the fire against obstacles the salvo of control is obligatory. If the salvo comprises two or three long shots in four observations, this elevation is kept for the fire for effect. In the contrary case, the elevation is changed by 25 metres in the proper direction, and the salvo of control is repeated until this proportion is attained.

CHANGE OF THE OBJECTIVE.—The change of the objective may or may not demand a new lowering of the brake shoes, which is directed by the captain. The captain can in these two cases: (*a*) Designate the new objective and order a general change of the lateral sight allowance; (*b*) Give the new elements of fire. He can have the fire of a single piece directed upon the new objective, or that of a single section.

EXTENSION OR CONFINING OF THE OBJECTIVE.—The captain can increase or diminish the echeloning.

NEAR ATTACK.—When an objective arrives within less than 500 metres' range each chief of piece commands, *Upon such an objective, Fire at will.* The cannoneers execute what is prescribed for the change of the objective, if necessary, and for firing against a moving target. The corrector is set at 20. The graduated range disk and the cadran of the débouchoir are set at 200. The firing begins as soon as the layer commands "ready". The firing is with a single elevation; the number of projectiles to be cut in the débouchoir is undetermined. The pieces are individually sighted upon the whole of the front, each gunner following the movement of his own particular objective. The chief of piece stops the firing when the circumstances which have necessitated this kind of fire have ceased to exist.

FIRING AGAINST BALLOONS.—Progressive fire is employed. The firing is with time fuzes. In the ranging fire an endeavor is made to bring the bursts at the height of the balloon, and for the fire for effect the corrector is increased by 6 divisions in such a way as to utilize the greatest width of the sheaf of projectiles. It is not necessary, in fact, for the bullets which may reach the balloon to have a great remaining velocity, nor that the sheaf or cone of dispersion be very dense.

USE OF THE METHODS OF FIRE.

The captain has all latitude to choose the method of fire which is best suited to circumstances, and to adopt the method he may have chosen to the particular conditions of the concrete case in which he finds himself placed. He never loses sight of the necessity of paralyzing the adversary before the latter has had time to take away from his battery all liberty of action. But to apply judiciously the natures of fire placed at his disposition, he must fully appreciate their properties.

Firings in depth executed over a large fork are necessary to cover deep objectives. They are appropriate, moreover, when it becomes necessary to deprive an enemy as quickly as possible of his liberty of action; they are used with great advantage to confine an adversary in a definite zone, or again to stop him in a sudden movement, when ranging fire on the point of passage has not been first accomplished.

The means applicable for firings in depth are progressive fire and the firing by salvos or by "rafales" at the command of the captain. The first presents the advantage of utilizing the maximum rapidity of fire of the material; the second permits the captain always to keep control of his firing. It is applicable to any depth whatever, minimizes the expenditure of ammunition, and permits the rapidity of fire to be varied at will.

The firing with a single elevation supposes essentially a reliable observation in the neighborhood of the objective. It demands a more prolonged regulation, which is more minute and often more delicate than for the firing in depth, but, when the fire is regulated, it gives the maximum effect with the minimum expenditure of ammunition. It is suitable, then, for the destruction of obstacles or material or against an object particularly dangerous or tenacious. It is employed, on the one hand, to hold an enemy already mobilized, or to stop an adversary in movement at the moment of his passage at a point upon which it has already been possible to regulate the fire in advance. It can be conducted with extreme rapidity as the elements of fire do not vary during its whole duration. At the same time, in the fire against obstacles, rapidity is of secondary consideration; accuracy and the possibility of controlling the effects produced, being the conditions which it is most important to realize.

The application of the various methods for ranging and for the fire for effect naturally involve variations depending upon circumstances. But the *Règlement*, for illustration, gives 24 examples which fully set forth the guiding principles.

The following outline will serve to give a clear idea of the manner in which fire is executed, according to the foregoing rules; it includes the first example given in the *Règlement* (though others would serve equally well).

The captain has preceded his battery to the place indicated by the group commander, where he sees the target to be attacked, and receives instructions as to what portion of it falls to his battery. The guns are to come into battery without showing their positions, perhaps behind a hill for protection, or a hedge for concealment, etc. The gunners cannot see the target; time presses and the battery telescope will not be used for deliberate indirect laying. It is, nevertheless, set up as soon as may be to observe the points of bursts and to correct the range.

The captain indicates where the battery is to come into action; selects a place as nearly in front of it as possible where he can see the target; selects an auxiliary aiming point—some conspicuous mark—takes his hand scale for direction, estimates the plateau and tambour to be given to the collimator so that when it is pointed at this point the guns will be pointed at the target.

By this time the guns are unlimbered and ready to load. The captain calls his chiefs of section and the gun layers to him and gives his directions.

1. Point to aim at—such a tree.
2. Front, 60 millièmes.
3. First piece, plateau 2, tambour 170.
4. Other pieces at intervals of 15.
5. Angle of site, + 5 milliemes.

At the third and fourth indications, the layers announce the lateral allowances of their respective pieces for the captain to approve; thus, 1st piece, pl. 2, tambour 170; 2nd piece, pl. 2, tambour 185; 3rd piece, pl. 4, tambour 0; 4th piece, pl. 4, tambour 15.

All return now to their posts and the pieces are immediately laid. As soon as the layer is ready he commands "ready," and the chief of piece raises his arm and orders, "for the first shot." This command is a warning to the layer and the firer to get outside of the wheels, as the spade is not yet sunk and the whole carriage recoils a short distance. After the first shot these men remain on their seats.

The captain seeing all in readiness, now commands, "From the right, by battery, Corrector 18." The chiefs of section repeat these commands and the fuze cutter places the corrector at 18. To load and fire the captain now commands, 2600 (the range).

The chiefs of section repeat this command, the cadran of the débouchoir is set at 2600 and the fuze cut; the guns are loaded and without waiting for further command the fire is begun, beginning with the right piece. The others fire if quite ready, each immediately after the one on the right.

FIRING IN DEPTH AGAINST TROOPS AT A HALT OR IN MOVEMENT.

>>>————> Wind.

By the right, by battery.

Corrector 18.

Range and Fuze.	Height of Burst.	Overs and Shorts	Remarks.
2600 Corrector 18	high	not observed	height of burst $\frac{3}{1000}$ too high for observation.
2600 Corrector 16	burst on striking	short	Correction too great.
3000 Corrector 17	low	long	
2800 17	low	long	
2600[1] 17	low	short	[1]Salvo of control
Progressive fire, Corrector 19, 2500.			

The fork, 2800–2600 being thus established, a salvo of control is fired at 2600 metres, and then the following progressive fire (indicated at the bottom of the table) is immediately begun: Corrector 19 (2 millièmes more than when ranging), range 2500, two shots from each piece, then two shots at 2600, at 2700 and at 2800, as already described.

ORGANIZATION.

Each field battery consists of 4 guns, 12 caissons and 6 other vehicles; there are 4 officers, 170 non-commissioned officers and men, and 167 horses. Each 75mm. horse battery has 1 vehicle and 42 horses more. The personnel of the battery is divided into 9 subdivisions (*pelotons de piece*) each commanded by a sergeant, assisted by one or two corporals. The following table shows the component parts of the battery on a war footing:

1st section	1st "piece"	1st gun		Firing line: "Batterie de tir."	"Batterie de combat."	Field Battery on a war footing "Batterie de guerre."
		1st caisson				
	2nd "piece"	2nd gun				
		2nd caisson				
2nd section	3rd "piece"	3rd gun				
		3rd caisson				
	4th "piece"	4th gun				
		4th caisson				
3rd section	5th "piece"	5th caisson	1st supply caissons			
		6th caisson				
	6th "piece"	7th caisson		"Echelon de combat."		
		8th caisson				
		9th caisson				
4th section	7th "piece"	10th caisson				
		11th caisson				
		12th caisson				
	8th "piece"	Forge				
		Battery wagon				
	9th "piece"	Forage wagon		Regimental train.		
		Provision wagons (3 for field, 4 for horse)				

The "batterie de tir" is commanded by the captain personally. The first supply caissons maneuver under the direction of the battery artificer, conforming to the movements of the battery, but without interfering with it. The whole object of the instruction of the "batterie de tir" is to give it the greatest suppleness and highest maneuvering qualities so that, whatever may be the difficulties of the terrain, it can go into battery under all circumstances and perform its functions with ease and precision whether the battery is acting alone or forms part of a group.

CHARACTERISTIC PROPERTIES AND RESULTING GENERAL PRINCIPLES IN REGARD TO THE EMPLOYMENT OF R. F. ARTILLERY.

Rapidity of action is the characteristic property of the French rapid-fire field artillery. It results from two essential qualities of the material: 1. Rapidity and power of fire. 2. The possibility of acting by surprise.

1. The rapidity and power of its fire produces such an effect over the ground the artillery covers effectively by its fire that no troops in dense formation will be able to move openly over this ground without exposing themselves to losses serious enough to destroy their morale and to stop their progress; the usual obstacles of the battle field (walls, embankments, etc.) will, in a very short time, be completely destroyed, or rendered sufficiently untenable to drive out the defenders. However, it may be necessary at times to have recourse to the heavy artillery for action against those positions that the enemy may have had time to fortify.

2. The possibility, whenever tactical considerations lend themselves thereto, of making preparation for firing concealed from

view of the enemy, enables the artillery to reveal its presence only at the precise moment when its effect is to be produced. The effects due to rapidity and power of its fire are further enhanced, in such a case, by those resulting from surprise.

Consequently, to secure the full benefit of the artillery's rapidity of action, fire will be executed "by rafales," sudden, short and withering, depriving the adversary of all liberty of action and facilitating thereby the capture of the field by the other arms. Firings for effect, then, are necessarily intermittent.

The following general principles in regard to the employment of artillery result from its properties:

In the choice of objectives, always choose those clearly defined, and preferably those that more immediately and efficaciously oppose the advance of the infantry.

In the preparation and conduct of fire, have constantly at hand the greatest possible number of batteries ready to enter into action, but at the beginning none must fire but the number judged sufficient to obtain the desired result in the minimum amount of time. This number, in general, depends on the breadth of front to be covered by the fire. Install provisionally in a position of observation, or in a waiting position, *those batteries of which immediate use will not be made, in such a manner that they may, without loss of time and by means of a preparation for fire carried as far as possible, either act against new objectives as soon as the presence of the latter may be revealed, or concentrate their fire on an objective insufficiently covered. The fire of the artillery attains its maximum power, in fact, by the concentration of fire.

This brief summary is sufficient to indicate the great reforms introduced in the French artillery, which has no fear that it will not be able practically to apply all the results that can be deduced from the properties of material giving an extraordinary rapidity of fire:

Reduction of the number of guns of the battery to 4.

Caissons by the side of the guns, putting ammunition in great quantities in the hands of the loader.

Special apparatus for rapidly cutting fuzes.

The shots are fired no longer at the command of the chief of section or even chief of piece in certain firings, it being simply necessary for the layer to indicate "ready".

* A battery is said to be in a *position of observation* when it is in battery, concealed from view of the enemy, and ready to open fire.

A battery is said to be in a *waiting position* when it is limbered, concealed from view of the enemy, and near the position it will probably occupy.

The presumed importance of directions of danger, and the probability of subsequent movements lead to the adoption of the one or the other of these positions.

Distribution of fire, generally, at all distances.

Extensive use of collective pointing.

Corrections for regulating fire ordered after a fire by rapid salvos, or if it is a question of a single piece, after firing two shots.

Effective fire with the greatest rapidity possible, producing the result in the minimum time. It is said that a rate of fire of 25 to 30 rounds a minute can be obtained with this gun.

Introduction of mowing or sweeping fire, and firing in depth.

The careful preparation of the firing has assumed great importance by reason of the suddenness of the effects of regulated fire.

Masked fire has been facilitated by the perfecting of the apparatus and methods of laying.

Finally, the sudden and crushing effects of fire have made the principle of economy of force applicable to artillery. All the batteries ought to be ready to act, but the command to open fire ought to be given only to those that it is necessary to put into action in order to obtain the result. The others are in observation, ready to fire, or in a position of waiting, ready to occupy their firing position and to enter into action.

The new French *Règlement* is altogether imbued with the spirit of the offensive. It plainly declares that the *offensive* alone can obtain decisive results; it treats of the artillery battle exclusively from the assailant's point of view, and dismisses in five lines the use of artillery on the defensive.

If to this is added the fact that the *Règlement* attaches especial importance to the co-operation of the artillery with the infantry, —the effect of artillery never being considered for itself alone, but always as support in the infantry attack—that it seeks, moreover, to excite a spirit of decision and the feeling of responsibility, especially in what concerns the *sin of omission*,—the conclusion will be reached that the *Règlement* is fully abreast of its epoch.

CONTINUOUS-READING RANGE AND AZIMUTH FINDER AND PREDICTOR.

By JOHN F. MEIGS, Engineer of Ordnance,

Bethlehem Steel Company.

This system consists of two instruments provided with telescopes movable in azimuth, and aims at giving guns accurately and continuously the correct predicted range. The sights being kept continuously set in accordance, it is only necessary, when the sights are on the target, to fire the gun.

The novelty and advantage of this system consists primarily in the details of construction of the home station instrument, and in the method of continuously reporting the ranges and azimuths of the target to the guns which are served by the said instrument. Continuous readings by means of automatic indicators, of either the actual or the predicted ranges and azimuths of moving targets at every instant, for any distance of from 1000 yards to 15000 yards and an azimuth of 160°, are clearly presented at all times. The ranges are read in scales of 25 yards steps, and the azimuth for each 2 minutes of arc traversed. These steps are equal to 0.25 inch on the range, and 0.125 inch on the azimuth reading ribbons, and are read direct without the use of any verniers, which permits of the rapid continuous reading by noting the marks on a moving tape.

The ranges and azimuths, either actual or predicted, are constantly communicated to the various guns whose fire is being directed. The base line between the two instruments should be approximately at right angles to the fire of the battery of guns that are to be served, and may have any length between 100 and 6000 yards, although about 1500 yards is the preferable length of base line as the mean errors are smallest for this distance with the angular dimension of instrument as laid out for type designed to cover field of from 1000 to 15000 yards range.

The distant station instrument indicated at *B*, Fig. 1, is similar in principle to an ordinary protracting instrument, and consists of a protractor plate of 18 inches radius fixed to a pedestal, said plate being graduated for every degree of its sector, which is 180°, and having a quick reading dial

D co-acting with an index arm, which is fixed to the center pivot in the sector and moves jointly and parallel with the observation telescope in azimuth. Said dial is divided for each minute, one minute on the scale being equal to 0.25 inch actual measurement. The home station instrument *A* has a similar protractor plate fixed in position, with its straight edge parallel to the distant station protractor's straight edge. This protractor is also marked for every degree of sector, and provided with a minute reading dial D_1 attached to the index arm B_1. The index arm in the home station instrument does not move in lines parallel to the telescope of said instrument, but is independent of the movement of said telescope. It must be kept on a line parallel to the correct line of sight or azimuth at the distant station telescope and index arm. This is accomplished by constantly communicating the azimuth of the telescope at *B* to the index setter at instrument *A* by means of telephone or otherwise. The index arm for instrument *A* is pivoted at a position B_1, which, although in the center of the fixed protractor, is eccentric to the pivotal point A_1 of telescope of instrument *A*. The distance of said pivotal point A_1 of telescope from pivotal point B_1 of index arm represents in miniature the actual horizontal base line between the two observation instruments. In order to allow of ready and accurate changes in length of base line, or to proportion accurately the miniature base line A_1—B_1 to the actual base line, the protractor plate of instrument *A* is movably secured on an intermediate plate or disc, by means of dovetail grooves running parallel to the straight edge of the protractor.

The intermediate plate or disc is rigidly held in a fixed position with its pivotal point coinciding with the pivotal point A_1 of the telescope and of the home station limb of the angle measuring bars, this limb being parallel to the axis of line of sight and pivotally mounted in a pedestal, a flaring out about its pivotal point giving support to the intermediate plate, on which the protractor plate is fixed. The distant station limb of the angle measuring bars is formed by the prolongation of the index arm, of which it is really a part and which it actuates. The two limbs are secured to one another in a sliding pivotal bearing C_1 at their point of intersection and are, as previously stated, pivotally held at their junction to the base line A_1—B_1, formed by the straight edge of protractor. The two lines A_1—C_1 and B_1—C_1 and the base line A_1—B_1 form a triangle whose base in miniature is the distance between the stations *A* and *B*, and whose sides are the plotted distances *A—C* and *B—C* from said stations, respectively, to the target.

The position of the sliding pivot at C_1 is determined by the communicated azimuth from station *B*. A screw running parallel to and within the home station limb, is used for changing the position of sliding pivot or point of intersection of the two angle limbs. This screw is actuated by means of a hand wheel, one turn of which gives 1½ turns to the translating screw and moves the sliding pivot and the point C_1 0.75 inch, which is a distance equal to 150 yards change in range of target. This handwheel is constantly turned to keep the index arm and minute dial D_1 at a reading of azimuth corresponding to that communicated from the distant station *B*. A steel ribbon or tape, graduated 0.25 inch equals 25 yards, passes over a pulley secured to the cross-head carrying sliding pivot at point C_1. It has one end secured near center pivot and the other passes rearwardly over a guide drum to a spool drum, on which it is kept tightly wound by spring tension. The tape automatically unwinds as range increases and re-winds as it decreases, or as sliding pivot or point C_1 and nut on the screw move outwardly or inwardly due to turning of hand-wheel. Indicating or reading fingers *E*, (see letter *E* on any of figures illustrating parts) two of which (for the reason which will be made apparent in the next paragraph) are provided for each gun being served, automatically correct for the differences in actual range of instrument and of the guns to the target, both as to the actual distance and to that occasioned by change of azimuth. This is accomplished by means of cams *G*, which are laid off from calculations made for specific locations of guns and instrument. Predictions of range, plus or minus, for time of flight of projectile corresponding to given ranges are obtained by causing prediction fingers *F* to travel in a direction opposite to that of reading ribbons for a period of time according to the length of prediction required. Thus the number showing on the tape immediately under the end of the reading fingers gives the range and azimuth, either actual or predicted. The position of the ends of the reading fingers are affected, both for the range and azimuth, by the special cams *G*, depending upon the gun's position in the battery, and by the places in which the predicting fingers *F* are placed by the operator, as will be described in the next paragraph.

The time of prediction is obtained by means of a stop-watch. The readings on the ribbons will be an actual plus or minus range, corresponding to the increase or decrease of range for given time interval. To insure constant correct prediction of both ranges and azimuth a double reading arrangement is provided, so that continuous reading may not be interrupted. While one set of readings are being corrected for time of flight and consequent change in prediction, the range and azimuth readings are taken from the previously corrected reading points. The plus or minus prediction will hold good until a considerable change in range takes place (from 300 to 600 yards for direct fire), which is equal to one second change of time corresponding to average velocity of projectiles. This will be a safe factor for mean ranges, and the prediction fingers *F* should be placed at their zero marks or actual readings, and a new prediction made for each change of time required when ranges differ more than 600 yards. The time of flight must be taken from tables.

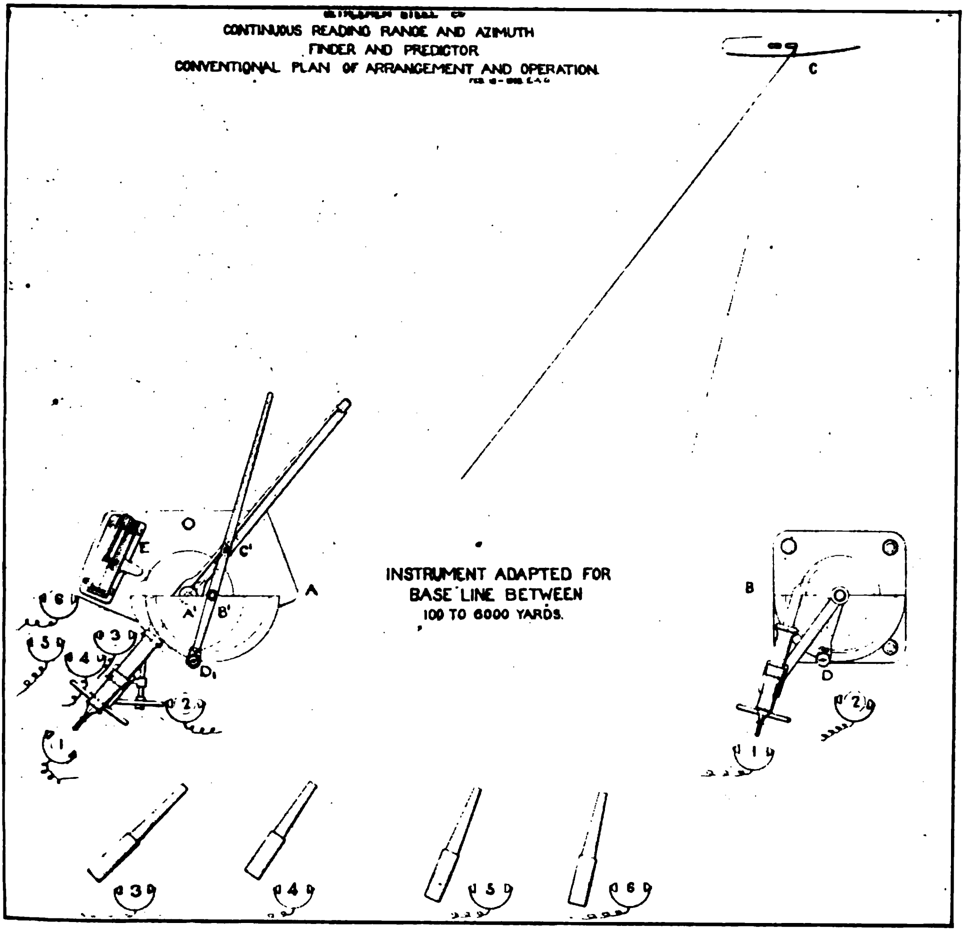
The position in azimuth is obtained by the movement of traversing the telescope and angle bar about pivot point A_1, said motion being communicated and increased in a ratio of 1 to 12 to the drum *E*, Fig. 1, on which is secured one end of the azimuth tape or ribbon, the other end passing over a guide drum and down to a spool drum, on which it is kept tightly wound by spring tension, in a manner similar to the range tape. Indicating or reading fingers E_1 Fig. 2, for each gun, automatically correct for the difference in azimuth of target from the instrument and the various guns, and give the true azimuth for each gun, the fingers being actuated by cams G_1 laid off from calculations of the relative position of the instrument and the guns for any specific location.

Predicting fingers F_1 Fig. 2, are also provided, which are actuated by contact with the azimuth ribbon, for a given period of time and in a manner similar to a given prediction for range. A prediction can be made for as much as 2 degrees of azimuth and for either direction within 160° of arc.

Two men are stationed at the distant station instrument *B*, No. 1 in charge of telescope, keeping the cross-hairs constantly on the point of target agreed upon between himself and No. 1 at the home station instrument *A*, who is the observer at its telescope, and with whom he is in constant telephonic or other communication.

The sole and only duty of Nos. 1 is to keep their respective telescopes sighted on the point agreed upon. No. 2 at the distant station instrument *B* reads the position of the bar in azimuth and repeats it to No. 2 of the home station instrument *A*, Nos. 2 being fitted with helmet receivers and transmitters similar to the observers No's. 1, but on a different metallic tele-

64-1



CONTINUOUS READING RANGE AND AZIMUTH
FINDER AND PREDICTOR
CONVENTIONAL PLAN OF ARRANGEMENT AND OPERATION
C
E
C'
A
A'
B'
D1
INSTRUMENT ADAPTED FOR
BASE LINE BETWEEN
100 TO 6000 YARDS.
B
D
6
5
3
4
2
1
3
4
5
6

FIG. 1.

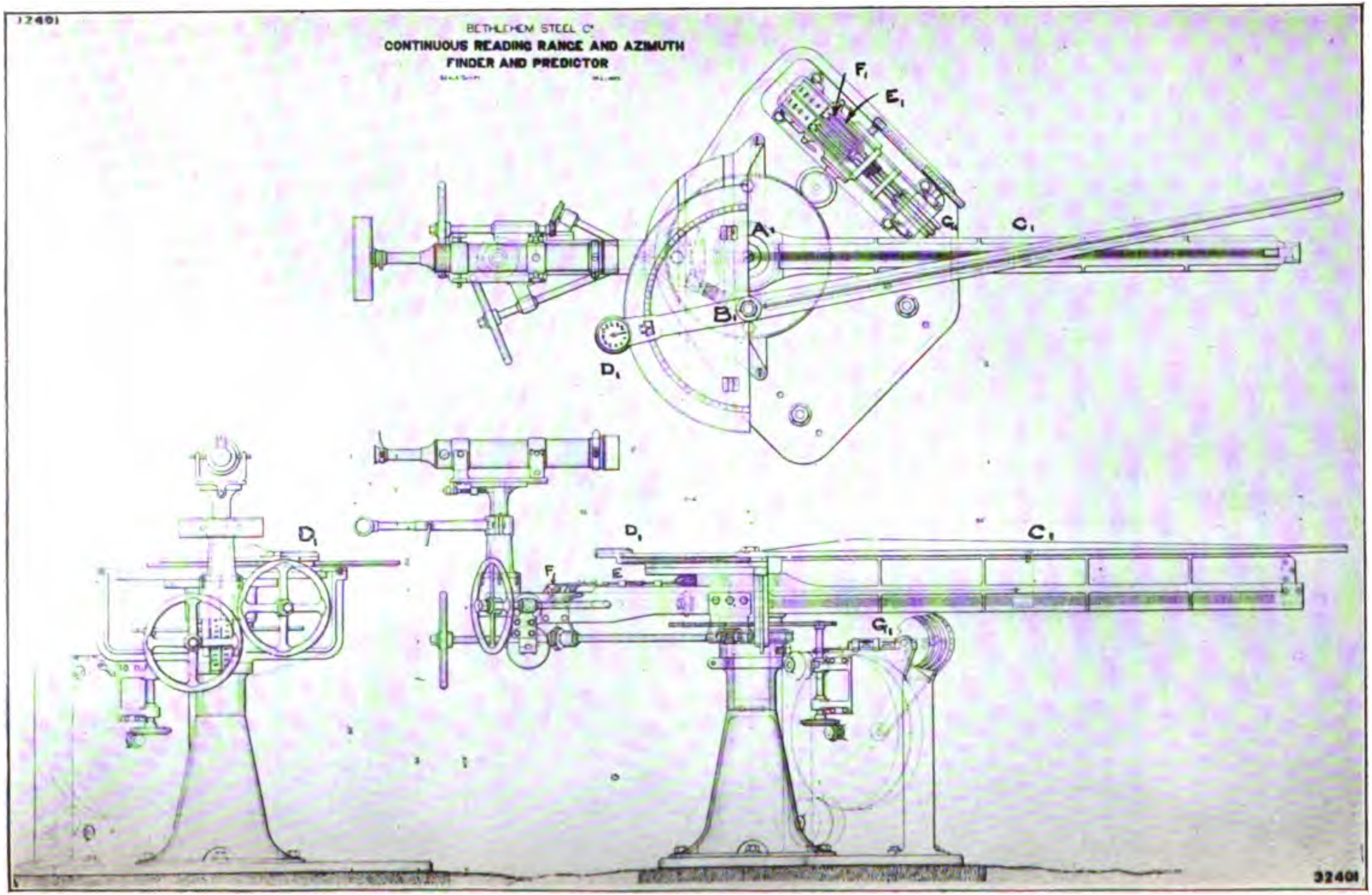

32401
BETHLEHEM STEEL Co.
CONTINUOUS READING RANGE AND AZIMUTH
FINDER AND PREDICTOR
F1
E1
A1
B1
C1
G1
D1
E
F1
32401

Fig. 2.

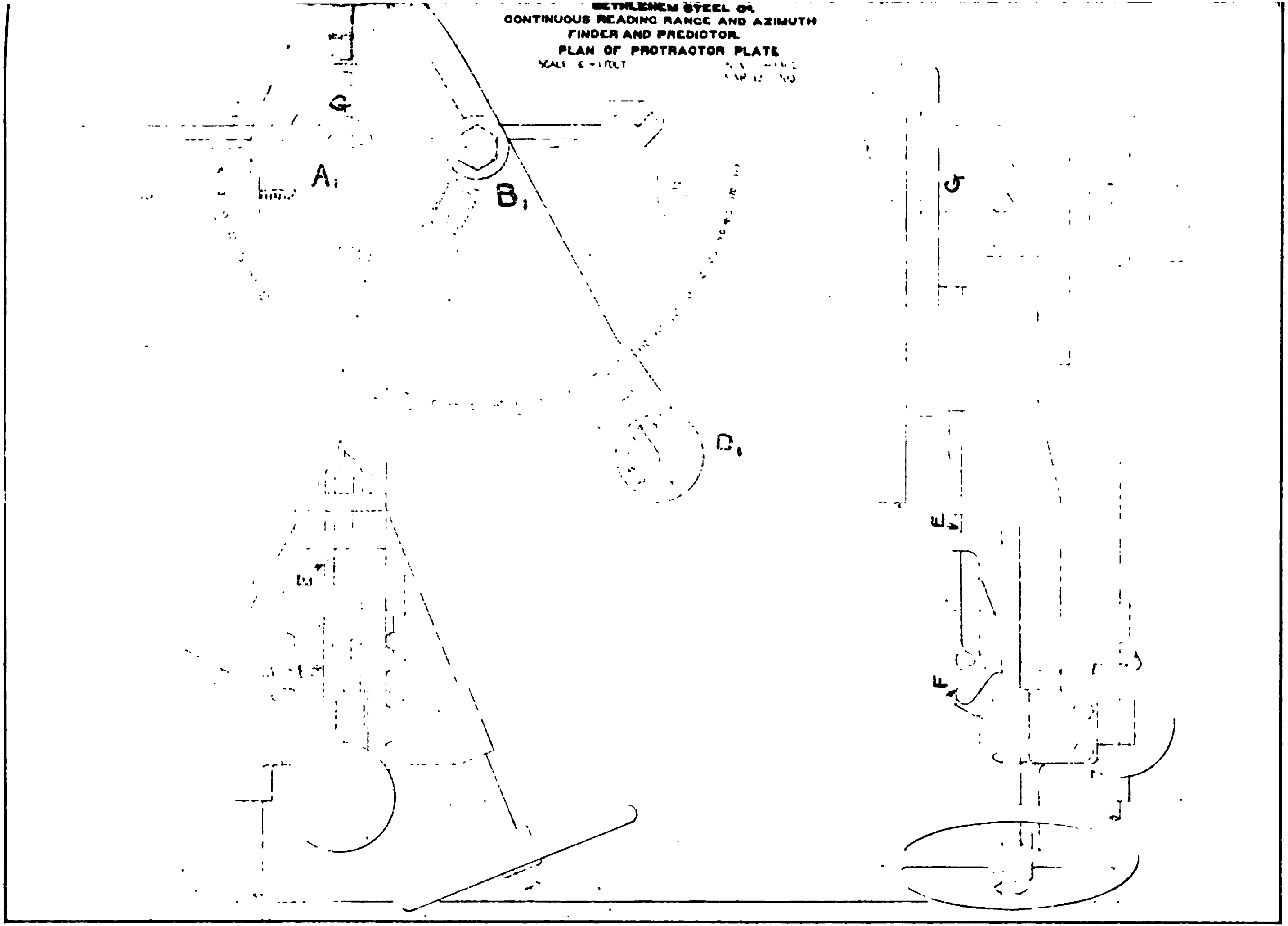

BETHLEHEM STEEL CO.
CONTINUOUS READING RANGE AND AZIMUTH
FINDER AND PREDICTOR.
PLAN OF PROTRACTOR PLATE
G
A₁
B₁
D₁
G
E
F

FIG. 3.

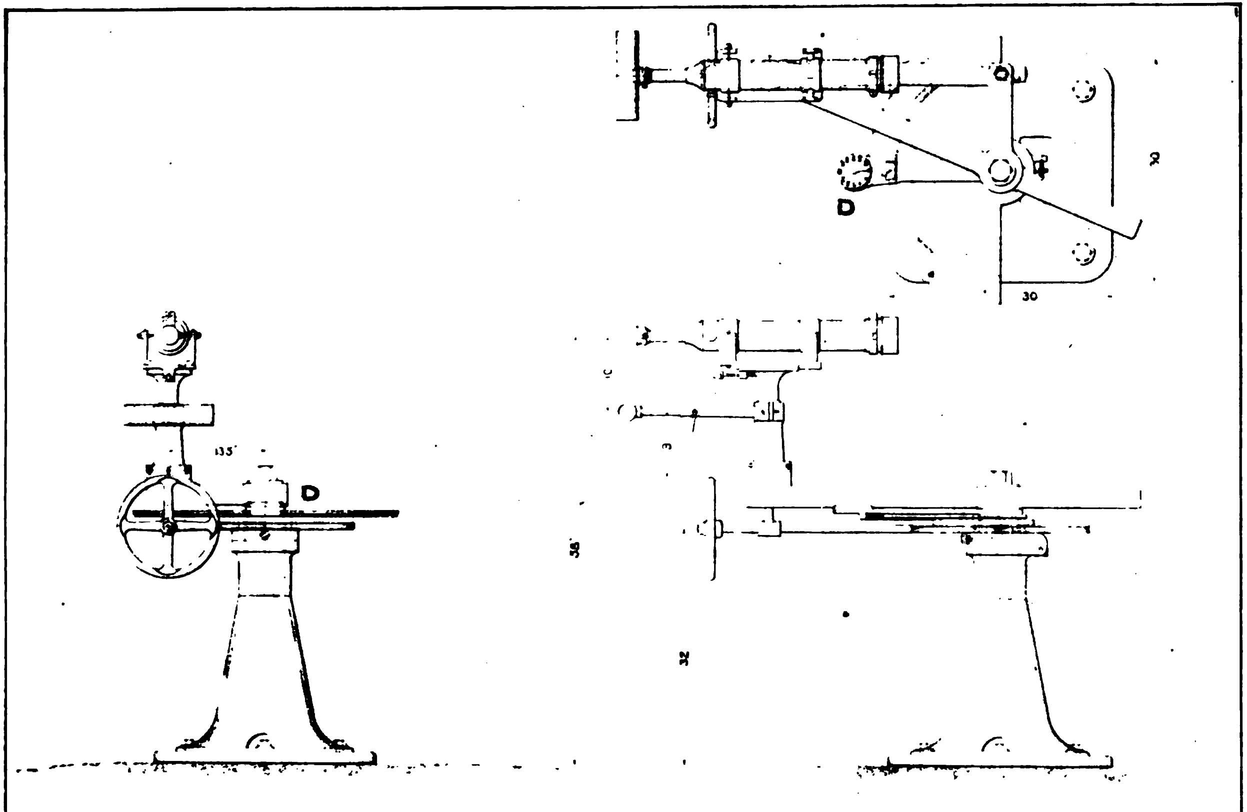


Fig. 4. — Continuous Reading Range and Azimuth Finder and Predictor. — General arrangement distant station.

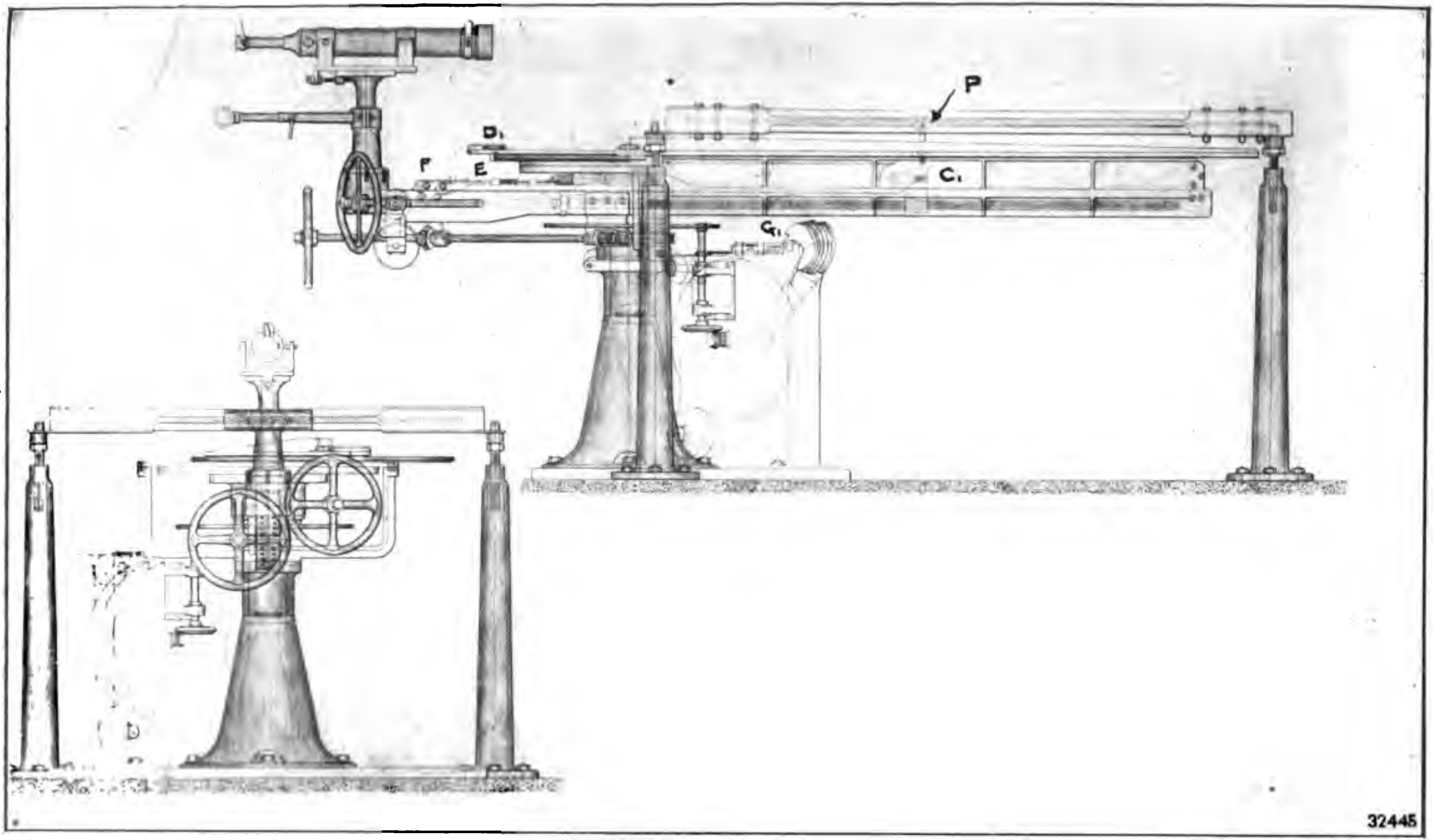


Fig. 5. — Continuous Reading Range and Azimuth Finder and Predictor. — Chart Attachment.

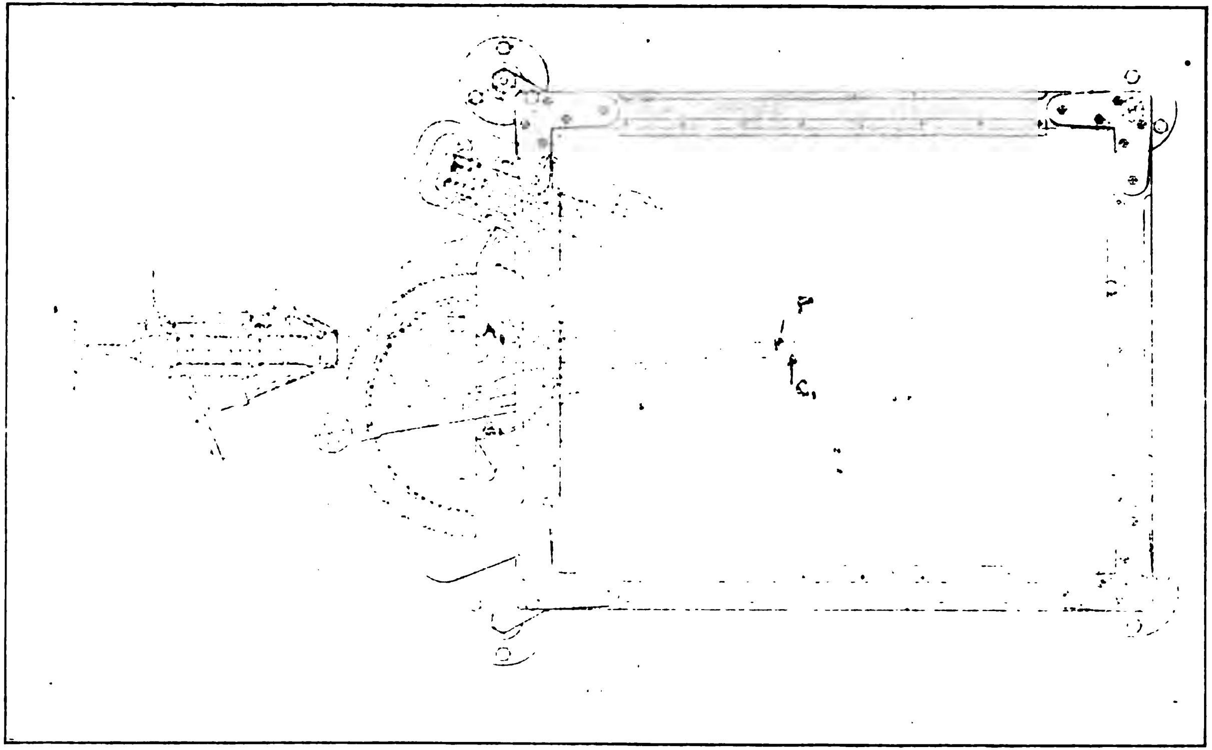


FIG. 6. — CONTINUOUS READING RANGE AND AZIMUTH FINDER AND PREDICTOR. — Chart attachment.

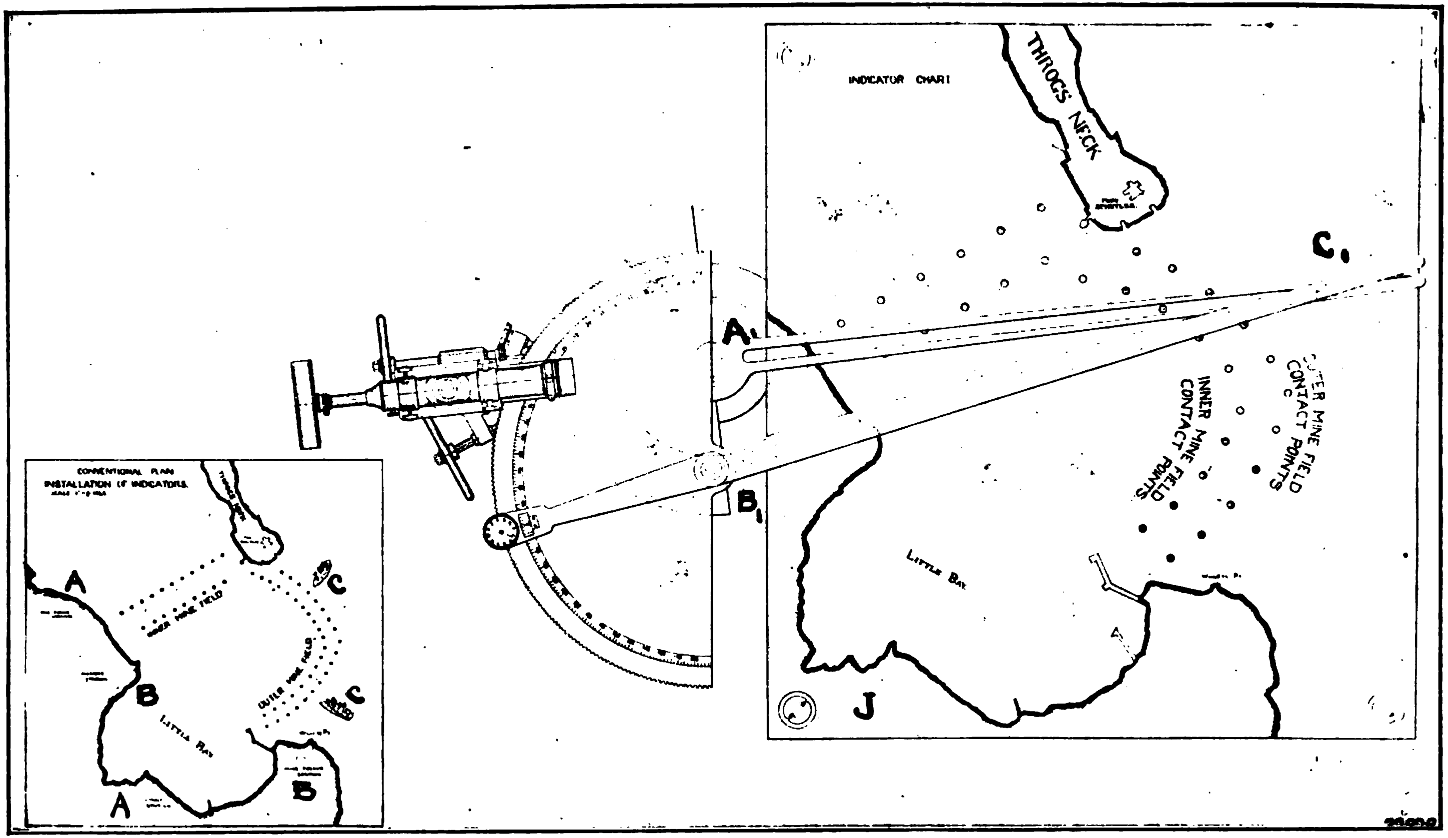


Fig. 7. — Position Mine Indicator and Exploder.

phonic circuit. No. 2, at *A*, then actuates the hand wheel until the azimuth shown on his index arm and minute dial *D*, corresponds to the transmitted azimuth from distant station *B*. The sole and only duties of the Nos. 2 are to transmit and keep the azimuths shown by the index arms of the two instruments *A* and *B* the same at all times. The chief in charge, who is stationed at the home station indicating instrument, looks at tables from which he obtains correct times of flight of projectiles for ranges indicated. He adjusts the predicting fingers F and F_1 at such intervals as he may deem necessary, and has general charge of the instruments. Nos. 3, 4, 5 and 6 are range and azimuth reporters, one for each gun in circuit. There may be as many as 6 reporters, but four is probably the greatest number of guns that should be served direct from one instrument, and the type designed is intended for this number or less.

The reporters are each in communication with a man at the gun he is serving, by means of a system of metallic circuit telephone or other signalling device. In other words, each gun has two men on range and azimuth reporting duty, one of the men being stationed at the automatic indicator and the other at a position near the gun. The former constantly reads and sends and the latter repeats the predicted ranges and azimuths. The gun is traversed, elevated or depressed continuously and kept in harmony with the repeated range and azimuth.

The mechanical errors of the instruments will not exceed 10 yards for the greatest ranges, when same is constructed with the ordinary accuracy usually given this class of work. Allowing another 10 yards (which equals ½ minute of arc at extreme range) for error of observers or telescopic errors, 20 yards will be the maximum error with instrument under ordinary circumstances.

Figures 5 and 6 show the before described range finder and predictor fitted with a chart attachment. The chart is mounted on a ground glass plate, the ground side being underneath. A pencil point *P* is secured to pivot cross head C_1 and the movement of said pivot C_1 will thus be automatically traced on the ground glass plate.

A chart printed on a transparent paper or cloth being properly placed on the glass plate, the position of the target will be seen at all times and a record of the movement of same preserved.

In practice work with a range finder it will be readily understood that a record of movement of the target is of great value in checking up the accuracy of observations made.

Figure 7 illustrates how the system can be used in position mine indicating and exploding. In connection with the instrument *A* there is provided a chart *J*, which has a number of indicated points provided with electric contact points, said points occupying the same relative position on chart as the actual mines or torpedoes occupy in harbor or channel.

From the above it follows that whenever the range and azimuth position of target is determined by the adjustment of the instruments *A B*, as before described, the position of the pivot C_1 upon chart *J* will indicate at once the position of the target with respect to the coast. Also when the pivot is above any of the indicated points it may be known that it is in position above a mine which can then be exploded, either automatically, or at will, by electric contact.

THE HAGOOD TRIPOD MOUNT FOR TELESCOPIC SIGHTS.

By Captain JOHNSON HAGOOD, Artillery Corps.
Instructor, Department of Philosophy, U. S. Military Academy.

In the United States coast artillery in recent years, sighting heavy guns has been much subordinated to what is known as Case III., or laying in elevation or azimuth by means of the graduated circles of the carriage. We have come to consider a "gunner" not as a man who is expert at hitting a target but as one who is expert at handling the instruments accessory to ranging, plotting, etc. There is at present a very evident reaction in favor of Case II., which involves the use of the telescopic sight, and it is quite probable that the latter Case is going to grow greatly in popularity in the future. At present the use of the telescopic sight is grouped with that of other angle measuring instruments in the course of gunner's instruction, and alone does not have as much weight as such obsolete subjects as cordage. There is no doubt in the writer's mind that in the future the question of *accurate sighting* for seacoast artillery will be considered one of the greatest importance, and in order to facilitate the instruction of gunners in this important subject he has devised a tripod mount for telescopic sights for the purpose of giving preliminary instruction in sighting—the coast artilleryman's "position and aiming drill and gallery practice".

The present difficulties which it is proposed to overcome are as follows:

I. *Away From the Guns*:—It is practically impossible to give any instruction in the use of the sight.

II. *At the Guns*:—

1st. Instruction can be given to only one or two men at once.

2nd. Much time is consumed.

3rd. Presence of gun detachment is required.

4th. Drill is interrupted.

5th. Instruction cannot be made thorough.

6th. Instruction can be given in fair weather only.

In explanation of the difficulty of giving instruction away from the guns, it may be said that the sight is heavy, not of convenient shape for handling, is apt to be dropped in passing from one to another, is subject to injury from the moisture of the hands. It is not practicable to give the most elementary instruction in ex-

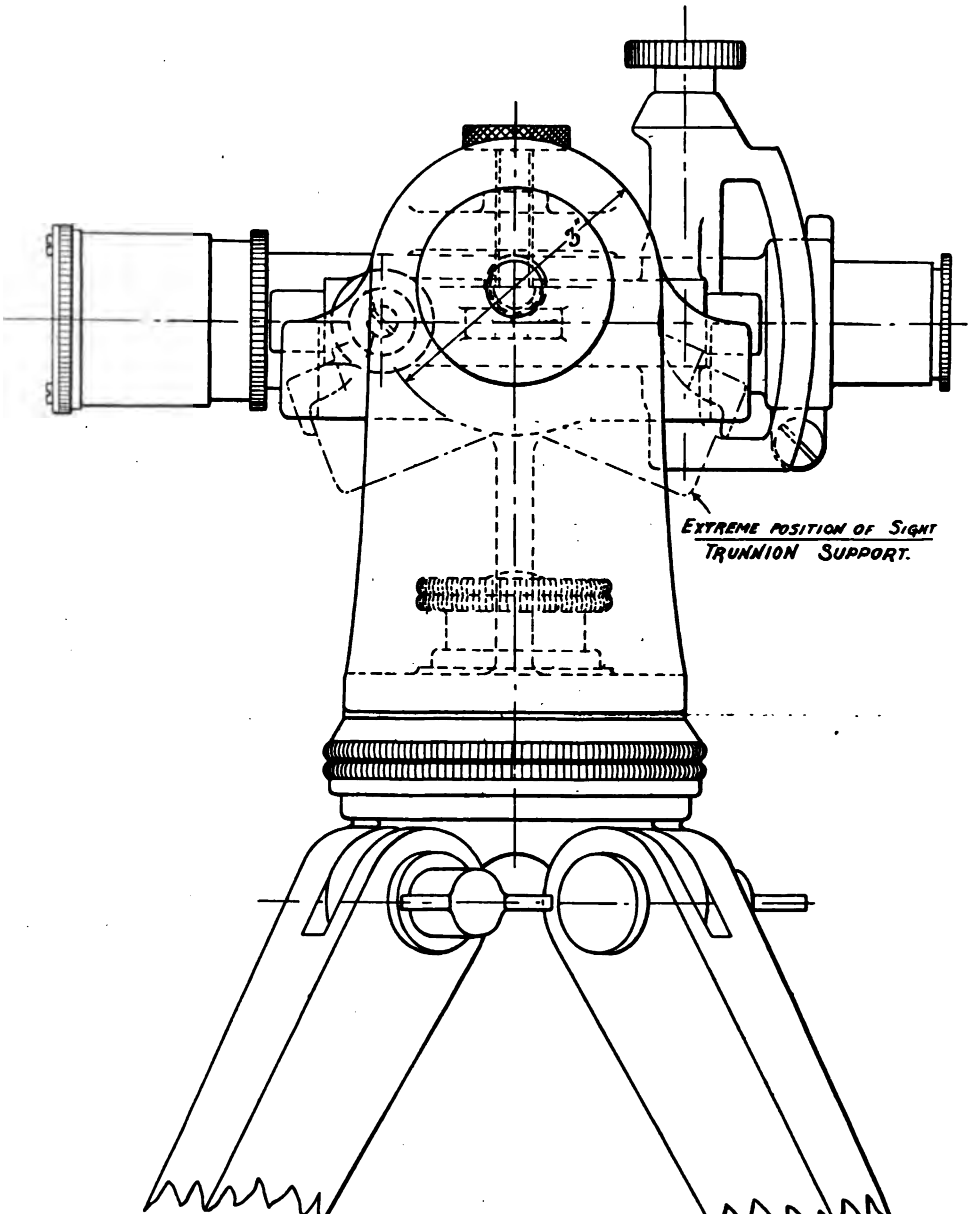


FIG. 2. — HAGOOD TRIPOD MOUNT FOR TELESCOPIC SIGHTS. — SIDE ELEVATION.

5th. It may easily be seen that under these circumstances thorough instruction of a whole class of gunners in the use of the sight is impracticable. No one gunner can have the opportunity of practicing frequently enough to become thoroughly proficient, much less expert, in handling the sight, in accurately focussing, setting, and adjusting for parallax, etc., or, finally in aiming at the target.

6th. Instruction at the guns is limited to fair weather when it is not too hot and not too cold. If the carriages are temporarily dismantled for repairs, or sometimes, even being painted or cleaned this instruction cannot be given.

The tripod mount consists, of the tripod, tripod head cap, the frame, and the sight bracket. The frame has a motion in azimuth and the sight bracket a motion in a vertical direction. The motions are regulated by the friction bearings, lock nuts, and screws shown in the accompanying figure. The parts are of brass except the tripod which is the same as that now issued for azimuth instruments.

It is seen that the telescopic sight placed in its bracket upon this instrument would have the same motion as if mounted upon the trunnion of a gun. Therefore all preliminary instruction may be given in the company school room along with similar instruction in the use of other instruments. The whole class may be assembled about one or two tripods and by constant practice thoroughly instructed in the adjustments and use of the sight.

By representing a target upon the blackboard and laying off a range on the floor with reduced scale, target practice may be simulated ; range tables may be used for obtaining elevation and drift and proper allowances made for assumed wind, result of last shot, etc. A small object upon a table moved by a cord or other mechanical device may be made to simulate a moving vessel and the gunners thoroughly instructed *in the use of the sight* in allowing for speed of vessel and for predicting position of target. In this manner when the gunners go to the guns for final instruction they can do quick and accurate work, and can sight the piece properly in the short time allotted to that purpose. These exercises are merely suggestive and many others will be developed by the instructor when the instrument is put into use. He will find a wide field open to him for developing this method of instruction and leading step by step, through the subcaliber practice to that under service conditions.

A company mechanic can construct a rough wooden model of this instrument which will be found fairly satisfactory for temporary purposes.

THE STORAGE BATTERY IN ITS RELATION TO U. S. FORTIFICATIONS.

By Second Lieutenant LEE HAGOOD, Artillery Corps.

In this article it has been the the writer's attempt to compile some data about the storage battery, with special reference to its application and use in seacoast fortifications. In collecting this material, the writer has been very fortunate, in that the manufacturers themselves have kindly supplied him with all information requested. What is presented to the reader, therefore, will have a degree of accuracy that otherwise would not occur.

The subject matter is divided into two parts: the first part is devoted to the technical features of the storage battery and the second part to its care and management. Under Part I are grouped the following heads, viz: The Applications of the Storage Battery to Seacoast Fortifications; The Cells used by the Government; The Theory of the Storage Battery; and the Installation of the Storage Battery.

INTRODUCTORY.

Before proceeding into the subject of this article, it is well to glance over some elementary principles governing the storage battery.

The terms secondary battery and accumulator are synonymous with the term storage battery. The last two terms are significant of what they represent while the first is in contradistinction to the term primary cell. The term cell applies to any of the units that make up a battery.

A primary cell is a contrivance by which chemical energy is converted into electrical energy. It consists of a jar containing a liquid and two metallic plates. These metal plates must be electro-positive and electro-negative respectively for the liquid used. When the liquid is conducting electricity, it undergoes electrolysis, or chemical change; on account of this phenomenon the liquid is called the electrolyte.

The quantity of current generated is proportional to the decomposition of the positive element, while the electromotive force is dependent only upon the material in the elements, regardless of their size and shape. The circuit may be closed or open: when closed the elements are connected by an electrical conductor, and when open the opposite is the case. The chemical action begins on closing the circuit and will last until the materials exhaust themselves. The energy developed by this chemical reaction appears in the form of electricity.

A secondary cell, on the other hand, is an arrangement similar in most respects but essentially different in its action.

It is in reality a cell that can be used as an electrical reservoir. The energy may be stored either from a primary battery or from a dynamo. The flow of current on discharge is opposite in direction and nearly equal in total amount to that sent in. It is on account of this secondary current that the term secondary cell arises.

The terminology, connecting up, flow of current, etc., are the same as for the primary. The secondary cell differs from the primary, however, in that the materials are not exhausted except after long and continued service. The loss in material is slight. Charging and discharging properly directed may take place thousands of times without injury. In fact, these reversals are absolutely necessary at frequent intervals for the preservation of the the plates.

The chemical change caused by charging a secondary cell sets up a potential difference of about two volts. As in the primary cell, this electromotive force is independent of the size and shape of the plates. The quantity of current that can be stored, however, is proportional to the exposed active surface of the plates; therefore, for any given type of cells, the current capacity is proportional to the number of pairs of plates. The number of plates for different sized batteries, runs in odd numbers, in order to take advantage of both sides of all the positives.

There are several classes of cells that produce a secondary current, but those of the lead-lead sulphuric acid class are the only ones used to any extent commercially. The value of the storage battery in the commercial pursuits is well recognized; it has long become an indispensable factor in central station work, substation work, automobile motive power, telegraph and telephone station work, etc. Its use is growing in importance and naturally keeps pace with the rapidly extending applications of electricity.

It was due to Planté that a successful lead-lead sulphuric acid cell was first created. His type is now the basis of all storage cells. In 1860, he discovered that if two pieces of sheet lead were placed apart in a jar and submerged in dilute sulphuric acid, and if a current were sent through in one direction for a short time, on release a secondary current may be obtained in an opposite direction. From this interesting laboratory experiment has been evolved the storage battery of today.

The charging current seems to produce a chemical change in the molecules of the surface of the lead plates; and, on closing the circuit afterwards, they tend to reestablish themselves in their former condition; in so doing, the opposite effect is produced, *i. e.*, a current in the reverse direction is established.

It was found upon experiment that, within certain limits, the more often a secondary cell was reversed the better the capacity for supplying current became. These chargings and dischargings seem to bring about a condition in the molecules of the surface of the lead that makes it peculiarly susceptible to these reversals. It was also found that by giving the plates certain electrolytic treatment in addition, this condition was attained more rapidly. This process of reducing the lead surface to active material is termed "forming". Before manufacturers ship their cells to the consumer, they are either wholly or partially formed.

In 1880 Faure discovered that by adding lead oxides direct, much time may be saved in the forming process. These oxides were applied in the form of a paste. He used for the positive minium or red lead, mixed with dilute sulphuric acid, and for the negative litharge mixed with this acid, the object of the acid being to give the paste a set.

All the lead cells of the present day are based on either the Planté or Faure methods. In many instances a combination of them is used in the construction of one cell.

PART I.

THE STORAGE BATTERY.

The Applications of the Storage Battery in Seacoast Fortifications.

Among all the electrical apparatus used at a modern seacoast fortification, the storage battery is undoubtedly next in importance to the generator itself. The following are some of the ways in which the storage battery is used in our service, viz:

(1) *As a reserve for the search-light.*—The proper sized battery can be relied on to serve the search-light for at least one hour, discharging at four times its normal rate.

(2) *As a reserve for the entire electric supply.*—The motor load, however, is at present excepted in designing the capacity of a battery, since mechanical reserves are available, and can in an emergency be readily resorted to.

(3) *In connection with harbor mines.*—Its ready supply of current makes a battery indispensable.

(4) *Its use with the telautograph.*—The writer has been informed by a telautograph expert, that the constant voltage from a storage battery gives the best results from these machines, and that most of the past troubles have been due to the uneven voltage supply of the mains upon which the machines were connected.

(5) *Its use at a sub-station.*—By setting up a battery at a distance from the central station, and by charging in series and discharging in parallel, a large reduction in the loss by transmission is obtained. This saving is about 75 per cent of that which would otherwise occur. Furthermore, this arrangement brings about a nearly constant load on the generating set, regardless of what demand may arise on the battery. This use of a storage battery is quite similar to the use of a water reservoir in connection with a pumping plant. In addition, all of the advantages obtained in "2" are gained here.

There are a number of other uses of the storage battery, however, in addition to those mentioned above that are commonly taken advantage of in commercial plants, and that could be applied equally well to conditions similar, but intensified by their importance, that exist, at present, in our fortifications.

As the function of the storage battery is, primarily, in our service, that of a reservoir for electric supply, it is only proper that the progress electricity has made in its applications to seacoast fortifications be reviewed.

Some several years ago it was decided to install electric plants in the various fortifications; in the beginning, the object was merely to obtain satisfactory lighting facilities. But so many applications of electricity have since arisen that at present, the electric supply has grown to be one of the most important considerations in the equipment of a modern fort. For the present conditions, its use may be divided into two heads, viz:

(1) In the fortifications.

(2) In lighting the post.

The lighting of the post, however, is only a secondary consideration: to be used by the garrison nearby in cases where such would be a commercial advantage. Furthermore, the fact that the machinery is used continuously insures its being better cared for.

About the fortification itself the electric supply is for the following purposes, viz:

"Class A." (1) Ignition of fuzes. (2) Lights for electric night sights. (3) Lights for range-finder cross-hairs. (4) For telephones. (5) For time interval bell circuits. (6) For master clock circuits.

"Class B." (1) Lighting the battery.* (2) Lighting of the fire commander's, battery commander's and secondary range finder stations. (3) Operation of the night signals. (4) Operation of the telautographs.

"Class C." (1) Operation of the search-light.

"Class D." Operation of the various motors, viz: (1) For control of guns—this requires a motor for traversing, and one, also for retraction and elevation. (2) For ammunition hoists. (3) For the shot room motors. (4) For the ventilating fans.

The feeding current for the above purposes must be uninterrupted and reliable. In fact this consideration is of such vital importance, that it has been decided to purchase only the best material.

Though the above considerations will guide the future installation of electric plants, those plants which are now installed were, except in a few instances, set up with a view to carrying only the loads of Classes A and B and in some cases Class C. In fact, up to 1902, the plants were designed† to meet such conditions as are imposed by intermittent service, and by inexpert and non-continuous attendance; however, so many uses of electricity had developed, it was decided then, by the Engineer Board called for the purpose, that in the future all electric plants should be designed for continuous service and for expert and continuous attendance.

Most of the plants which we find now in the fortifications were set up before 1902. The idea prevailing then was to centralize not beyond the generating plant, a reserve in the shape of a storage battery being used by the batteries in the immediate vicinity. We have, therefore, about each fortification a number of small plants. They consist, in general, of a small oil engine, or steam engine, for driving a generator, the latter being used for charging the storage battery, and the current is used as desired, either direct or from the storage battery.

Since 1902 there have been only a few plants installed to meet the present requirements.

In the present stage of development there are new conditions that arise daily, and, naturally, there are various theories as to the proper method of meeting these requirements. In reality,

* The term battery, as a part of a fortification, means the entire structure for the emplacement, protection and service of one or more cannon. [Def. given by Engineers].

† See Supplement Professional Papers, Corps of Engineers, No. 27.

the local conditions alone must be the controlling factors. It is certain, however, that large central plants will be used. Some advocate the use of high voltage alternating current generators, with a motor D.C. generator at each end of the gun batteries for converting this current into direct; while others are in favor of direct current generators, with a motor A.C. generator for the garrison lighting, the long transmission over the line to be economically accomplished by the ordinary step-up and step-down static transformers.

The use of a storage battery reserve is advocated by some, but others are of the opinion that it is of small value in this connection, since with the machinery of the best material and in duplicate, there is but small chance of a break-down. The storage battery is advised by all, nevertheless, as being indispensable in certain cases. It can, for example, be used for Classes A and B when the generating set is not running.

It is probable that a D.C. plant will be used wherever the cost of copper for the line transmission allows it; in fact, in the commercial plants, it has been found a paying investment to use the D. C. on the Edison three-wire system for lighting purposes, wherever the distances are within a mile.

Where long transmission is required it will doubtless be necessary to use the alternating current with motor generators at the batteries. As for reserves it seems to be the intention to have an auxiliary plant at each sub-station, and also a storage battery.

In all that has been written upon the subject, the writer has not yet seen any reference to a most important problem, the voltage regulation. Of course, if the generator sets are unusually large this is not so serious; but in designing the capacity of a plant, it is only natural to assume as a basis a load somewhere between the minimum and the maximum load. If the maximum load were used as a basis, it would be well and good, for the voltage regulation problem would be less difficult. But the extravagance would be shocking! At the present time when thrift is reduced to such a science, economy to a reasonable extent must be considered.

In all commercial plants where an efficient voltage regulation is required, the combination of a booster and storage battery system is invariably used. By this arrangement the following advantages are secured, viz:

(1) Small construction of machinery and reduction of attendance.

(2) More efficient operation and ease of adjustment.
(3) Finer regulation of load on engines and generators.
(4) Continuity of service when generators are shut down.
(5) Absolute reliability in operation.

In this article the subject of storage batteries cannot well be discussed without some reference to the booster; for, since its introduction, the storage battery has been perfected thereby into one of the best voltage regulators known. This system is an indispensable auxiliary to all electric plants exposed to fluctuating loads. Besides this important use, there are many other valuable applications, in connection with storage batteries, that may be put to advantage. For example, with the proper booster, the installation of end-cells or C.E.M.F. cells may be avoided.

Before proceeding to the application of such a system, a short account will be given of the different types of booster, their methods of construction and their uses.

BOOSTERS.

The term "booster" applies to a specially designed electric transformer which is used in connection with storage batteries. Boosters are either driven mechanically or by a motor. They are primarily for providing extra voltage in the line, either for the charging of, or for discharging from, the battery. In some cases both of the above functions are combined in one machine, so that the voltage of the "bus-bars" is automatically kept constant within the limits of saturation of the booster fields, regardless of the fluctuations and peaks in the external load.

A storage battery, connected in parallel with a generator to the bus-bars, will to a great extent act as an equalizer for the bus voltage, in that the battery will charge, remain neutral or discharge, varying as the external load is below normal, normal or above normal. This arrangement alone is not perfect, however, since a battery itself, on account of its internal resistance, cannot respond to a heavy demand without its E.M.F. dropping.

Furthermore, the E.M.F. of a battery varies, also, according to the extent of charge or discharge. For example, the voltage per cell when discharged is 1.8, while at the end of a charge it would require 2.5 volts; this difference multiplied by the number of cells would give the maximum variation in voltage which occurs across the battery terminals. If the proper type of booster is installed, these extra voltages may be supplied automatically, and a practically constant load maintained on the generating machinery.

On account of carrying the main current, the boosters windings are necessarily of large cross-section, and large commutator bars are required; as a rule, only a small number of turns are needed, because the generation of only a low voltage is necessary; with these two exceptions, however, the principles that are involved in the construction of a dynamo govern the design of a booster. We have, therefore, the series, the shunt or the compound, depending, respectively, upon their field windings. Each of these has its own particular application.

The series type of booster is usually placed across the bus-bars in series with the battery. This type, however, is not often used since other arrangements give better results.

The shunt booster is connected in the same manner as the series type, *i. e.*, in series with the battery across the bus-bars. The shunt field is placed across the line. This type is automatic to a certain extent for charging purposes, the further regulation being controlled by a rheostat in the field of the booster. Its use is recommended for charging purposes in plants where the battery is used for helping out during peaks, and for taking care of the entire load when the generator is shut down.

The compound booster, as its name signifies, is a combination effect of the series and the shunt windings. It is employed in plants where the storage battery is used as a voltage or load regulator. The types of compound booster most generally used are those which are differentially wound; the series and shunt windings are here arranged, so that under certain conditions they either work together or work in opposition; the result accomplished is that the proper E.M.F. can be supplied automatically for charging the battery, or for making the battery take care of any fluctuations that arise in the external load.

There are several types of these machines; broadly, they may be classed as constant voltage and constant current types. Those which are used for automatically maintaining a constant voltage across the line as well as a constant load on the generator are described, in general, by manufacturers as the "differential" boosters, while those which simply maintain a constant load on the generators are termed "constant current" boosters.

Before proceeding to the application of boosters to our conditions, it will be necessary to glance at the kinds of loads our plants have to take care of. These may be defined as fluctuating and constant loads, the former in Class D and the latter in Classes A, B and C. The switching in and out of the search-lights, of course, would create large fluctuations, but after they are once in circuit their demand is more or less constant. This applies equally well to the other circuits in this classification. The motors, on the other hand, create at all times a fluctuating load.

Reliability in the electric supply for fortification service is absolutely essential. In fact, its importance is so great, it is really beyond mere cost consideration. Unless the proper precautions be taken for voltage regulation, however, the motors will not only interfere with one another, but with all the electric circuits.

A reliable voltage regulation for commercial plants has long been regarded as a necessity. The storage battery with a booster system has stood the test as being the best method known.

A few systems that are commonly used in central plants, and that could be applied most valuably to our conditions, will be described below.

THE CONSTANT CURRENT BOOSTER SYSTEM.

This system is recommended where the line is short and the motor load intermittent and its average relatively small in comparison to its momentary maximum.

Figure 1 is a diagram of such a system. The load is approximately what would be required for a 10-inch battery with two guns. As a matter of fact two 10-inch guns are but a small part of the armament of a fortification.

In this figure it will be noticed that two bus-bars are used, one supplying the motor, or fluctuating load, and the other the constant load; the generator is connected across the motor bus, and the battery across the constant current bus, the booster and battery being in series. This diagram gives the field windings of a booster furnished by the Gould Storage Battery Co. It is their constant current counter E.M.F. type, and consists of a booster and automatic regulator. The latter is a small generator whose field winding is in series with the booster and whose armature is in series with the booster field, but generates a counter E.M.F. to the E.M.F. in the booster field circuit. Any change in the load will cause the C.E.M.F. generator to act on the field of the booster in an inverse manner to the load conditions.

By this system the *average current* of the fluctuating load is supplied as a *constant load* on the generator. If the external load is less than the average, the battery charges; if equal, the battery remains neutral; and, if greater, the battery supplies the excess demand. If it were desired at any time to shut down the generator, the battery could be used for either circuit by throwing in switches 1 and 5.

This system is only recommended, however, under the restriction previously indicated ; there are two reasons for this limitation, viz :—

(1) When an excess load is thrown on the battery, its E. M. F. drops. Though in some instances this may interfere with the speed of the other motors, it has, nevertheless, certain advan-

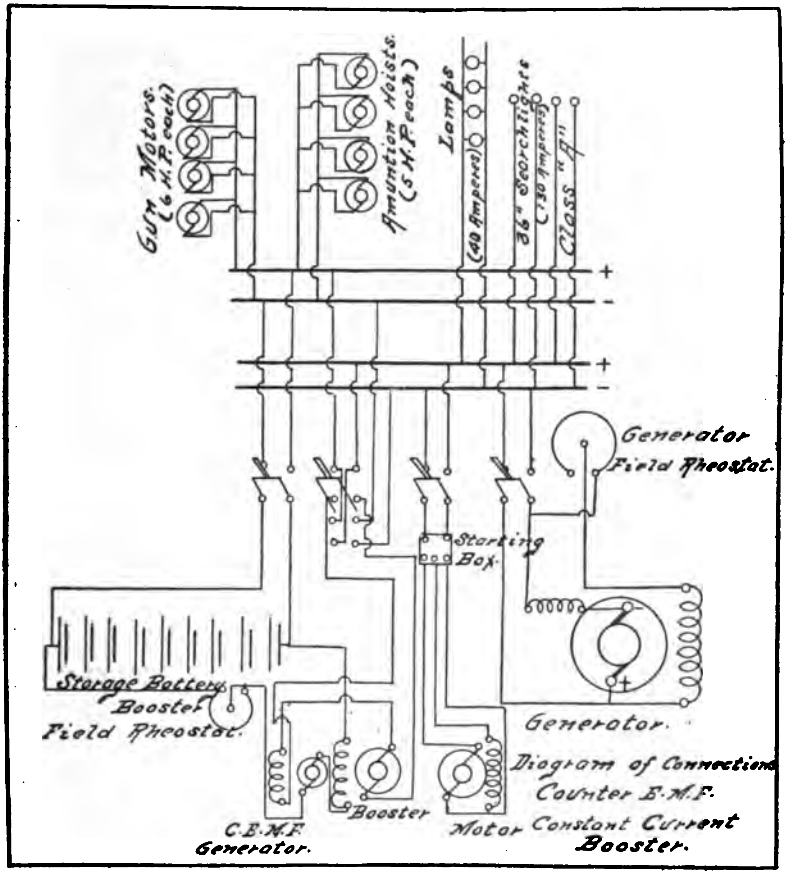


Figure 1.

tages, in that it will cause a motor to start more easily.

(2) The load on the generator is constant only in reference to the fluctuating load bus. Any change, therefore, in the constant load might show its effects on the generator.

This type, however, has the advantage of being cheaper than the others, and would, notwithstanding the above objection, give a very good regulation.

In figure 2 is given another variety of constant current booster. From the diagram it may be noted that this type of booster also carries only the average load. The same objections would hold to this system as to the one above, and it has practically the same advantages. The dropping of the battery voltage is not considered very objectionable for the motors, since it would cover a range of only about 10 to 15 per cent. This system is frequently installed for elevators, and undoubtedly it could be used very successfully for the ammunition hoists.

As an illustration of a constant current booster system a certain small isolated plant * will be described. It consists of a 35 K.W. generator, a type F. II-plate, 58-cell battery, and a 8 K.W. capacity constant current booster; all of them being connected up as in figure 2. The constant load consists of 512 lamps, and

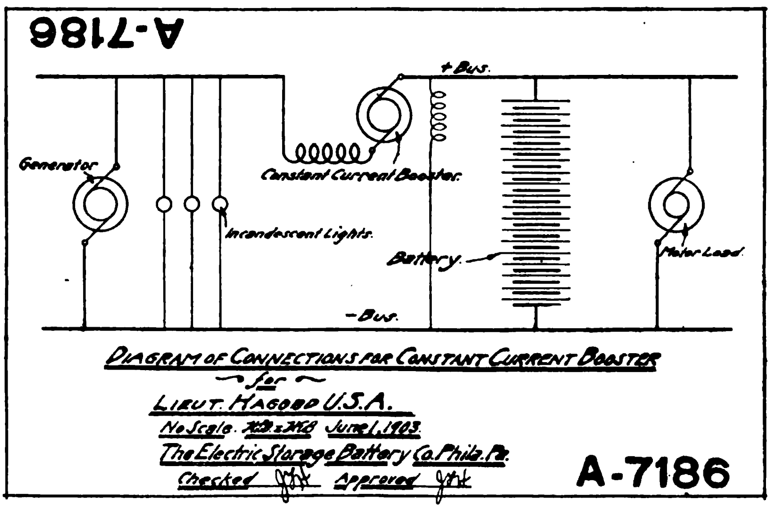


Figure 2.

the fluctuating load is caused by nine motors in the following sizes: ½, 1, 2, 3, 3½, 5, 7½, 20 and 30 H.P., respectively. Figures 3 and 4 show the fluctuations in the load. It may be noted that under the heaviest and most sudden changes the battery voltage varies only a very small amount. In this plant the lights show no flickering whatever.

THE DIFFERENTIAL TYPE OF BOOSTER SYSTEM.

In this type the faults mentioned above disappear, but it is considerably more expensive.

In figure 5 is given the diagram of the Gould C. E. M. F. differential type of booster, while figure 6 is a photograph of same. As in figure 1, it consists of an automatic regulator in the form

* This plant is in use by the Hastings' Sons Publishing Company, Lynn, Mass.

of a small C. E. M. F. generator, the field being in series with the main load, while its armature is in series with the booster field; but, as in the constant current type, it generates a current oppo-

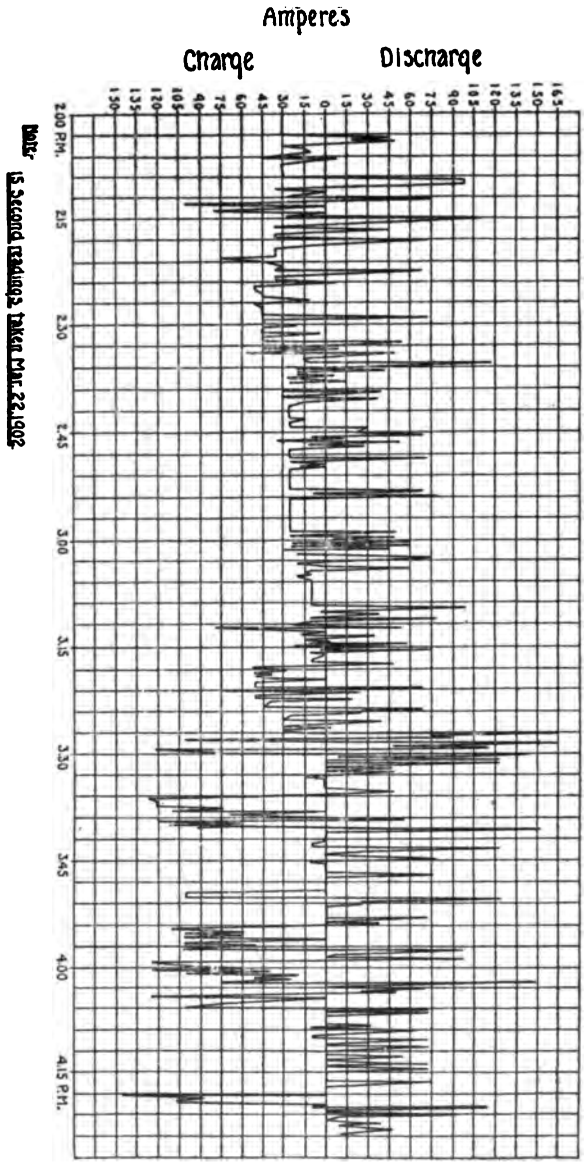


Figure 3.

site in direction to the line current as applied to the booster field The booster armature voltage, by this arrangement, varies inversely as the load conditions. The battery, therefore, will

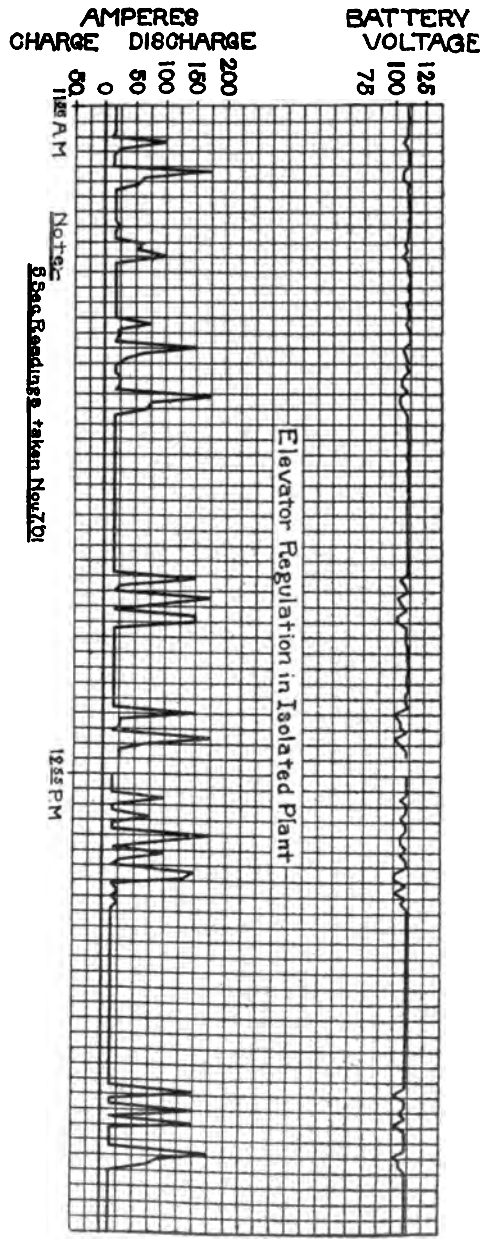


Figure 4.

charge, remain neutral, or discharge, depending upon the load being below normal, normal, or above normal.

If it were desired to shut down the generator, by closing the circuit with the switch 2, the battery could supply the load. With this type of booster connected as above, the starting or stopping of any particular motor would not interfere with its neighbors, or be disturbed by the dropping of its battery E. M. F.

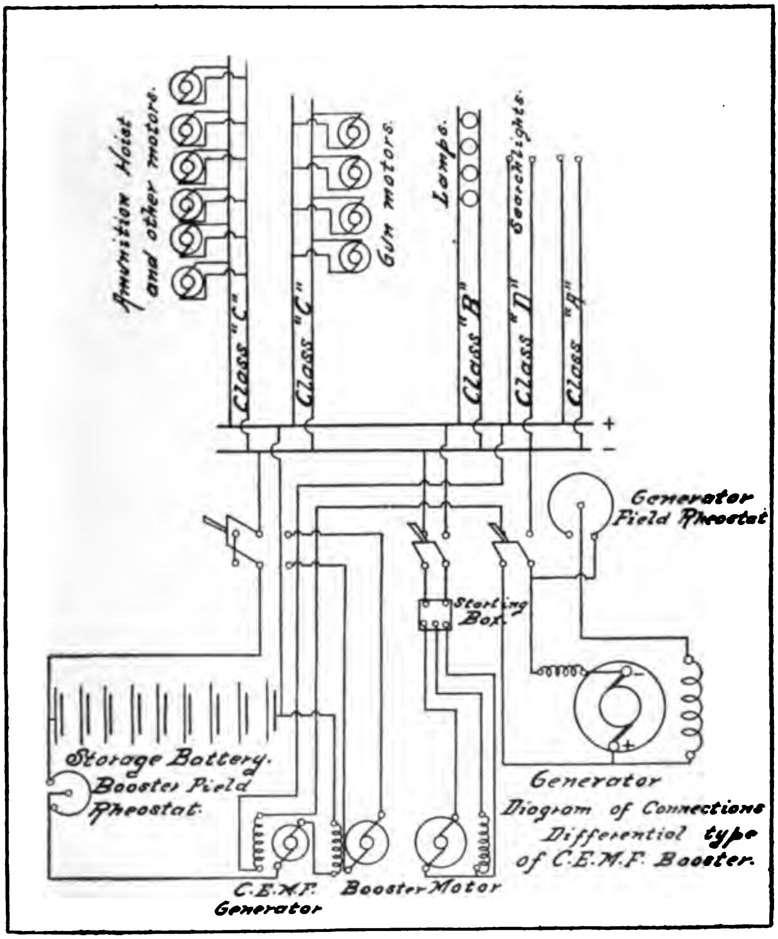


Figure 5.

Furthermore, throwing in or out of the search-lights would not vary the load on the generator.

In figure 7 is given another type of the differential booster somewhat simpler ; this and figure 2 are diagrams of the machines furnished by the Electric Storage Battery Company. In this system two bus bars are likewise required, one for the fluctuating and the other for the constant loads. It will be noted that the search-light is here placed on the fluctuating bus ; for occasions may arise when it might be necessary to throw the search-light in and out of circuit repeatedly, and such changes in current demand might interfere with the other circuits. To avoid this it is placed where it could do no damage. Again, the search-light service is perhaps the most important of all the current supply ; therefore no chance should be taken of having its supply unequal to the demand.

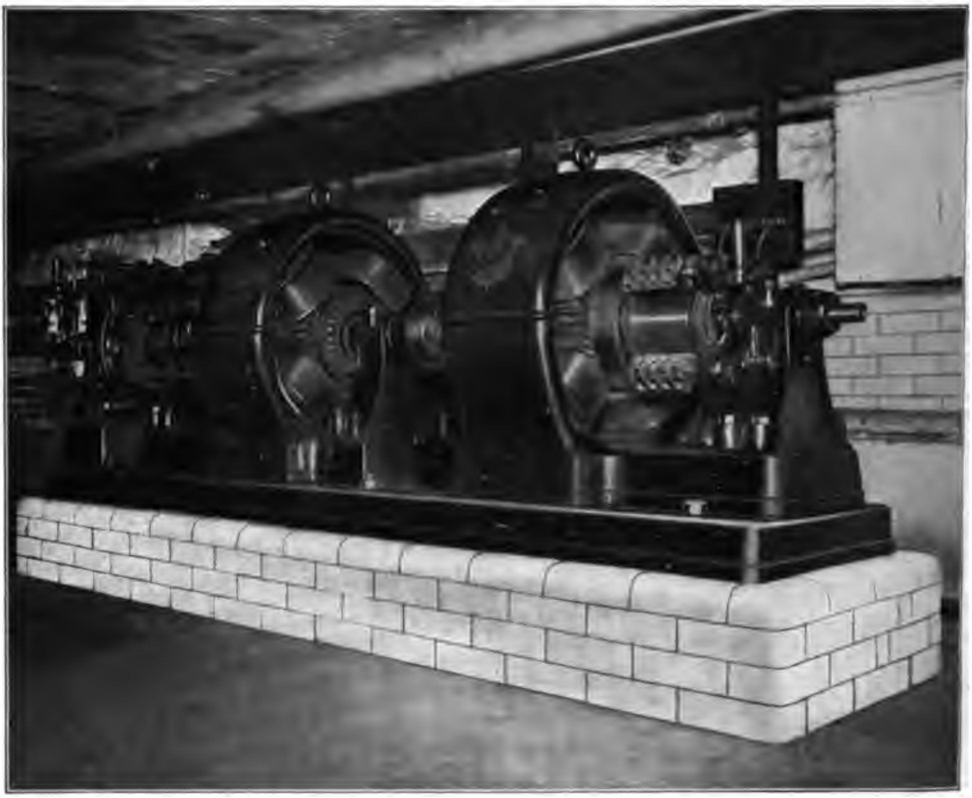


Figure 6. Gould Differential Type of C. E. M. F. Booster.

As is shown in the diagram, the shunt field coil is across the battery, while the series coils divide, the one near the generator carrying the average current and the other carrying the total current for the fluctuating load. By this arrangement the shunt field circuit works in opposition to the series coils, so that the booster will act, viz : (1.) At normal load, the shunt and series fields neutralize each other and the battery "floats." (2) At over-load the shunt and series combine, assisting the discharge of the battery ; and (3) at under-load, the field predominates over the series assisting in the charge of the battery. The results of this system are quite similar to those described for the "Gould".

Both the differential and the constant current types have their respective applications in service. The local conditions, of course, will have to determine the best type of booster and the proper size of battery.

These systems can be used in large or small units. Wherever the central station uses direct current, a large unit could be used also at the station itself, and wherever the central station uses

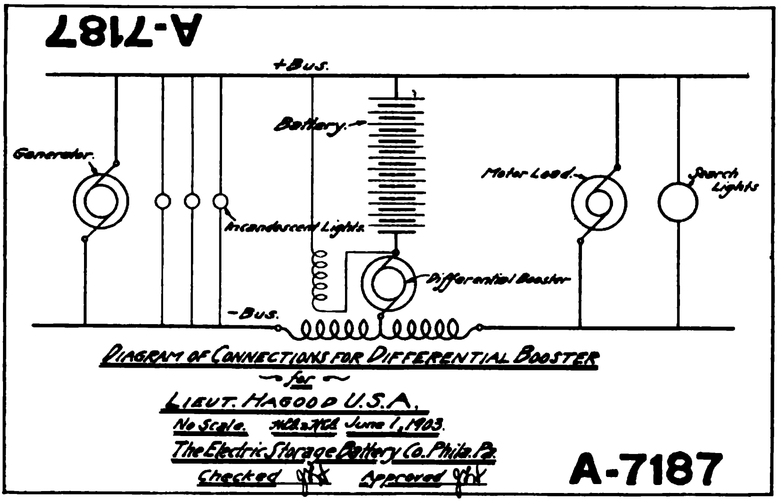


Figure 7.

alternating current, small units could be used at each of the sub-stations. The motor generator would here be substituted for the generator in the above systems.

For a mechanical reserve in each of the sub-stations, the oil engine undoubtedly is the solution of the problem of a motive power, since it stands idle without deterioration and can be started up so very quickly—about twenty minutes is required. Furthermore, the fuel is cheap and readily stored. The shafts of the motor D.C. generator could have an extension for a belt connection, using the generator side for supplying current, or a separate generator may be installed ; in both cases, however, the generator could take its place in the regular system.

The DeLaVergne Refrigerating Machine Company has recently put on the market a vertical type of oil engine, fitted with the "Rites" patent governor which directly controls the oil supply. This engine is connected direct to the generator.

The old trouble of varying speed is here overcome, and it is claimed that not the slightest fluctuation can be detected in the voltmeter. In figure 8 is given an illustration of this engine.

Whatever additions may, in the future, be made for perfecting the system of current supply, it is certain that some provision must be made for the voltage regulation. The correct solution of the problem is undoubtedly the storage battery with its proper booster system.

Whenever a fortification becomes engaged with an enemy, that of all times is the one when every link in the fighting chain must be reliable.

The fight will be short and decisive. Time is then most important. Any delay would be serious. Nothing could cause more delay and confusion, than a failure in the electric plants. Probably the non-electric reserves could be resorted to, but these are awkward and require too much time.

As for the search-light, a failure in the current supply would put it out of action. Indeed, this would be a hazardous occurrence during a night attack. The recent maneuvres have brought out clearly to all eyes the value of search-lights.

No such calamity, however, as above pictured, could occur were the proper storage batteries and boosters installed. In the first place, by having an efficient voltage regulation, the search-lights, motors, lamps, telautographs, etc., would all work harmoniously together because free from the danger of disturbance of one by the others.

Secondly, the storage battery here installed constitutes a reserve always at hand with an instantaneous supply of electrical energy ; sufficient, in fact, to carry the entire load for a few hours, at the end of which time, if the attack were not over, the proper repairs, undoubtedly, would have been completed—the defensive strength of the fortifications, not for a single minute, having felt any weakness.

THE CELLS USED BY THE GOVERNMENT.

As in the commercial usage of the storage battery, so it has been in the government usage : the lead-lead sulphuric acid cell is practically the only one that can stand the requirements of hard service.

Approximately there are one or more storage batteries in use at every fortification having guns of 6-inch calibre and upwards. Among these we find, in, general, either the Chloride or Willard cells. A few months ago the government took under consideration a cell manufactured by the Gould Storage Battery Company, and a battery of these has recently been installed in one of the fortifications.

Though there are other cells in use, the above mentioned types are the ones we are perhaps most concerned about. Furthermore, these are well known and widely used types in the commercial world. They have therefore been chosen for description, and the details of their respective methods of construction are given below. In order to avoid repetition, different features of interest about each type has been discussed. For example, in describing the Willard the "forming" process is described; as a matter of fact, the "forming" process of most of the Plante class is quite similar to this method.

THE CHLORIDE CELL.

This cell is manufactured by the Electric Storage Battery Company of Philadelphia. It is known as the "Chloride Accumulator." Though formerly the chloride method of construction was used, it has since been abandoned for the process described below. The former name, however, has been retained as a trademark.

Though in theory the positive and negative plates are interchangeable, it has been found in practice that the same form in both does not give the most efficient results. This belief has led many manufacturers to make the positives and negatives of different construction. The makers of the Chloride cell have followed this method. It will be well, therefore, to describe each plate separately.

THE POSITIVE PLATE.—The process of construction here used brings this plate into the general class known as the Planté type, in which that part of the plate entering into the chemical portion of the plate called the active material, is formed by an electro-chemical process from the metallic lead itself. This particular plate, *i. e.*, the Chloride, is known as the Manchester positive, and is made exclusively by the Electric Storage Battery Company.

The plate consists essentially of two parts; first, the frame or grid of lead alloy much resembling type metal and possessing a much greater stiffness than pure lead, made in the form of a flat plate, about ⅜-inch thick, with a large number of ¾-inch round holes through it, placed as closely together as is consistent with stiffness. The grid is made by casting it under pressure in an iron mould provided with numerous cores for producing the holes. The other part of the plate—the active material—consists of a number of pure lead buttons, inserted in the holes of the grid and locked in by their own swelling which occurs during the formation process. Each button consists of a spiral coil of lead ribbon, corrugated on one side and rolled up by a special machine for the purpose. The lead ribbon is made by forcing or squirting soft lead under very heavy pressure through an oblong opening of suitable section.

Th assembled plate, then, consisting of hard alloy frame and pure lead buttons, is subjected to an electro-chemical forming process which in a few days attacks the surface of the pure lead and produces there an adherent layer of lead peroxide, which is particularly adapted to enter into combination with the acid of the cell and thus forms the active material of the positive plates.

THE NEGATIVE PLATE.—The negative plates made by the Electric Storage Battery Company are of two kinds, differing only in the construction of the supporting grid. In all negative plates pure spongy metallic lead forms the active material and this is made of litharge or lead monoxide. The manufacture of litharge is in itself a very important industry and a very brief description of it may be of some interest.

A large reverberatory furnace with an open front and slightly dipping hearth is heated by a coal fire at each side, the products of combustion all finding their exit in the front of the furnace. Upon the hearth is kept some 100 pounds of molten lead and this is kept in constant agitation by being stirred with a long iron hoe, fresh surfaces being thus continually exposed to the action of heat, air and gases in the furnace; each surface as exposed quickly becomes tarnished and the dross, or litharge, thus formed gradually accumulates and is from time to time removed.

This first product, however, besides being very lumpy and uneven, contains considerable metallic lead from which it must be freed. To this end, the mass of dross is passed between a pair of mill-stones with a stream of water constantly flowing upon it and here it becomes thoroughly ground and mixed with the water; the resulting emulsion is then run into a trough, where the coarser particles of litharge and the heavier particles of lead quickly settle to the bottom, the fine pure litharge being carried off to the further end of the trough, where it is slowly deposited and whence it is removed from time to time. For some uses it is desirable to give the material another roasting after this in order to thoroughly dry it and bring it all to an even composition.

The resultant product is known to the arts as finest floated litharge.

To proceed now with the negative plates, of which the larger size, known as the box negative will be first described. The sup-

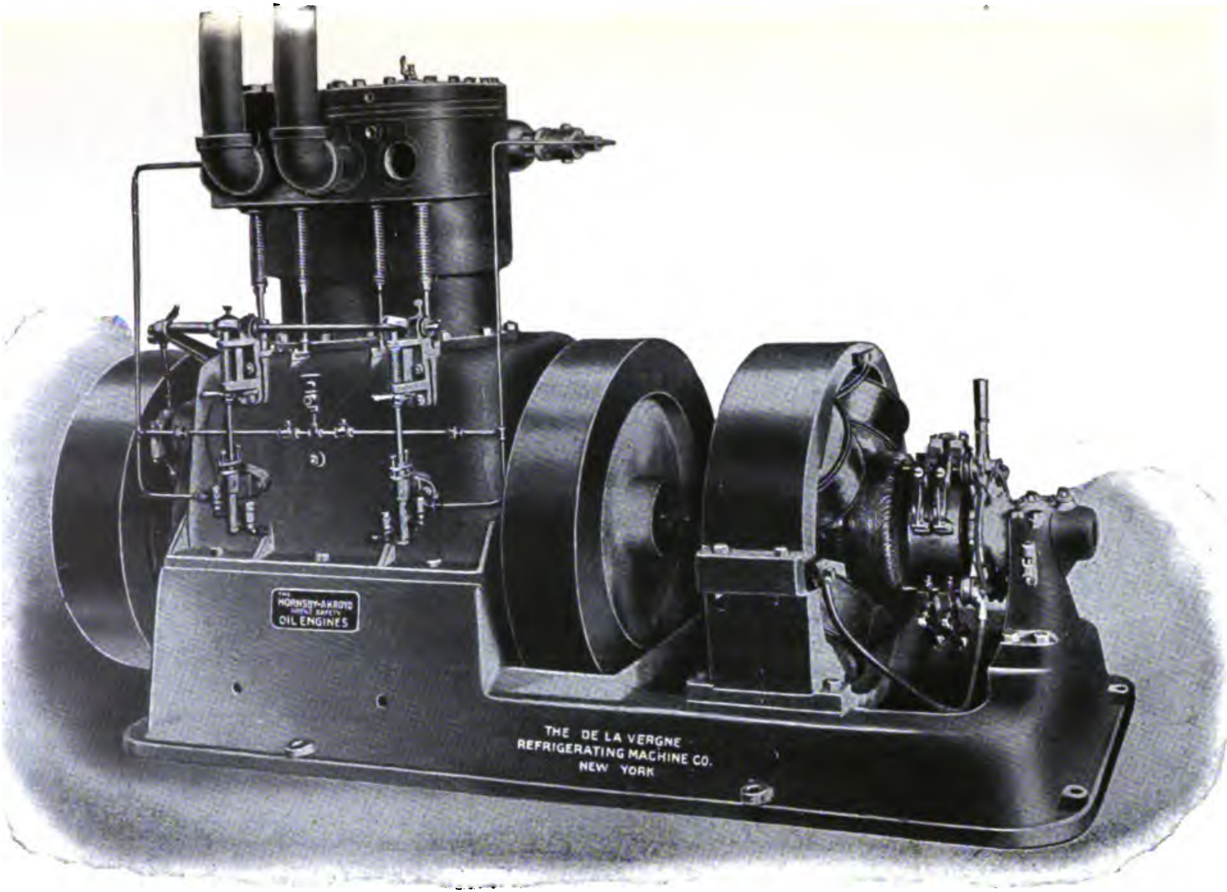


FIG. 8 — "HORNSBY-AKROYD" 15 HORSE POWER ENGINE DIRECT CONNECTED TO DYNAMO, FITTED WITH RITES PATENT GOVERNOR.

Perfect regulation of speed.

porting grid for the material consists of two similar pieces, each of which in turn consists of a sheet of thin perforated lead, upon which are cast small ridges in such a manner as to divide the sheet into a large number of small square pockets about ⅛ inch deep and 1½ inches square. Into these small squares or boxes, is then put the litharge intended subsequently to become the negative active material; the two grids are then placed together and riveted by means of small lead rivets cast upon one of the grids and corresponding holes cast in the other. The advantage

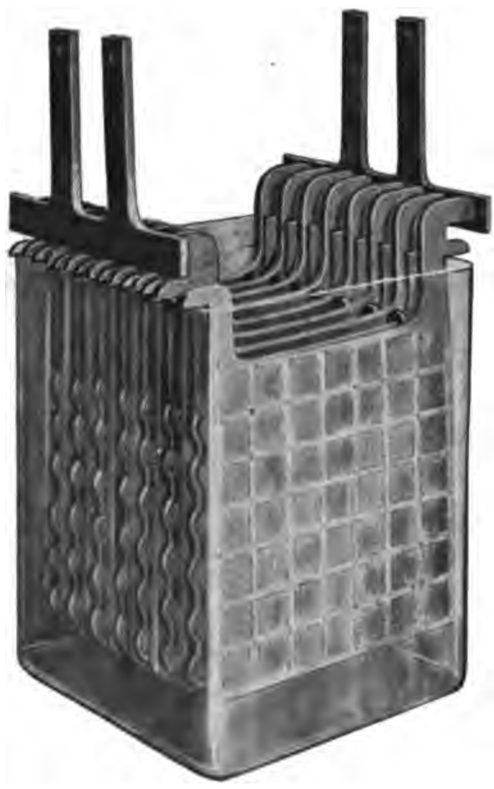


Figure 9. Chloride Accumulator.

of this construction is that while allowing free access of the electrolyte to all parts of the active material, the perforated sheet lead cover makes a very efficient support for the active material and makes it almost imopssible for this to fall away from the grid as has sometimes occurred with the older form of negative plates.

Directly after the riveting process and some necessary trimming around the edges, the negative plates are ready for shipment, since the first charge always given to a new battery after its installation is quite sufficient to reduce the litharge thoroughly to the required condition of sponge lead.

For all cells larger than Type E the box negative is used. In figure 9 is given a 15-plate Type F mounted in a glass jar. For the Type E and smaller sizes the negatives are made as follows: The grid, or supporting frame, is made in much the same manner as that described for the positives, except that the receptacles for the active material are made square instead of round. The litharge is mixed with dilute sulphuric acid in the proper proportion which causes it to assume a pasty constituency.

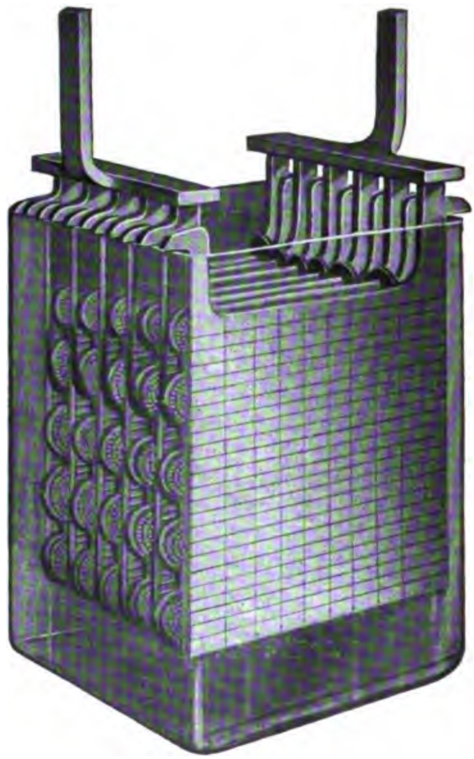


Figure 10. Chloride Accumulator.

When in this condition it is smeared with a spatula into the receptacles of the grid, and the plates then put aside to dry and set; subsequntly they are put through an electrolytic treating process, after which they are washed and again dried. The plates are then ready for shipment. It may be noted that both of these negatives belong to the general class known as the Faure type. In figure 10 is a type E cell with eleven plates in a glass jar.

THE WILLARD CELL.

This cell is manufactured by the Willard Storage Battery Company of Cleveland, Ohio. Both the negative and the positive plate belong to the Planté type. The lead supporting frames in each are pure lead, in fact, the same from which the active material is finally formed. The process of manufacture is as follows, viz.:—

First, rolled lead is taken and its surface cut up with an instrument similar to an ordinary plough, turning up leaves or shelves so that they stand at an angle to the surface of the plate. After the blanks are cut in this manner the plates are immersed in the forming tanks, containing a solution of nitrate of ammonia and sulphuric acid, where they are connected up temporarily to receive the forming current. The surface of all the leaves is attacked by the nitric acid, which is liberated by the action of the current passing through the solution. The chemical reactions are continuous. First, nitrate of lead is formed, then immediately changed into sulphate of lead, and afterwards into peroxide of lead from the splitting up of the solution, by the action of the current, into oxygen and hydrogen gases. Regarding the chemical reactions which occur during this forming process, it is thought that the following equations represent in part the various chemical combinations, viz.:—

(1) $2NH_4NO_3 + H_2SO_4 = (NH_4)_2 SO_4 + 2HNO_3$
(2) $Pb + 2HNO_3 = Pb(NO_3)_2 + H_2$
(3) $4H_2SO_4 + 4HNO_3 = 2H_2(SO_4)_2 + 2NH_4NO_3 + SO_2$
(4) $6H_2 + SO_2 = 6H_2O$
(5) $Pb(NO_3)_2 + (NH_4)_2SO_4 = PbSO_4 + NH_4NO_3$
(6) $PbSO_4 + H_2(SO_4)_2 + 2H_2O = PbO_2 + 3H_2SO_4$

After the space between the leaves is filled the plate is thoroughly washed and then pressed to a uniform thickness. In the case of the negative the plates are placed in tanks containing dilute sulphuric acid with dummies in the place of positives; the current is passed through the tank, and the peroxide plates, which are to become negatives, absorb the hydrogen gas evolved at the negatives.

The formation of the positive or peroxide plate takes about thirty-six hours, the formation of the negatives about sixty hours. After the negatives are reduced to the metallic or spongy state, they are partly discharged in water and allowed to dry.

There are several advantages claimed for this method of construction of plates. It has always been urged against the ribbed plate that the same would buckle, break apart, or disintegrate, for the reason that there is not enough provision in the same for expansion. This may be true in an old plate constructed like the "Brush" plate with projecting ribs at right angles

Figure 11. Willard Storage Battery.
(Type F—13 Plates in Glass Jar.)

to the surface of the plate. The reason that the original Brush plate was a failure was on account of the growth of the active material having nowhere to go; therefore the plate grew longer in the portions on which the greatest action took place, this causing the same to buckle. The Willard plate has provision for this growth of active material, owing to the fact that the ribs, when the plate is new, stand at an angle ; as the growth of active material takes place, the ribs open up thereby giving more room between the ribs. This principle can be demon-

Figure 12. The Willard Storage Battery.
(Type G—21 Plates in Lead-lined Tank.)

strated on a piece of paper, by drawing four or five equi-distant lines intersecting a vertical line ; start at the points of intersection and draw parallel lines at different angles. It will readily be seen that the nearer the direction of these lines approach a perpendicular position to the vertical line, the greater the space will be between the parallel lines or ribs. While this not claimed to be an infallible cure for buckling, it is claimed, however, to reduce the same to a point where it becomes harmless. The size, capacity and method of assembling of the Willard plate is almost identical with those of the Electric Storage Battery Company.

In figure 11 is given a Type F 13-plate cell in a glass jar while in figure 12 is shown a Type G 21-plate cell in lead lined tank.

THE GOULD CELL.

The Gould plates are constructed in a similar manner to those of the Willard. Pure sheet lead is used, and by ploughing up the surface, so to speak, a large area is obtained for the action of the forming process. The active material therefore is made also from the same lead as its supporting plate.

The details of construction, nevertheless, are quite different. For the Gould plate sheet lead blanks are placed in steel frames, that reciprocate between rapidly revolving shafts on which are placed alternately discs and spacing washers. The discs are made of steel and are brought to bear on the lead blanks with a steady pressure. As they progress into the lead, ridges and grooves appear and a very large area of surface is thereby obtained without removing any lead.

These circular knives, in spinning out this lead, leave a fine web through the center of the plate and, also, a solid portion at each end. Each of the ribs is anchored to this web and solid portion. Figure 13 is a vertical cross-section of a plate made up of a single section, while figure 14 is the same of a four section plate. Such a plate as the latter is given in figure 16. It may be noted in figures 13 and 14 that the diagonal lines represent the solid portion of the plates and that the line through the center represents the web.

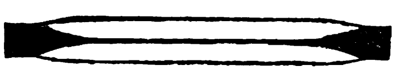


Figure 13.

Figure 14.

At the juncture, in a vertical direction, of two sections the solid portion forms two half diamonds, see figure 14, and, extending across this plate, this solid portion forms a cross bar of conducting material. In figure 16 the line across the middle of the plate represents this solid portion. At the juncture of two sections laterally, an unspun portion is also left, and represented by the vertical line in the center of the figure.

The number of sections or subdivisions of a plate are determined by the dimensions of the plate. In figures 15 and 16 are

Figure 15.

Figure 16.

the positives and negatives respectively, of a Type O plate, size 10½x10½.

The strength of this plate is provided for by the cross-bars of unspun lead which give lateral strength, while the ribbing which forms a "bridge" construction, together with the unspun vertical portions between the sections, supplies the vertical strength. This construction of the supporting parts is designed to allow fully for the change of volume in the active material. By having the active material evenly distributed over the surface, and in contact with such a very large area of the lead supporting frame a uniform distribution of current is obtained, and thus further provision against buckling secured.

When the mechanical construction of the plates is completed, the plates are placed in the forming tanks. Due to the action of the current on the chemical solution therein, a composition is formed in the surface between the ribs, which is immediately reduced to the active material itself.

The sizes and capacities of these plates are, also, almost identical with those of the Chloride Storage Battery Company.

[To be continued.]

PROFESSIONAL NOTES.

ARTILLERY MATERIAL.

Capped Shot and Armor.

It has now been thoroughly determined that if a shot strikes a cemented plate direct, or nearly so, with a velocity exceeding 1800 f.s., the use of a cap will add about one-sixth to the penetrative power. A shot capable of piercing a 6-in. plate, uncapped, could be easily driven through a 7-in. plate if a cap was used. But the cap loses its value when the impact is oblique, the loss of efficiency beginning at an obliquity of about 15 degrees, and being complete at an angle of about 30 degrees. The function of the cap being to preserve the point of the shot or shell intact, there is usually complete success or complete failure; that is, either the one-sixth advantage is gained or nothing. There are, however, exceptions to this rule; and more than one instance has occurred when the obliquity was between 20 degrees and 30 degrees and the velocity nearly as low as 1800 f.s., where there was some appreciable gain, but nothing like one-sixth.

The fact that the cap is of little or no use when the velocity falls to 1800 f.s. seriously handicaps the smaller guns, and puts the older low-velocity guns completely out of court. Suppose that a 6-in. and 12-in. gun both have a muzzle velocity of 2600 f.s., caps would be useful to the 6-in. gun up to 2200 yards, and to the 12-in. up to 5000 yards. Again, an up-to-date 12-in. gun, with velocity 2800 f.s., can use a cap profitably up to 6000 yards; whilst the 13.5-in. gun, which forms the principal weapon of 15 of our "first-class battleships," * with its feeble muzzle velocity of 2016 f.s., can only use it up to 1800 yards. In other words, the cap is of no use to the 13.5-in. gun, as nearly all the fighting will take place outside 1800 yards. For the same reason the cap is of no use to the following:—

4.7-in. Q.F.,
6-in. Q.F.,
6-in. VII. and VIII. (only inside 2000 yards).

The guns in the British service that really profit by it are the 7.5-in., 9.2-in., and 12-in. Most foreign guns have higher velocities than ours. This is especially the case with French, Russian and American guns. The French use lighter projectiles than we do, which, for a given striking energy, get a little more penetration. But even if the muzzle energy be greater, more energy is lost during flight, especially with light projectiles, so that if there is any gain it is with the heavier guns, where the advent of the cap certainly benefits the gun with light shot most. The new French ships, with the 1896 pattern 6.46-in., will profit by the cap at short and medium ranges, as also the Russian that carry 50 calibre 6-in. guns; but, generally, there is little profit to guns under 7-in. calibre. The question of the disability of the capped projectile, owing to its failure on oblique impact, was dealt with two years ago, when it was demonstrated that under average fighting conditions 50 per cent. of the hits will be sufficiently near the normal to benefit by the cap.

* So called in Parliamentary Return.

From this it follows that in considering protection against the shot from heavy guns the cap must always be reckoned with; but with armor devised to give protection against light guns the cap is not of any great moment.

It must not be forgotten that even when the penetrating power of an uncapped shot is sufficient to carry it through the armor, a cap would still be advantageous, for a capped shot would come through with far more energy and do more damage inside. Moreover, the use of a cap would enable an armor piercing shell to be substituted for a shot where there was some reserve of piercing power, and the cap would give the shell more chance of carrying its bursting charge through. Once more it is the heavy gun that gains here. Such a gun as the 6-in. will seldom find any armor against which it has a reserve of piercing power, at any rate, not for new ships; but the 9.2-in. armor piercing shell, when attacking 6-in. or 7-in. armor, should decidedly benefit by a cap.

The rule of thumb computation that the cap adds one-sixth to the piercing power does not apply exactly to all guns. Seeing that the cap acts by neutralising the effect that the hard face of the plate exercises on the point of the projectile, it is natural that the cap should be most valuable when the hard face is most formidable. It has been abundantly proved that the hard face is most useful to plates of from 6-in. to 9-in. thickness. Here it is, then, that the effect of the cap is most notable. The high figure of merit of a 6-in. K.C. plate is mainly dependent on the fact that the point of the projectile is always broken until the piercing power reaches a very large proportion to the thickness of the plate. Directly the point remains unbroken the special excellence of the plate disappears.

It may be useful to give a short table showing the estimated resistance of Krupp cemented plates, as compared with wrought iron plates, and also the corresponding resistance to capped projectiles, striking within 20° of the normal, and with not less than 1800 f.s. velocity.

RESISTANCE OF KRUPP CEMENTED ARMOR.

Thickness of Plate.	Equivalent to Wrought Iron When Attacked by		Figure of Merit.	
	Capped Projectiles.	Uncapped Projectiles.	Capped Projectiles.	Uncapped Projectiles.
Inches.	Inches.	Inches.		
4	7½	9½	1.9	2.3
5	10	12	2.0	2.4
6	13½	16	2.25	2.7
7	15½	18	2.5	2.6
8	17	20	2.15	2.5
9	19	22	2.1	2.45
10	20½	23½	2.05	3.35
11	22	25½	2.0	2.3
12	24	27½	2.0	2.3

The 6-in. plates have the highest figure of merit, and those thinner or thicker do not show so well. The difference between maximum and minimum figure of merit is more marked with uncapped then with capped projectiles.

Journal 7.

The table given below shows the advantage gained by increasing the power of guns of various calibres. Three muzzle velocities are chosen (*a*) 2800 f.s., (*b*) 2600 f.s., (*c*) 2400 f.s.—as representing :—(*a*) Guns now being mounted; (*b*) Guns mounted within the last five years; (*c*) Guns five years old or more. There are, of course, older guns afloat, such as the 13.5-in., British gun, the penetration of which is exactly equal to an (*a*) 10-in. gun, and the 6-in. Q.F. which, as regards penetration, is between the 5-inch (*b*) and (*c*); but these must almost inevitably be replaced, unless the ships that carry them are relegated to the third or fourth rank. There is this to say for the old pattern 6-inch—its newer rivals also have inadequate penetration, so that, before very long, as the new ships with thicker armor become more numerous, the battleship guns of this calibre will be reduced to spattering the outside of an opponent's armor with fragments of shells.

It is considered that 3000 yards is a useful fighting distance, and that it is no use loading with piercing projectiles unless an uncapped shot will pierce at this range. The Table refers exclusively to 3000 yards.

PENETRATING POWER OF GUNS OF VARIOUS VELOCITIES AT 3000 YARDS RANGE WITH CAPPED AND UNCAPPED PROJECTILES.

In all cases the British or heavy type of projectile is assumed to be used.

GUN.	Muzzle Velocity.	Remaining Velocity. 3000 yards.	By Tressider's Formula. Penetration. Wrought Iron.	Penetration. Krupp Cemented Plates. Direct Fire. Capped Shot.	Penetration. Krupp Cemented Plates. Direct Fire. Uncapped Shot.	REMARKS.
12-in. (850-lb. shot)	f.s.	f.s.	ins.	ins.	ins.	The following ships have guns of these types :—
(*a*)	2800	2300	35.0	18	16	{ Hindustan, Connecticut, République?
(*b*)	2600	2120	30.6	16	14	King Edward, Iena?
(*c*)	2400	1940	27.5	13½	12	Majestic, Suffern?
11-in. (650-lb. shot)						
(*a*)	2800	2240	30.5	16	14	Braunschweig?
(*b*)	2600	2085	27.8	13½	12	
(*c*)	2400	1910	24.3	12	10½	
10-in. (500-lb. shot)						
(*a*)	2800	2180	27.0	13½	12	West Virginia.
(*b*)	2600	2030	24.0	12	10½	Pobieda.
(*c*)	2400	1870	21.2	10	8½	
9-in. (360-lb. shot)						
(*a*)	2800	2100	23.0	11½	10	King Edward (about)
(*b*)	2600	1960	20.8	10	8½	Kaiser class (about)
(*c*)	2400	1825	18.7	8	7½	
8-in. (250-lb. shot)						
(*a*)	2800	2030	19.5	9⅓	8	Georgia.
(*b*)	2600	1890	17.5	8	7	
(*c*)	2400	1740	15.5	6	6	
7-in. (165-lb. shot)						
(*a*)	2800	1950	15.9	7	6	Connecticut.
(*b*)	2600	1810	14.2	5½	5½	
(*c*)	2400	1740	12.5	5	5	

PENETRATING POWER OF GUNS, ETC.,—Continued.

Gun.	Muzzle Velocity.	Remaining Velocity. 3000 yards.	By Tressider's Formula. Penetration. Wrought Iron.	Penetration. Krupp Cemented Plates. Direct Fire. Capped Shot.	Uncapped Shot.	Remarks.
6-in.* (100-lb. shot) (*a*)	2800	1810	11.9	5½	4¾	Suffren, République, etc., have 6.4-in., which just fail at 6-in. plates.
(*b*)	2600	1680	10.7	4½	4½	Formidable and recent armored cruisers. Also recent Russian ships.
(*c*)	2400	1550	9.4	4	4	Kaiser class.
5-in.* (60-lb. shot) (*a*)	2800	1680	9.2	4	4	
(*b*)	2600	1570	8.2	3½	3½	The 6-in. Q.F. in all ships up to Canopus class has this power, as has also the French 5.5-in. Q.F. inCharlemagne and older ships.
(*c*)	2400	1440	7.2	3	3	

* These guns will pierce about ½ greater thickness of K.N.C. than of K.C. plates with uncapped projectiles.

The last column is the most important one. It shows clearly enough the superiority of the heavy gun. Thus the 12-inch gun pierces twice as much as the 8-inch, and three times as much as the 6-inch. Both the 6-inch and 5-inch are completely out of court when 6-inch armor has to be pierced. The high velocity 6-inch is barely effective against hard-faced 5-inch plating. Against 5-inch K.N.C. armor an (*a*) 6-inch gun would just suffice, but it would fail against 6-inch K.N.C. A gun of 7.5-inch calibre, even of the (*b*) type, would pierce 6-inch K.C. armor readily enough, but against 7-inch plating there is scarcely sufficient margin. The best 8-inch gun is only just effective against 8-inch plates, and can do nothing against a 9-inch belt; so that where the 7.5-inch fails the 9.2-inch should be resorted to. An (*a*) of this type, such as that for the King Edward, will just be effective against the 10-inch plating of the Kaiser or Pobieda. The German 11-inch gun for the new ships, being probably of the (*a*) type, is adequate for dealing with existing armor, but the 12-inch gun has a margin for meeting an increase in the thickness of the belt and heavy gun barbettes. This gun would also do much more damage after penetration, besides which it would succeed on oblique impact where the lighter gun would fail.

—*The Naval Annual*, 1903.

DRILL REGULATIONS, MANEUVERS AND PRACTICE.

Manual of Drill and Fire Direction for 12-inch B. L. Mortars.

BY CAPTAIN, J. W. HINKLEY, JR., ARTILLERY CORPS.

GUN DETACHMENT:—GUN COMMANDER, GUNNER AND 10 CANNONEERS.

Name of Detail.	*Duties and Posts.*
Gun Commander (Sergeant)	See "General Duties," pp. 76, 77, D.R. Examines carriage while stores are being brought up; tests elevating gears; examines breech. Gives commands for preparing for drill, examining gun, loading, firing, relaying gun, discontinuing the drill or firing, and securing the piece. *Post.*—Two yards in rear of the breech, facing it.
Gunner (Corporal or private, duly qualified.)	See "General Duties," pp. 76, 77, D. R. Gives commands for procuring stores; goes to store room, sees that the cannoneers bring out the proper stores, place them about the piece properly and take proper posts; brings out gunner's quadrant and gives it to the gun commander. Examines recoil cylinders and tests traversing gears. *Post.*—On left of gun commander.
Breech Detail (4 privates, Nos. 1, 2, 3 and 4.)	No. 1 carries out and returns scraper, bucket of oil and hand sponge and places them convenient to the breech; operates translating roller in opening and closing breech; assists No. 2 in cleaning bore and breech mechanism, and in sponging and ramming. No. 2 carries out and returns firing machine and reel (if used), and loading tray, and places them as directed by the gunner; operates rotating crank in opening and closing the breech; assisted by No. 1, cleans bore and breech mechanism; assisted by Nos. 1, 3 and 4, sponges bore and chamber; commands "ram" and "home, ram" and, assisted by Nos. 1, 3, 4, 5 and 6, rams projectile; inserts and takes out loading tray; insert cartridge. No. 3 equips himself with lanyard [if used] primer pouch, primers, primer key, primer wire; also places reamer and gimlet convenient for his use. Assists in sponging and ramming; serves vent and fires. No. 4 carries out and returns bore and chamber sponge and places it on rack or prop; brings up and replaces sponge and assists in sponging out the bore and chamber. (When firing with smokeless powder and when not necessary to use the bore and chamber sponge, No. 4 brings up the

bucket of oil, hand sponge, and scraper.)

Posts.—In line, immediately in rear of breech, facing it, and in the following order from left to right: Nos. 4, 2, 1, 3.

Elevating Detail (2 privates, Nos. 5 and 6.)

No. 5 carries out and returns rammer; places it on rack or prop; assists in bringing piece to loading (horizontal) position and in giving elevation; brings up and replaces rammer for pieces on right of pit; assists in ramming.

No. 6 carries out and returns prop (when there are no racks) places it on side of piece next to wall; assists in bringing piece to loading position and in giving elevation; removes muzzle cover; brings up and replaces rammer for pieces on left of pit; assists in ramming.

Posts.—At elevating hand wheels, facing them, No. 5 on the right, No. 6 on the left.

Traversing Detail (2 pri- Nos. 7 and 8.)

No. 7 carries out and returns wrench for filling plugs of recoil cylinders; takes out and replaces filling plugs; traverses piece, assisted by No. 8 if necessary.

No. 8 carries out and returns funnel and oil measure of hydroline; fills cylinders; goes for cartridge; hands it to No. 2; assists No. 7 to traverse piece, if necessary; goes for next cartridge.

Posts.—At traversing cranks, facing mortar, No. 7 at the right crank, No. 8 at the left.

Charge Detail (2 privates, Nos. 9 and 10.)

Nos. 9 and 10 bring projectile on truck to the mortar, return truck to the magazine, load truck, and return with loaded truck to gallery entrance.

Posts.—Near entrance to gallery.

Ammunition Detachment (For Each Pit.)

Ammunition Sergeant and Six Privates.

Ammunition Sergeant

Superintends supply of ammunition for the group; exercises immediate control over all the details; sees that all equipment pertaining to the service of ammunition is at all times in proper condition.

Shell Detail (4 privates, Nos. 1, 2, 3 and 4.)

Operate the shell tongs and trolleys and assist No. 9 and 10 of the gun detachment to load the trucks.

Cartridge Detail (2 privates, Nos. 5 and 6.)

Uncase cartridges; keep at least 8 rounds of each weight of charge in each lot in powder gallery.

TO LOAD AND FIRE.

The gun commander commands:

1. Prepare for drill. 2. Examine gun. 3. Load.

PREPARE FOR DRILL.

The gunner commands:—*Procure stores.* The gunner and the cannoneers bring out the equipments and stores and take posts. The mortar is brought to the loading position and traversed so that it can be conveniently loaded.

EXAMINE GUN.

Muzzle cover removed, breech ; gun commander inspects the bore, chamber, breech box, breech block, breech mechanism ; if necessary, directs the parts to be cleaned and oiled ; breech closed ; filling plugs removed, gunner inspects the cylinders ; if necessary, has them filled and plugs replaced ; piece is traversed right and left and elevated and depressed to test the gears. The gun commander then reports the condition of the piece to the battery officer.

LOAD.

(After firing the piece is securely clamped in the loading position before the breech is opened and it is traversed so that it can be conveniently loaded.)

Breech opened, mushroom head cleaned and oiled, gas check pad oiled, bore and chamber cleaned, if necessary, with chamber sponge. As soon as the breech is opened, old primer is removed, vent cleared and new primer inserted. Projectile is brought up, launched, truck removed, projectile rammed home, loading tray inserted, cartridge brought up and inserted, loading tray removed, breech closed, lanyard hooked or firing wires attached, piece given the proper elevation and direction, gun commander commands, "Ready"; detachment formed in rear of pit, and wires connected to the firing box.

NOTES ON THE MANUAL.

The posts of the detachment as given above are for inspection and preparatory to the service of the piece.

The gun commander, gunner, and ammunition sergeant go, during the drill, wherever their presence may be necessary.

The reserve is posted wherever the battery officer may direct.

The members of the shell detail have charge of the loading of the trucks for the pieces of the pit corresponding to their own numbers. The trucks are brought into the magazine for projectiles so that they will be, when being loaded, in the same relative position as the mortars in the pit. Each member of the shell detail engages a projectile in the shell tongs, raises it about a foot from the floor and pushes it on the trolley to the entrance to the shell gallery, taking position there, projectile pointing in the way the trucks are to go out, so that Nos. 1 and 2 will be on the right of the trucks and Nos. 3 and 4 on the left, Nos. 1 and 3 being in rear. When the Nos. 9 and 10 of the gun detachments bring their trucks in, they halt them under the trolley track, hoist the projectiles and place them on the trucks, the members of the shell detail steadying them. The trucks are then run to the magazine entrance and the shell detail run the tongs down for new projectiles. At drill the projectiles are alternately put on and taken off the trucks, the trucks going to the guns alternately loaded and unloaded. There should be at least four dummy projectiles in each mortar battery.

In ramming, Nos. 1, 2, 3, 4, 5 and 6 take hold of the rammer on their respective sides, Nos. 1 and 2 next to the breech, and at the command "Ram", shove the projectile forward well off the shell pan and into the chamber. The truck being then removed, No. 2 commands "Home, Ram". At the first command the cannoneers reach well to the rear and take a firm hold on the rammer; at the second command they send the projectile home with all possible force.

After firing, No. 7 traverses the piece to a convenient position for loading. No. 8 instead of forming with the detachment in rear of the pit, goes at once to the entrance to the powder gallery and waits until the new powder charge is announced, when he gets the proper charge from the supply and carries it to No. 2. No. 2 inserts the charge, pushes it forward so that the mushroom head will shove it into the powder chamber when the breech is closed.

When the detachment is formed in rear of the pit, No. 3 tautens the lanyard or connects the firing wires to the firing box and draws up the handle. Upon receiving the proper directions, the gun commander gives commands or repeats the commands for the firing of the piece. No. 3 fires the piece.

After firing No. 3 disconnects one wire from the firing box and the cannoneers load again without command.

At the command "Relay Gun, Same charge" the gun commander commands "Relay Gun". No. 3 disconnects one wire from the firing box or moves close to breech to prevent interference with lanyard. The gun commander, gunner, the elevating detail and No. 7 only, resume their posts at the mortar.

At the command "Relay Gun, Powder charge", indicating a new powder charge, the gun commander commands, "Cannoneers, Posts". All cannoneers resume their posts. The wires are are disconnected or lanyard detached, the piece leveled, breech opened, old charge withdrawn and given to No. 8 when he brings up the new charge, new charge inserted, brecch closed, and piece given new azimuth and elevation. As the change in azimuth will seldom be great, the piece should not be traversed before inserting new charge.

To discontinue the firing, the gun commander repeats the command "Cease firing". The cannoneers resume their posts at the piece, it is brought to the loading position, the breech opened. If the piece is loaded, the cartridge is withdrawn and replaced in the magazine. If the piece is not loaded it is traversed to a position convenient for loading.

To discontinue the drill, the gun commander commands "Secure piece and Replace stores". The gunner superintends the replacing of stores and detachment forms in rear of pit.

The following equipments and stores are required for each mortar:—electric firing machine and reel or lanyard, gunner's quadrant, loading tray, prop, bore and chamber sponge, rammer, primer pouch, primers, primer key, primer wire, reamer gimlet, funnel, oil measure, wrench for filling plugs, scraper, bucket of oil, and hand sponge.

Racks, to take the place of the prop, for the rammer and sponge should be built on the side walls of the pit so as to leave as great a floor space in the pit as possible.

System of Fire Direction.

USED AT BATTERY STOTSENBURG, PRESIDIO.

The instrumental equipment of the P.F. Station is as follows:

Lewis D.P.F., Type "A" instrument, plotting board with scale arms 300 yards to the inch, drift and elevation ruler, speed and set-back ruler, two stop watches, telephone connection and signal bell to battery.

The plotting board is divided into zones corresponding to the powder charges and showing the overlaps. These zones are numbered from the shortest range to the longest, and the powder charges are numbered to correspond. The average time of flight for each zone is marked on the board under the number of the zone.

The plotting arm (scale arm) is pivoted at the point corresponding to the P.F. Station. The drift and elevation ruler is pivoted at the directing pit. It is so constructed as to correct automatically for drift, on the principle of the ruler described in the *Artillery Journal.* Instead of having a range scale, it reads elevations directly.

The speed and set-back ruler is constructed to the scale of the board. The set-back distance in yards for the average time of flight for each zone corresponding to speeds of target in yards per minute at intervals of 25 yards is tabulated on the board next to each zone number.

POSITION FINDER DETAIL.

Battery commander and 4 enlisted men.

Battery commander.—Indicates target, gives commands for tracking, chooses predicted point, announces zone, makes corrections for fire, sets instrument for the observation of fire, gives signal for firing.

No. 1, *Observer.*— Follows target with instrument, calls off range at "take" after No. 2 has read off azimuth, resumes tracking.

No. 2, *Time-keeper, reader, and recorder.*—Indicates times for taking observations, calls off azimuth at "Take", records it and the range on Form "D".

No. 3, *Plotter.*—Plots azimuths and ranges as read from the instrument, using drift and elevation ruler; determine and calls off elevation and corrected azimuth of the predicted point indicated by the B.C.; determines speed of the target, marks set-back point and calls off its azimuth.

No. 4, *Recorder.*—Records necessary data for the mortars on Form "F". (After drill or practice, assisted by the plotter, fills out Form "E" from Form "F" and the plotting board.)

Telephone man.—(No. 4 may also act as telephone man.) Transmits data for the mortars to the battery—powder charge, elevation, and azimuth.

At the battery (at each pit.)

Telephone man.—Receives and records on Form "F" data from P.F., repeating aloud each message as he receives it.

Black-board man.– Records data on black-board.

THE DRILL.

The battery having been reported "Ready", the B.C. indicates the target to the observer and commands, "Prepare to track". The observer sets his instrument on the target, water-lines and follows it, and calls "Ready". No. 2 repeats "Ready" and calls "Take", and at "Take" starts his stop watch. At "Take" the observer stops his instrument and, after No. 2 has called off and recorded the azimuth, calls off the range and again follows the target. No. 2 records the range. The plotter sets the scale arm at the proper azimuth and marks the location of the target at the proper range with a cross [X]. At 16 seconds No. 2 calls "Ready, one, two, three, take", so that the second observation will come out at the end of 20 seconds. The plotted position of this point will be marked with a small dot. Observations are made and plotted in like manner at 40 seconds and at the end of the minute. After the first minute, observations are taken and plotted only at end of each minute aud when called for by B.C.

The B.C., observing the plotted course and speed of the target, chooses a point called the predicted point, about three minutes travel ahead of the last plotted position and calls off the zone in which the point lies. He encloses the predicted point in a small circle.

The plotter then swings the scale arm to one side, swings the drift and elevation ruler to the predicted point, calls off elevation and azimuth of the predicted point for the directing pit, swings drift ruler out of the way and scale arm back into the field of fire. He notes the speed of target, marks set-back point and calls off its azimuth to B.C., who sets his instrument.

No. 4 records necessary data for the mortars and sees that the telephone man sends it to the battery.

The signal that the battery is ready to be fired is one short ring on the signal bell. The B.C. signals "Ready" to the battery by one short ring on the bell as the target approaches vertical hair of his instrument. A second ring by the B.C. signals the battery to fire.

If for any reason the B.C.'s instrument cannot be used—as when the target is moving directly toward or away from his instrument and when it is therefore continually on the vertical hair,—by watching the plotted course of the target and plotting it at frequent intervals, the B.C. is able to determine with accuracy the time of firing.

After the B.C. has located the predicted point he calls frequently for readings from the observer in order to determine as early as possible any change in the direction of the target, so that if it becomes necessary to assume a new predicted point it may be done with the least delay. If a reading shows a decided change in direction of the target, the B.C. should at once call for another reading and use its plotted position to test the accuracy of the last. He can early determine whether or not the target will pass reasonably close to the predicted point. Whenever it becomes necessary to assume a new predicted point it will be taken far enough ahead to allow time for determining the new data and relaying the mortars, but if possible in the same zone. The command "Relay gun, Powder charge number, .. ", indicating the new charge, will be sent at once to the battery.

The fire may be corrected as follows:

An observation on the splash is taken and plotted. The B.C. assumes an auxiliary point over or short and right or left of the new predicted point according to whether the splash is plotted short or over and left or right of the *last predicted point.* The plotter determines the elevation and corrected azimuth for this *auxiliary point*, the set-back being made from the *predicted point* Care must however be taken in correcting shots after the first correction has been made to increase or decrease the *previous correction* according to the fall of the shot, and after the mortars are on the target to continue with the same relative auxiliary point. In case no observation of the splash is plotted the B.C. determines the error of the shot with reference to the actual position of the target at the splash. Care must be taken in assuming any error of fire and in determining the auxiliary point to see that the target passed over the last predicted point on the plotting board and that the apparent error was not due to a change in the course of the target. It will assist if the plotting board is practically oriented in the field of fire.

If, during the determining of the data for the mortars, the plotter fails to plot a reading, he calls for it when he has time, No. 2 calling off the last azimuth and range. Observations taken and recorded other than at the end of a minute are indicated on Form "D" by a check mark and plotted with a dot. An observation at the end of a minute is plotted with a cross.

The system of Fire Direction above outlined admits of modifications. It is still to be decided how a battery of sixteen mortars is to be fired:—by pit, by battery, or by half battery. The system outlined is especially adapted to firing by battery, but probably the greatest volume of fire would be obtained by furnishing all pits simultaneously, every minute or oftener, the data for a predicted interval ahead and allowing the pit commanders to fire on time set-back as rapidly as possible and independently of each other, the pits starting the firing successively and the B.C. correcting the fire by correcting the predictions. In this case a predicting ruler would have to be used for accurate time predictions, and the time of the predictions and the time of flight would have to be sent to the mortars in addition to the other data. In this case it will be found convenient to tabulate 60 seconds minus the time of flight instead of the actual time of flight: *i. e.*, suppose the prediction is for 10:24 and the actual t. f. is 46 seconds, data comes to the battery "t. f. 14" and the pit commander fires at 10:23:14. It is as convenient to tabulate the one as the other and this method reduces the liability of error. After a bit some pits would be firing simultaneously, but this could be obviated by having special clocks or by speeding up our clocks until they marked off 60 seconds in 45 seconds actual time. If pits were then fired successively there would be a three minute interval, true time, between pit salvos, which I believe is the least practicable for any continued firing. Of course the time of flight would have to be reduced to this fictitious time, but the P.F. work could be done and I believe that the matter is worthy of attention especially if the firing by pit is adopted for mortar batteries.

For target practice however I favor the method outlined to this method of firing. In both cases the party on the tug may be endangered by errors in the laying of the piece, but in the former system the officer firing knows that the tug has passed the danger line, while in the latter errors in time as well as a slowing up of the tug may cause uneasiness to the crew and make the hiring of tugs expensive.

INDIRECT FIRE.

FORM D.

Battery......... ....190......

Azimuth.	Range.	Azimuth.	Range.	Azimuth.	Range.

To be signed and turned in to ....
Battery Commander immediately after drill. ....*Co., Coast Art.*

INDIRECT FIRE.

FORM E.

Battery.......................... ....190......

Charge.	Predicted.		Corrected.			Speed.	T. F.	Charge.	Predicted.		Corrected.			Speed.	T. F.
	Range	Azimuth	Range	Elevation	Azimuth				Range	Azimuth	Range	Elevation	Azimuth		

To be filled out by Computer, from notes, immediately after drill, signed and turned in to Battery Commander. ....
.. ...*Co., Coast Art.*

INDIRECT FIRE.

FORM F.

Battery........ ....190 .....

Powder Charge	Elevation	Azimuth	Powder Charge	Elevation	Azimuth

To be signed and turned in to Battery Commander, immediately after drill.

....
......*Co.*, *Coast Art.*

BOOK REVIEWS.

The Naval Annual. Edited by T. A. Brassey. Portsmouth: J. Griffin & Co., 2, The Hard. 1903. 34+534 p. O. 15 shillings net in Great Britain.

It is always a pleasant event of the naval year to welcome the appearance of this noted authority on naval matters. This volume for 1903, the seventeenth year of publication, treats of a great variety of interesting naval topics in a clear, impartial and well-informed manner, and while all its permanent features have been maintained, most of them have been improved, so that the *Annual* has advanced in merit and utility. In fact, this volume is so admirably filled with information, and contains so many things of interest and value that it merits high praise. While founded mainly for the purpose of being of value to the naval officer, the *Annual* is also of great value to the well informed coast artilleryman. It gives him not only standard information relative to his *targets*, but also some of the latest results and experiments in armor and projectiles, progress in guns, mountings and gunnery, in addition to much other matter of professional interest.

Lord Brassey this year contributes an introduction giving a general review of naval progress, with observations on navy estimates 1903-4, the need of economy, types of battleships, cruisers, etc., and discussing at some length the question of strength, recruiting and training of personnel, with some cogent remarks on naval reserves. On the subject of estimates, he says:

"In framing estimates for the British navy we have chiefly to look to the policy of other powers. We do not, however. regard the United States as a possible foe. No other power—no combination of powers—could vie with the people of the United States, if it were their policy to employ their unrivalled and rapidly growing resources in the creation of a predominant navy. Their own position is impregnable. They are self-contained, and their situation does not compel them to divert expenditure to the defense of land frontiers. In her political relations with the United States, old England may confidentially reckon that the claims of kinship will always prevail. Blood is thicker than water. Great Britain and the United States are bound to one another as no other nations are, by religion, race, language, and material interests. On many issues the two countries can work together and exert a commanding influence".

Sir John Colomb's return shows the expenditure for the British navy as approximately equal to that of France, Russia and Germany. Navy estimates have grown rapidly in Russia and Germany. In France they have been stationary. M. Pelletan considers it useless to fight where the contest is a matter of millions. France has not such a long purse as her rivals, and, even if she could equal Great Britain, how could she enter the field if Germany and the United States were engaged in conflict? He, therefore, dissents entirely from the advocates of the *grande guerre*.

In regard to comparative strength, Lord Brassey quotes figures which show the battle fleets of the great Powers in 1907, that is to say, when all ships now building are completed. France, Russia and Germany aggregate 861,000 tons against 749,000 tons for Great Britain. "If, however, we include the new and more powerful battleships about to be laid down in this country, we shall be more nearly equal in battleship tonnage to the combined strength of France, Russia and Germany. We have an unchallenged superiority in all classes of cruisers, and not least in those of the most powerful type. We are much more than equal to France and Russia combined".

In chapter I., of Part I., the editor, the Hon. T. A. Brassey, gives the usual interesting survey of progress in the British fleet during the past year, and in chapter II., in colloboration with Mr. John Leyland, he similarly reviews the situation of the foreign navies. These chapters give details of the new constructions and carefully note the changes made in the older ships.

Then follows the estimate of comparative strengh : "The additions to the battleship strength of the navies during the past year have not been very numerous. Germany is almost the only Power who has succeeded in carrying out its program, and, as a consequence, the Germany navy stands now, for the first time, second to our own in completed first-class battleships. In this, the chief element of naval strength, we are more than up to the two-Power standard. * * In completed battleships of the first-class, we are equal to a combination of any three Powers ; but if we include vessels under construction, we have 43 ships to a total of 56 for France, Germany and the United States." This position will be maintained in 1904, and, on a probable estimate for 1905, "the British navy will, in first-class battleships, still be practically equal to a combination of any three Powers." "In the important class of armored cruisers, which, in the latest designs, are approaching the battleship in offensive and defensive power, the present position is satisfactory. We have twenty completed to a total of ten for Germany, France, Russia and the United States." The program of construction for these classes appears sufficient to meet the efforts that are being made elsewhere. A large number of medium sized cruisers are needed for the protection of commerce.

The chapters on submarine cables, naval works and marine engineering are interesting and contain much information admirably summarized and presented. Mr. Dunell's chapter on Marine Engineering is especially excellent, containing a brief account of the marine steam turbine, and of the various difficulties in the way of oil fuel.

Naval maneuvers in 1902 are ably described in two chapters, one by Mr. Leyland, who describes those of France, Germany, the United States and other countries, and the other by Mr. Thursfield, who discusses and criticizes the Mediterranean maneuvers. "If a broad general lesson may be drawn from the naval maneuvers of the foreign powers in 1902, it is that greater efficiency than ever is necessary in the cruiser service. Hardly any squadron engaged possessed a sufficiency of the vessels of the class to keep it well informed of the movements of the adversary, and when touch was gained there was sometimes failure in organization, which made it impossible for it to be maintained. It is certainly deserving of note that the General Board of the United States navy, reporting since the maneuvers to the naval secretary upon the subject of a ship building programme, has recommended that for every four battleships put in hand, two armored cruisers, four cruising scouts, and four seagoing destroyers, as well as certain auxiliaries, shall be begun." Mr. Thursfield brings out his points very clearly. In conclusion, he states : "Their lessons are invaluable. We know now how to conduct a blockade so as to give the enemy far too many chances of escaping. We should know in future how to conduct it so as to give him as few chances as possible".

Chapters IX. and X. are devoted to a discussion of the New Scheme for Naval Training considered from independent points of view, Lieut. Carolyn Bellairs supporting the Admiralty plan, though perhaps "intrinsically not the best," while Sir Vesey Hamilton, arguing from the opposite standpoint, condemns it altogether.

Part II., as usual, contains the lists and plates of ships. The arrangement of the lists has undergone important modifications. The object of the changes has been to eliminate information which has ceased to have much value, and to substitute more useful particulars. Hence some of the former columns have been omitted and new ones substituted. The principal change has been in further developing the columns devoted to protection ; the side armor above the belt is shown, as well as the protection given both to main and secondary guns. These alterations add considerably to the value of the tables, and with other minor improvements that have been introduced, will be appreciated by all using them.

Part III. is devoted to armor and ordnance, experiments with plates and guns, progress in guns, etc., new propellants and naval gunnery, all of which is most instructive and interesting to the artilleryman as well as the naval officer. On a previous page has been given an extract from one of these chapters.

Part IV. contains statistics, official statements and papers, and gives in full the new Admiralty scheme of naval training.

The book is illustrated by an unusual number of excellent plates, the chapter on naval works containing many handsomely re-produced plans of new harbor works. A large page illustration shows the new Dartmouth Naval College, and eleven page plates illustrate recent types of battleships.

On the whole, this volume fully sustains the standard of its predecessors, and is well worthy of its reputation as an authority on naval matters. It will be found valuable by the artillery officer also, as it furnishes reliable data for the problems he may have to solve.

Neuen Formen der Panzer-Fortification. Victor Tilschkert, k. u. k. Oberst. Wien : L. W. Seidel und Sohn. 1902. Pp. 42, with 15 colored plates.

This is an excellent presentation of some of the new forms of fortifications in use for land forts on the continent of Europe, especially Sauer's armored turrets. These structures are so entirely different from our own that it is very difficult to give a clear and correct idea of them in a few words.

The author first discusses the great principle of modern fortification of scattering the forts, and illustrates the disadvantages of the old system by the south forts of Paris in 1871. The systems of the Prussian Lieutenant-Colonel Schumann and the Bavarian General Sauer are next considered, and their turrets are contrasted with those of Montalembert and Archduke Maximilian. The material, form and resisting power of the turrets, or armored casemates, are next discussed, and the various new forms described. Their position in the forts, as well as their attack and defense, and their armament (with references to the views of the well known authorities Leithner, Witte and Von der Goltz) are fully considered.

The pamphlet is beautifully illustrated by means of 15 colored plates, which alone can give a clear idea of the general character of the modern Continental method of fortifying land forts, and to a great extent also sea forts. J.P.W.

Der Angriff in Festungskriege. Eine kritische Studie. Gustave Smekal, k. und k. Oberstleutnant des Generalstabskorps. Wien: L. W. Seidel und Sohn. 1902. Pp. 90.

Colonel Smekal, of the Austrian General Staff, the author of this work, is a military writer of note, best known, perhaps, for his works on the tactics of field artillery, particularly his practical field problems illustrating proper handling of field batteries in a campaign.

The purpose of the present work is to combat the long accepted notion that the subject of the *Attack and Defense of Fortifications* belongs exclusively to the Engineers and Artillery, arguing that since the attack of previously prepared positions (in other words, *land fortifications*) will be abundantly represented on future battlefields, the army at large must take up the subject and master it. To present this subject in un-technical language for the use of the army in general is the object of this work.

The author first describes the *means* of attack and defense (troops, siege train, mobile artillery, engineer park, field railroads, telegraph, telephone, search lights and balloons,) and then discusses the principles of attack.

Coming from such source, a recognized authority on the tactics of field artillery, this critical study is valuable not only to those to whom it is particularly addressed, the army at large, but also to the Artillery arm in particular. It is a thoroughly digested and carefully considered essay, constituting a valuable addition to the literature of the subject. J.P.W.

The Story of Our Army. By Captain Owen Wheeler. London: George Newnes, Ltd. Pp. 192.

This little volume is a very readable and interesting number of the useful series of small manuals entitled *The Library of Small Stories*, sold at one shilling each.

It is the story of the British Army from the early British Fighting men and the Norman Conquest to the Army of Today, with its very latest improvements and changes of organization. The history is divided into five epochs; the *first* treating of knighthood, chivalry and the archers, exemplified by the campaigns of Crécy and Poitiers; the *second* opening with the rise of the hired soldier, and illustrated by Agincourt, passing through the times of the Tudors and closing with the army of Cromwell; the *third* discussing the beginnings of a standing army after the Restoration, and the army of the Georges, with the early fighting days in India; the *fourth* considering the Peninsular War, Waterloo, the Crimean War and developments in India; and the *fifth* and last, the wars in Egypt, India and South Africa.

The story is fascinating from beginning to end, not only to British subjects but to all who are interested in the world's development, and in noble deeds of brave men who perform their duty to their country. The development of the army is clearly traced, and the work is thus also a study in organization and administration. The language is so simple withal, that the general reader will find no technicalities to mar his enjoyment in reading the book. The subject-matter is what every school-boy should be familiar with, and we know of no more agreeable presentation of it than this little work.

J. P. W.

Storage Battery Engineering. A Practical Treatise for Engineers. By Lamar Lyndon. New York: McGraw Publishing Company, 114 Liberty Street. 1903. 382 p. O. Cloth, $3.00.

This volume is essentially a practical engineers' manual, intended to assist the electrical engineer in designing, installing and properly caring for storage battery equipments. The want of a *practical* work on the storage battery and its applications, particularly adapted for the use of those who have such duties to perform, has long been felt; hence the value of Mr. Lyndon's book, which, treating the subject altogether from an engineering standpoint rather than from that of the manufacturer, covers all questions that may arise in storage battery practice and gives one a satisfactory solution thereof. Mathematics have been avoided as far as possible, and when the proper treatment of any subject has compelled their use, all operations have been carried through with explanatory text, so that the reasoning may be easily followed, and in many instances each mathematical discussion is further elucidated by a concrete example.

The work is divided into two parts. Part I. discusses the lead storage battery in detail. Its general theory and requirements; voltage and its variation; the active material and the electrolyte; quantity of discharge, internal discharge, influence of temperature, internal resistance and efficiency; and durability and causes of deterioration, constitute the first twelve chapters. Methods of testing to determine the condition of a cell, and instructions for testing, purification and proper mixing of the elements are given. A chapter is devoted to diseases and their remedies, and another to the care and management of a battery. The author then describes the various types of cells and their construction, each distinctive type of grid being illustrated by a well known make. He then considers containing cells, assembling and installing the battery, and concludes the first part with a very complete chapter on testing.

The treatment throughout this part is almost entirely physical, the electrochemical theories involved being given only to a limited extent, as the chemistry of the storage battery is beyond the scope of the text.

Part II. is devoted to auxiliary apparatus, systems and applications. The various uses of the storage battery arising in practice are discussed, followed by a detailed consideration of the subject of end cell regulation of voltage, including the various appliances necessary, such as switches, automatic switches, indicators and conductors. The various systems of boosters are then described, an analytical discussion of each of all the different types being given, also the application of boosters to two and three wire systems, with notes on their design and selection. Alternating current systems are touched upon, and the use of line batteries, those which are connected across the feeder system or line some distance away from the generator, discussed and explained. The question of plant efficiency is fully treated, and finally the last chapter gives an example of the application of a battery to an isolated plant, determining its size and the estimate of its cost.

This summary serves to show the scope of the work and how thoroughly the subject is covered. The author presents his information in an eminently clear and satisfactory manner throughout the book. In addition, the extensive use of concrete examples assists in following the discussions, and in explaining the rules and principles enunciated. Another excellent feature of the book is that the chapters are short and each treats of one particular subject only. This arrangement brings together all information pertaining to one topic and facilitates reference. The text is fully supplemented by 178 illustrations and diagrams and 4 large plates.

With the increasing applications of electricity in the service, and the numerous storage battery plants found in our fortifications, the coast artilleryman is called upon to know more and more about the practical details connected therewith. Hence he will find this book of value in learning about the storage battery and its applications, and of assistance in the proper care and management of such a plant. It can be recommended as being the most complete and satisfactory practical work that has yet appeared; it is well worth buying and studying.

Electrical Instruments and Equipments of the U. S. Signal Corps. Prepared under the direction of Brigadier-General A. W. Greely, Chief Signal Officer, U. S. Army, by Captain Edgar Russel, Signal Corps. Washington: Government Printing Office. 1902. Pp. 159. O. Cloth.

This book, forming No. 3 of the Signal Corps' manuals, contains full instructions for the installation and care of the electrical instruments and equipments of the Signal Corps of the army, and much information of practical value to the artilleryman on storage batteries, switch boards, instruments and fire control material.

Much of this data may be found in technical publications and various books, but it is widely scattered and usually associated with much not immediately useful, hence not in such a shape as to be readily consulted. Captain Russel's object has been to collect all available matter regarding the instruments and electrical appliances used in the army, co-ordinate it and present it in condensed and convenient form for the use of officers and enlisted men. He has been able to include also some valuable data from the files of the office of the Chief Signal Officer of the army.

After a short chapter on electrical definitions and terms, and another concisely describing primary cells, manner of grouping, and the use and care of storage batteries, the author devotes eight chapters to telegraphy and systems of installation. The instruments used, office equipments, the various systems, including Stearns' duplex, the Polar duplex, etc., are fully described and discussed. The author's long practical experience with telegraph apparatus has eminently fitted him for appreciating what is of value in this line. Eliminating what is useless, he presents the resulting information in a clear, satisfactory and practical manner.

Much of the matter in an important chapter on Testing and Location of Faults is new, and includes the application of the ohmmeter to line testing by methods suggested and put in practice by Mr. R. C. Lord.

Chapter XI. is important for the artilleryman, containing descriptions and diagrams of fire control material, electric clock and time interval system, anemometer and telautograph.

The illustrations, which, except in the case of some showing cells and telegraph instruments, receivers, repeaters, etc., are mainly diagrammatic, show the circuits and arrangement of apparatus. They are numerous and assist one materially in following the text.

This Manual will be found of great practical value in the service, and, in connection with No. 1, on Telephones, essential for the efficient administration of electrical communication installations.

The New International Encyclopaedia. Editors D. C. Gilman, LL.D., President of Johns Hopkins University and of Carnegie Institution, H. T. Peck, Ph. D., L.H.D., Professor in Columbia University, F. M. Colby, Professor in New York University. Volumes VII. and VIII. New York: Dodd, Mead and Company. 1903.

The successive volumes of this great work, as they appear, confirm the good opinions generally expressed by reviewers and critics on the initial volume. The high character of the work is maintained, and the good taste of the editors becomes more and more evident as the undertaking nears completion.

Volume VII. has the usual number of colored plates, maps and engravings. The maps include several very interesting ones: one showing the average date of the *first killing* frost in autumn in the United States, at various latitudes; another the average date of the *last killing* frost in spring; a third exhibits the forest regions in the United States; and four others show the changes in the map of Europe from the time of Charlemagne to the Congress of Vienna. The most striking of the engravings are the Roman Forum and excellent portraits of Faraday, Franklin and Frederick the Great. The more important military articles include a very satisfactory one on Explosives, another very complete one on Fortifications, besides a number of shorter ones on Fencing, Field Artillery, Field Cooking, Field Glass, Franco-German War, French and Indian War, Friedland, and a number of Forts in the United States.

Among those of general interest, we find a masterly essay on Evolution, an attractive article on Florence, and a splendid outline of the interesting points about the French Language and Literature. Turning to the useful, the subjects of Food and Flour are presented in an attractive and very instructive form.

Volume VIII. is particularly rich in fine colored plates, every one of them being most beautiful: Fungi, Marine Gasteropods, Greenhouse Plants and Game Birds. Among the maps, the most interesting is that of The Known World at various times. Many of the engravings are also beautiful, and some are well-known favorites: Gainsborough's *The Blue Boy*, Ghirlandajo's *Nativity of the Virgin Mary*, Gloucester Cathedral, Greuze' *The Broken Pitcher*, and good portraits of Grant, Goethe, Gladstone and Garibaldi.

Tne system of arrangement and treatment make the work particularly satisfactory in the ease with which any desired information may be found, and the useful bibliography at the end of the article on each important word completes this effect.

On the whole these two volumes but emphasize what we have said of their predecessors and fully sustain the character of the work as originally outlined.

J.P.W.

Modern Rifle Shooting from the American Standpoint. By W. G. Hudson, M.D. New York: Laflin & Rand Powder Company. 1903. 160 p. D. Blue cloth. $1.00.

Dr. Hudson, so well known to the shooting fraternity, both in important rifle shooting events in this country and by the number of fine scores to his credit, has produced in this litttle book a very interesting and satisfactory work on rifle shooting. His object in writing has been to give the beginner such elementary assistance as will bring him to the point where his interest will be quickened; with that awakened, the enthusiasm of sport, "in what is in reality a national duty of great importance," together with intelligent effort and attention to details will soon lead him to become an expert rifleman.

The author's experience in rifle shooting both as a study and as a pastime, well qualifies him to write authoritatively on this subject. In his experiments and investigations he has acquired a large fund of information, which he here presents clearly and concisely, recording the obstacles which are experienced by most riflemen, giving remedies and making suggestions.

The book treats of rifles, bullets, etc., selection of a rifle, proper equipment of a rifleman, sights, adjustments, sighting and aiming, helps thereto, positions in rifle firing, targets, ammunition, the rifleman himself, and gives a final chapter on the National Rifle Association of America. An appendix contains some useful and practical information on appliances and accessories of a rifleman's outfit.

Modern arms, and in particular the U. S. Magazine Rifle, the Krag, are the rifles considered. Hence the book should prove useful in establishing a more thorough acquaintance with the latter weapon, "one which above all others should be most familiar to the American citizen-soldier," and with which he will in future be equipped.

The sweeping victory for America in the recent international match, and the bringing back of the Palma Trophy, should undoubtedly do much to arouse further enthusiasm in rifle shooting in this country. Dr. Hudson's book will prove not only a reliable guide for beginners, but a useful book of reference for the skilled shot.

EXCHANGE AND BOOK NOTICES.

Termes Militaires Francais-Anglais. By Albert Septans and Victor Schmid. Paris: Henri Charles-Lavauzelle. 10 Rue Danton. 1903. 25+246 p. O. Paper, 4 francs.

Entfernungsmesser-Systeme und die Telemeter Paschwitz. E. v. Paschwitz, Berlin: Verlag "Der Mechaniker," Potsdamerstr. 113. 1903. 12 p. O. Paper, 1 Mk.

Practical Gunnery in the Lecture Room and in the Field A Series of Lectures for the use of all Ranks of Artillery. Compiled by Captain H. T. Russell, Royal Artillery. London: Gale & Polden Ltd. 1903. 93 p. D. Illustrated. Two-and-Six.

Messrs. Gale & Polden have brought out a third edition of **Organization and Equipment Made Easy**, by Major S. T. Banning. The book is a well prepared manual containing a digest of the most salient features of the British system of organization and administration. Due to the recent numerous and important alterations in the Army system, this edition has been extensively revised, the changes noted and thus the book brought up to date. It will be found an exceedingly useful manual not only for the purpose for which it is intended, but also for the military student who may desire to get an insight into the British military system.

Another interesting number of Gale & Polden's Military Series is **The Army Handbook of Physical Training,** a little book of 134 pages containing various exercises, gymnastics, drill with arms, parallel bars, rope climbing, jumping, etc., with illustrations of the different positions. With the increasing development of athletics in the army, the exercises here given furnish some suggestive ideas of which use could be made.

INDEX TO CURRENT MILITARY LITERATURE.

PERIODICALS CITED.

Abbreviations employed in index are added here in brackets.

All the periodicals are preserved in the Artillery School Library, Fort Monroe, Virginia.

ENGLAND.

Arms and Explosives. [*Arms and Ex.*] *Effingham House, Arundel Street, Strand, London, W. C.*	*Monthly.* *Per year* 7 *s.*
Army and Navy Gazette. [*A. and N. Gaz.*] 3 *York Street, Covent Garden, London. W. C.*	*Weekly.* *Per year* £1 12*s* 6 *d.*
Canadian Military Gazette. [*Can. Gaz.*] 232 *McGill Street, Montreal, Canada.*	*Fortnightly.* *Per year* $2.00.
The Engineer. [*Eng.*] 33 *Norfolk Street, Strand, London, W. C.*	*Weekly.* *Per year* £2 6 *d.*
Engineering. [*Eng'ing.*] 35-36 *Bedford Street, Strand, London, W. C.*	*Weekly.* *Per year* £2 6 *d.*
Journal of the Royal United Service Institution. *Whitehall, London, S. W.* [*Jour. R.U.S.I.*]	*Monthly.* *Per year* 24 *s.*
Journal of the United Service Institution of India. *Simla, India.* [*Jour. U. S. I. India*]	*Quarterly.* *Per year* $2.50.
Page's Magazine. [*Page Mag.*] *Clun House, Surrey Street, Strand, London, W. C.*	*Monthly.* *Per year* 16 *s.*
Photographic Journal. [*Photo. Jour.*] 66 *Russell Square, London.*	*Monthly.* *Per year* 12 *s.*
Proceedings of the Institution of Civil Engineers. 25 *Great George Street,* [*Proc. I. C. E.*] *Westminister, London, S. W.*	*Annual.*
Proceedings of the Institution of Mechanical Engineers. *Storey's Gate* [*Proc. I. M. E.*] *St. James' Park, Westminister, London, S. W.*	
Proceedings of the Royal Artillery Institution. *Woolwich, England.* [*Proc. R. A. I.*]	*Monthly.*
Professional Papers of the Corps of Royal Engineers. *Chatham, England.* [*Prof. Papers C. R. E.*]	
Review of Reviews. [*Rev. Austral.*] 169 *Queen Street, Melbourne, Australia.*	*Monthly.* *Per year* 10 s. 6 d.
Transactions of the Canadian Institute. 58 *Richmond Street,* [*Trans. Can. Inst.*] *Toronto, Canada.*	*Annual.*

Transactions of the Canadian Society of Civil Engineers.
Montreal, Canada. [*Trans. Can. Soc. C. E.*]

Transactions of the Institute of Naval Architects.
5 *Adelphi Terrace, London, W.C.* [*Trans. Inst. N. A.*]

United Service Gazette. [*U. S. Gaz.*] *Weekly.*
245 *Dashwood House, New Broad Street, London, E. C.* *Per year* £1 10 *s* 6 *d.*

United Service Magazine. [*U. Serv. Mag.*] *Monthly.*
23 *Cockspur Street, Charing Cross, London, S. W.* *Per year* 27 *s.*

FRANCE.

Armée et Marine. [*A. Marine.*] *Weekly.*
3 *Place du Théatre Français, Paris,* *Per year* 35 *Fr.*

Le Génie Civil. [*Génie C.*] *Weekly.*
6 *Rue de la Chaussée d'Antin, Paris.* *Per year* 45 *Fr.*

La Marine Française. [*Marine F.*] *Semi-monthly.*
26 *Rue de Grammont, Paris.* *Per year* 30 *Fr.*

Mémoires et Compte Rendu des Travaux de la Société des Ingénieurs Civils.
19 *Rue Blanche, Paris.* [*Memoires I. C.*] *Monthly.* *Per year* 36 *Fr.*

Memorial des Poudres et Salpêtres. *Semi-annually*
Quai des Grands-Augustins, 55 *Paris, France.* [*M. Poudres.*] *Per year* 13 *Fr.*

Le Monde Militaire. [*Monde.*] *Fortnightly.*
6 *Rue de la Chaise, Paris.* *Per year* 8 *Fr.*

Revue d'Artillerie. [*R. Artillerie.*] *Monthly.*
5 *Rue des Beaux-Arts, Paris.* *Per year* 22 *Fr.*

Revue de Cavalerie. [*R. Cav.*] *Monthly.*
5 *Rue des Beaux-Arts* 5, *Paris.* *Per year* 53 *Fr.*

Revue du Cercle Militaire. [*Cercle.*] *Weekly.*
37 *Rue de Bellechasse, Paris.* *Per year* 27 *Fr.*

Revue du Génie Militaire. [*Génie M.*] *Monthly.*
5 *Rue des Beaux-Arts, Paris.* *Per year* 27 *Fr.*

Revue d'Infanterie. [*R. Inf.*] *Monthly.*
10 *Rue Danton, Paris.* *Per year* 25 *Fr.*

Revue Maritime. [*R. Maritime.*] *Monthly.*
Rue et Passage Dauphine 30, *Paris.* *Per year* 56 *Fr.*

Revue Militaire des Armées Etrangères. *Monthly.*
R. Chapelot et Cie., Rue et passage Dauphine 30, *Paris.* [*R. M. Etrang.*] *Per year* 15 *Fr.*

Revue Militaire Universelle. [*R. Univ.*] *Monthly.*
10 *Rue Danton, Paris.* *Per year* 25 *Fr.*

Revue des Questions Militaires. [*Quest. Mil.*] *Monthly.*
6 *Rue de la Chaise, Paris.* *Per year* 15 *Fr.*

Le Yacht—Journal de la Marine. [*Yacht.*] *Weekly.*
55 *Rue de Chateaudun, Paris.* *Per year* 30 *Fr.*

GERMANY.

Die Armee. [*Armee.*] *Weekly.*
Jul. Bagel. Mülheim-Ruhr. *Per year* 9 *M.*

Beiheft zum Militaer-Wochenblatt. *Occasional.*
Koch Strasse, 68, [*Beiheft.*]
Berlin. S.W., 12.

Internationale Revue. [*Int. Rev.*] *Monthly.*
Weintraubenstrasse 21, 1. *Dresden–N.* *Per quarter* 8 *Fr.*

Jahrbuecher fuer die deutsche Armee und Marine. *Monthly.*
Mohren Strasse, 19, [*Jahrbuecher.*] *Per year* 24 *M.*
Berlin, *W.* 8.

Kriegstechnische Zeitschrift. [*Kriegstech.*] *Ten numbers a year.*
Koch Strasse, 68-71, *Berlin*, *S. W.* *Per year* 10 *M.*

Marine Rundschau. [*Rundschau.*] *Monthly.*
Koch Strasse, 68-71, *Berlin*, *S. W.* *Per year* 8 *M.*

Militaer-Wochenblatt. [*Wochenblatt.*] *Semi-weekly.*
Koch Strasse, 68, *Berlin*, *S. W.* 12. *Per Year* 20 *M.*

Schiffbau. [*Schiffbau.*] *Semi-monthly.*
Emil Grottke's Verlag, *Per year* 18 *M.*
Wilhelmstrasse 105, *Berlin*, *S. W.*

Stahl und Eisen. [*Stahl u. Eisen.*] *Fortnightly.*
Jacobistrasse 5, *Düsseldorf.* *Per year* 24 *M.*

Ueberall. [*Ueberall.*] *Weekly.*
Verlag : Boll and Pickardt, *Per year M.* 23.60.
Georgenstrasse 23, *Berlin*, *N. W.*

Die Umschau, [*Umschau.*] *Weekly.*
H. Bechhold Verlag, *Per year M.* 21.20.
Frankfort A. M.

AUSTRIA.

Mittheilungen aus dem Gebiete des Seewesens. *Monthly.*
Pola. [*Seewesens.*] *Per year* 17 *M.*

Mittheilungen ueber Gegenstaende des Artillerie und Genie-Wesens.
Getreidemarkt 9. [*Mitth. Art. u. G.*] *Monthly.*
Wien, *VI*, *Per year* 20 *M.*

Organ der Militaer Wissenschaftlichen Vereine. 8-14 *numbers.*
Strauchgasse No. 4 [*Organ.*] *Per year* 20 *K.*
Wien I.

Zeitschrift des Oesterreichischen Ingenieur und Architekten Vereines.
Eschenbachgasse, *No.* 9. [*Zeitschr. I. A. V.*] *Weekly.*
Wien. I. *Per year* 30 *K.*

SWITZERLAND AND BELGIUM.

Allgemeine Schweizerische Militaer-Zeitung. *Weekly.*
Basel, *Switzerland.* [*A.S.M. Zeit.*] *Per year*, 8 *Fr.*

La Belgique Militaire. [*Belgique M.*] *Weekly.*
Rue Albert de Latour, 50, *Per year F.* 12.50.
Schaerbeek, *Brussels.*

Revue de l'Armée Belge. [*A. Belge.*]	*Bi-monthly.*
22 *Rue des Guillemins, Liège, Belgium.*	*Per year* 13 *Fr.*
Revue Militaire Suisse. [*R. M. Suisse.*]	*Monthly.*
23 *Escaliers-du-Marché, Lausanne, Switzerland.*	*Per year Fr.* 12.50.
Schweizerische Militärische Blätter.	*Monthly.*
Frauenfeld, Switzerland. [*S. M. Blaetter.*]	*Per year* 12 *Fr.*
Includes:	
Monatschrift fuer Offiziere Aller Waffen.	
Zeitschrift fuer Artillerie und Genie.	

ITALY AND RUSSIA.

Rivista di Artiglieria é Genio. [*R. Artig.*]	*Monthly.*
Tipografia Enrico Voghera, Via Astalli 15, *Rome.*	*Per year* 30 *L.*
Rivista Marittima. [*R. Maritt.*]	*Monthly.*
Economo del Ministero della Marina, Rome.	*Per year* 25 *L.*
Voyennyj Sbornik. [*Sbornik.*]	*Monthly.*
Madezhcdinskoi Dom. No. 21, *St. Petersburg, Russia.*	*Per year* 4.80.

HOLLAND AND SCANDINAVIA.

Artilleri-Tidsskrift. [*Art. Tids.*]	*Bi-monthly.*
Artillerigården Stockholm, Sweden.	*Per year, U. S.,* $1.75
De Militaire Gids. [*M. Gids.*]	*Bi-monthly.*
De Erven F. Bohn, Haarlem, Holland.	*Per year, U. S.,* $2.00
Militaert Tidsskrift. [*M. Tids.*]	*Bi-monthly.*
Copenhagen, Denmark.	*Per year, U. S.,* $2.50
Norsk Artilleri-Tidsskrift. [*N. Art. Tids.*]	*Bi-monthly.*
Christiania, Norway.	*Per year* $1.50.
Norsk Militaert Tidsskrift. [*N. M. Tids.*]	*Monthly.*
Christiania, Norway.	*Per year, U. S.,* $2.50

SPAIN, PORTUGAL, MEXICO AND SOUTH AMERICA.

Annaes do Club Militar Naval. [*Club Mil. Nav.*]	*Monthly.*
43 *Rua do Carmo, Lisbon, Portugal.*	*Per year* $3.85.
Boletin del Centro Naval. [*Boletin.*]	*Monthly.*
Florida 659 *Buenos Aires, Argentina.*	*Per year* $\$^{m}/_{n}$ 11.00.
Liga Naval Portuguesa, [*Liga Nav.*]	*Monthly.*
95 *Rua Garrett, Lisbon Portugal.*	*Per year* $4.50.
Memorial de Artilleria. [*M. de Art.*]	*Monthly.*
San Lorenzo 5, *bajo, Madrid, Spain.*	*Per year,* $3.60.
Revista Cientifico-Militar. [*Cientifico.*]	*Semi-monthly.*
5 *Calle de Cervantes, Barcelona, Spain.*	*Per year* 40 *Fr.*
Revista de Engenheria Militar. [*Eng. Mil.*]	*Monthly.*
27 *Rua Nova do Almada, Lisbon, Portugal.*	*Per year* 16 *Fr.*
Revista do Exercito e da Armada.	*Monthly.*
Largo de S. Domingos 11, [*Exercito.*] *Lisbon, Portugal.*	*Per year U. S.* $6.00.

Revista General de Marina, [*R. G. de Marina.*]		*Monthly.*
56 *Calle de Alcalá, Madrid, Spain.*		*Per year* $4.45.
Revista de Marina.	[*R. de Mar.*]	*Monthly.*
Casilla del Correo 976, *Valparaiso, Chili.*		*Per year* $10.00.
Revista Maritima Brazileira. [*R. Marit. Brazil.*]		*Monthly.*
Rua Conselheiro Saraiva n. 12. *Rio de Janeiro, Brazil.*		*Per year* $6.60.
Revista Militar.	[*R. Mil. Portugal.*]	*Semi-monthly.*
262 *Rua da Princeza, Lisbon, Portugal.*		*Per year,* $2.60.
Revista Militar.	[*R. Mil. Brazil.*]	*Monthly.*
Rio de Janeiro, Brazil.		

UNITED STATES.

American Electrician.	[*Amer. Elec.*]	*Monthly.*
120 *Liberty Street, New York.*		*Per year* $1.00.
American Journal of Mathematics.		*Quarterly.*
Johns Hopkins University, Baltimore, Md.	[*Jour. Math.*]	*Per year* $5.00.
American Machinist.	[*Amer. Mach.*]	*Weekly.*
256 *Broadway, New York City.*		*Per year* $3.00.
American Manufacturer and Iron World.		*Weekly.*
55 *Ninth Street, Pittsburgh, Pa.*	[*Amer. Manfr.*]	*Per year* $4.00.
Army and Navy Journal.	[*A. and N. Jour.*]	*Weekly.*
New York City.		*Per year* $6.00.
Army and Navy Register.	[*A. and N. Reg.*]	*Weekly.*
Washington, D. C.		*Per year* $3.00.
Bulletin of the American Mathematical Society.		*Ten numbers per year.*
University Heights, New York City.	[*Bulletin Math. Soc.*]	*Per year* $5.00.
Cassier's Magazine.	[*Cas. Mag.*]	*Monthly.*
3, *West* 29*th Street, New York City.*		*Per year* $3.00.
Electrical World and Electrical Engineer.		*Weekly.*
114-118 *Liberty Street, New York City.*	[*Elec. World.*]	*Per year* $3.00.
Electrical Engineering.	[*Elec. Eng'ing.*]	*Monthly.*
Monadnock Block, Chicago, Ill.		*Per year* $1.00.
Electrical Review.	[*Elec. Rev.*]	*Weekly.*
41 *Park Row, New York City.*		*Per year* $3.00.
The Engineer.	[*Eng. Cleve.*]	*Fortnightly.*
Blackstone Building, Cleveland, Ohio.		*Per year* $2.50.
Engineering Magazine.	[*Eng'ing. Mag.*]	*Monthly.*
120-122 *Liberty Street, New York City.*		*Per year* $3.00.
Engineering and Mining Journal.		*Weekly.*
261 *Broadway, New York City.*	[*Eng. and Min. Jour.*]	*Per year* $5.00.
Engineering News and American Railroad Journal.		*Weekly.*
220 *Broadway, New York City.*	[*Eng'ing News.*]	*Per year* $5.00.

The International Quarterly. *Burlington, Vt.*	[*Int. Quart.*]	*Quarterly.* *Per year* $3.00.
The Iron Age. 232–238 *Williams Street, New York City.*	[*Iron Age.*]	*Weekly.* *Per year* $4.50.
Journal of Electricity. 144 *Union Square Ave, San Francisco, Cal.*	[*Jour. Elec.*]	*Monthly.*
Journal of the American Chemical Society. *Easton, Pa.*	[*J. Chem. S.*]	*Monthly.* *Per year* $5.00.
Journal American Society of Naval Engineers. *Navy Department, Washington, D. C.*	[*A.S.N. Engrs.*]	*Quarterly.*
Journal of the Association of Engineering Societies. 257 *South Fourth Street, Philadelphia.*	[*Jour. Eng. Soc.*]	*Monthly.* *Per year* $3.00.
Journal of the Association of Military Surgeons. *Carlisle, Pensylvania.*	[*Jour. Mil. Surg.*]	*Monthly.* *Per year* $3.00.
Journal of the Franklin Institute. *Philadelphia, Pa.,*	[*Frank. Inst.*]	*Monthly.* *Per year* $5.00.
Journal of the Military Service Institution. *Governor's Island, New York City.*	[*Jour. M. S. I.*]	*Bi-monthly.* *Per year* $3.00.
Journal of the U.S. Cavalry Association. *Fort Leavenworth, Kan.*	[*Jour. U. S. Cav.*]	*Quarterly.* *Per year* $2.00.
Journal of the Western Society of Engineers. 1737 *Monadnock Block, Chicago, Illinois.*	[*W. Soc. Eng.*]	*Bi-monthly.* *Per year* $2.00.
Marine Review. *Cleveland, Ohio.*	[*Mar. Rev.*]	*Weekly.* *Per year* $2.00.
Military Information Division. *War Department, Washington, D. C.*	[*Mil. Information Div.*]	*Occasional.*
Mines and Minerals. *Scranton, Penn.*	[*M. and Min.*]	*Monthly.* *Per year* $2.00.
The National Guardsman. 134 *Van Buren Street, Chicago, Ill.*	[*N. Guard.*]	*Monthly.* *Per year* $1.00.
Pennsylvania Magazine of History and Biography. 13 *Locust Street, Philadelphia.*	[*Penn. Mag.*]	*Quarterly.* *Per year* $3.00.
The Photographic Times. 60 *and* 62 *E.* 11*th Street, New York City.*	[*Phot. Times.*]	*Weekly.* *Per year* $5.00.
Physical Review. *Cornell University, Ithaca, New York.*	[*Phys. Rev.*]	10 *numbers per year.* *Per year* $5.00.
Popular Science Monthly. 72 *Fifth Avenue, New York City.*	[*Pop. Sc. Mo.*]	*Monthly.* *Per year* $5.00.
Popular Mechanics. *Journal Building, Chicago, Ill.*	[*Pop. Mech.*]	*Weekly.* *Per year* $2.00.
Proceedings of the American Philosophical Society. 104 *South Fifth Street, Philadelphia, Pa.*	[*Proc. A. Phil. Soc.*]	

Proceedings of the American Society of Civil Engineers. *Monthly.*
220 *West 57th Street,* [*Proc. A. S. C. E.*]
New York City.

Proceedings of the Engineers' Club of Philadelphia. *Quarterly.*
1122 *Girard street,* [*Eng. C. Phila.*] *Per Vol.* $2.00.
Philadelphia, Pa.

Proceedings of the U. S. Naval Institute. *Quarterly.*
Annapolis, Md. [*Naval Inst.*] *Per year* $3.50.

Review of Reviews. [*R. of Rev.*] *Monthly.*
13 *Astor Place, New York City.* *Per year* $2.50.

The Scientific American. [*Scien. Amer.*] *Weekly.*
361 *Broadway, New York City.* *Per year* $3.00.

Science and Industry. [*Scien. and Indus.*] *Monthly.*
Scranton, Pennsylvania. *Per year* $1.00.

Shooting and Fishing. [*S. and Fish.*] *Weekly.*
293 *Broadway, New York City.* *Per year* $3.50.

The Spanish War Journal. [*Span. War Jour.*] *Monthly.*
320 *Indiana Ave., Washington, D. C.* *Per year* $1.00.

Technology Quarterly. [*Tech. Quart.*] *Quarterly.*
Mass. Inst. of Tech., Boston, Mass. *Per year,* $3.00.

Telephone Magazine, [*Tel. Mag.*] *Monthly.*
Marquette Building, Chicago, Ill. *Per year* $1.00.

Transactions American Institute of Electrical Engineers.
26 *Cortlandt Street,* [*Trans. Inst. Elec. E.*] *Monthly.*
New York City. *Per year* $5.00.

Transactions American Institute of Mining Engineers.
99 *John Street,* [*Trans. Inst. Min. E.*]
New York City.

Transactions of the American Society of Civil Engineers.
220 *West 57th Street,* [*Trans. A. S. C. E.*]
New York City.

Transactions of the American Society of Mechanical Engineers.
12 *West 31st Street,* [*Trans. A. S. Mech. E.*]
New York City.

Transactions of the Society of Naval Architects and Marine Engineers.
12 *West 31st Street,* [*N. A. and Marine Eng'rs.*]
New York City.

United Service. [*U. Serv.*] *Monthly.*
49 *Wall Street N. Y. City.* *Per year* $3.00.

Western Electrician. [*West. Elec.*] *Weekly.*
510 *Marquette Building, Chicago, Illinois.* *Per year* $3.00.

World's Work. [*World's Work.*] *Monthly.*
34 *Union Square East, New York City.* *Per year* $3.00.

[Periodicals of April, May, June, 1903.]

ARTILLERY MATERIAL.

The use of wooden axles and their proper designing for military transport and carriages.—**Kriegstech.**, 4, 1903.
Field guns of the Skoda works.—**S. M. Blaetter**, April, May.
Ammunition supply of the French field artillery.—**S. M. Blaetter**, April.
General Rohne on guns recoiling on carriage.—**S. M. Blaetter**, April.
Shrapnel vs. explosive shell.—**Cientifico**, March 15, April 1, 15, May 15.
The new field material of the Swiss artillery.—**R. M. Suisse**, May.
The re-armament of the Swiss artillery.—**S. M. Blaetter**, May.
The 75 mm. R. F. field artillery material, Nordenfelt system.—**A. Belge**, March–April.
Present day field guns.—**Beiheft zum M. W.**, 4, 1903.
The field gun of 1903.—**Proc. R.A.I.**, January-March; **U.S. Gaz.**, June 13, 20.
Turkish field howitzers in the Graeco-Turkish campaign of 1897.—**Wochenblatt**, May 16.
German 5-cm. field gun and its gunnery trials.—**Sbornik**, April.
Ship armor and its attack.—**U. Serv. Mag.**, April.
Krupp works at Essen.—**Scien. Amer.** Supplement, May 9, 16.
Steel for projectiles.—**R. Artig.**, April.
Tests of the efficiency of hoisting tackle.—**Eng'ing News**, June 11.
Paint as a preservative of iron from rust.—**Eng.**, May 22.
Development of projectile fuzes in the Prussian artillery.—**Kriegstech.**, 5, 6, 1903.
Considerations on the choice and use of explosives in war.—**M. de Art.**, March.
Classes of powder and their application in war.—**M. de Art.**, April, May.
New safety explosive.—**Proc. A. S. C. E.**, May.
Krupp telescopic sight for field guns.—**R. Artillerie**, May.
Grenfells sighting and signalling gear.—**Seewesens**, 5, 1903.
Major Ghenea's sight for field guns and field howitzers.—**Kriegstech.**, No. 5, 1903; **R. M. Suisse**, June.
The panoramic telescopic sight.—**R. M. Suisse**, May; **S. M. Blaetter**, May; **R. Artillerie**, May.

AUTOMOBILES, BICYCLES, AEROSTATION.

The "Lebaudy" airships.—**Genie C.**, June 13.
Observation war kites.—**Scien. Amer.**, June 13.
The tetrahedral principle in kite construction.—**Scien. Amer.** Supplement, June 13.
The kite principle in aerial navigation.—**Scien. Amer.**, June 27.
The Serpollet steam automobile.—**Scien. Amer.** Supplement May 16, 23; June 13.
Mechanical road traction and its application to military transport.—**R. M. Suisse**, May.
Some motor car works.—**Eng.**, May 8, 29.
Columbia electric 5-ton truck.—**Iron Age**, June 25.

BALLISTICS.

The probability of effective hitting in batteries with shields.—**Kriegstech.**, 4, 1903.
Methods for determining the position of the axis of projectiles at the end of the trajectory.—**Kriegstech.**, 4. 1903.

Method and rules for fire from coast batteries.—**M. de Art.**, April.

Determination of the position of targets in fortress warfare by means of angular measurement.—**R. Artig.**, April.

CHEMISTRY AND PHOTOGRAPHY.

Combustion and combustibles.—**R. de Mar.**, March, April.

Radium.—**Memoires I. C.**, March; **Soien Amer.** Supplement, May 30.

Radium and other radioactive substances.—**Scien Amer.** Supplement, May 30; **Trans. Inst. Elec. E.**, May.

Color photography.—**Scien. Amer.** Supplement, May 9,

Stereoscopic distortion.—**Photo. Jour.**, April.

Action of the violet and ultra violet in photography.—**Photo. Jour.**, April.

Application and aims of photography for use in the navy.—**Seewesens**, VI, 1903.

Stevens electro-photographic printer.—**West. Elec.**, May 23.

Intensification and reduction.—**Scien. Amer.**, June 27.

Simple emulsion for matt or printing out paper.—**Scien. Amer.** Supplement, July 4.

DRILL REGULATIONS, MANEUVERS AND PRACTICE.

New firing regulations for field batteries.—**M. de Art.**, March.

A point in the new French infantry firing regulations.—**Monde**, April 1.

Embarkation of guns on pontoons.—**Jour. U. S. I. India**, April.

Musketry.—**U. Serv. Mag.**, June.

Battle principles of the new French drill regulations for infantry.—**Armee**, May 8.

Physical education in the army.—**A. Belge**, March-April.

Conduct of field exercises.—**A. & N. Jour.**, June 13.

Physical culture in the army.—**R. Univ.**, June.

Provisional infantry drill regulations, France.—**S. M. Blaetter**, May; **Cercle**, July 4.

A judging distance "gim".—**Proc. R. A. I.**, January-March.

Method of obtaining the correct line of fire, when observation is from a flank.—**Proc. R. A. I.**, Jan.-March.

A target for aiming tube practice from light Q. F. guns for use in a drill-shed.—**Proc. R. A. I.**, Jan.-March.

Aids to instruction in fighting a coast battery.—**Proc. R. A. I.**, Jan.-March.

Point of direction on the march and changes of front in infantry drill.—**Wochenblatt**, May 5, 30.

Considerations on the new French firing regulations.—**A. S. M. Zeit.**, May 9.

Training and instruction of commanders and the new field artillery armament.—**A. S. M. Zeit.**, June 13.

Battle training of the Sotnia.—**Sbornik**, April, May.

Fleet and landing maneuvers in the northern Adriatic, 1902.—**Organ**, lxvi, 3.

Garrison maneuvers.—**Belgique M.**, April 26, May 17, 24, June 28.

Blockade maneuvers of the English fleet before Argostoli in 1902.—**Rundschau**, May.

Experiments on snow by the I. Italian army corps (parapets, marches over, and snow bivouacs).—**Kriegstech** 5, 1903; **R. Inf.**, May, June.

French Alpine maneuvers in Haute-Savoie, 1902.—**Armee**, May 22.

The First Brigade in the cavalry maneuvers, September, 1902.—**R. M. Suisse**, May.

Imperial grand maneuvers in Koursk, 1902.—**R. M. Etrang**, May, June.
Japanese grand maneuvers, 1902.—**Cercle** June 6.
French general staff on German maneuvers, 1902.—**Wochenblatt**, May 21.
Organization and execution of the grand maneuvers in Germany, Austro-Hungary, France and Italy in 1902.—**Sbornik** April.
French grand maneuvers, 1903.—**A. Marine**, June 28.
The training of our torpedo flottillas.—**U. Serv. Mag.**, April.
Naval gunnery.—**Eng.**, May 15, June 5.
Test of a battleship's turret.—**Eng.**, May 15.
Gunnery in the English navy,—**R. de Mar.**, March.
Target practice in Switzerland.—**Cercle**, June 20.
Prize shooting in fighting formations.—**Wochenblatt**, May 9.
Musketry training.—**Wochenblatt**, May 28; **A. & N. Gaz.**, June 20.

ELECTRICITY.

Lodge-Muirhead system of wireless telegraphy.—**Page's Mag.**, May.
The "speaking" arc-light and its application in wireless telegraphy.—**Kriegstech.**, 4, 1903.
Development of Marconi's system of wireless telegraphy.—**Scien. Amer.** Supplement, May 9.
Telegraphy and telephony.—**Zeitschr. I. A. V.**, June 5, 12.
Telegraphic communications of the world.—**R. de Mar.**, April.
Phelps printing telegraph system.—**West. Elec.**, May 30.
A new telephone receiver.—**West. Elec.**, May 30.
The designing of telephone apparatus.—**Elec. Rev.**, May 16, 23, June 6.
Some problems in space telegraphy.—**Elec. Rev.**, May 16.
Clark space telegraph system.—**West. Elec.**, May 16.
Branly Popp aerial telegraph system.—**Elec. World**, May 16.
Magneto bell troubles and their remedies.—**Tel. Mag.**, May.
Common battery systems.—**Tel. Mag.**, May.
Proper switchboard circuits with apparatus.—**Tel. Mag.**, May.
Ruhmer's system of light telephony.—**Scien. Amer.**, June 6.
Collins wireless telephone.—**Elec. World**, June 20.
Simultaneous telegraphy and telephony.—**Elec. World**, June 20.
Gruhn telechirograph for transmission of handwriting.—**Elec. World**, June 20; **Scien. Amer.**, July 4.
Hertzian wave wireless telegraphy.—**Pop. Sc. Mo.**, June, July.
Fessenden space-telegraph inventions.—**West. Elec.**, May 23.
The Crompton potentiometer for electrical measurements.—**Scien. Amer.** Supplement, May 16.
On electrons.—**Scien. Amer.** Supplement, May 16, 23, 30, June 6, 13, 20; **West. Elec.**, May 9.
The properties and applications of selenium.—**Scien. Amer.** Supplement, May 30.
Firing guns by electricity.—**Boletin**, April.
Insulating materials.—**Elec. Rev.**, May 9.
Electricity in the shop—the generator.—**Amer. Manfr.**, June 25.
Testing of insulators.—**Trans. Inst. Elec. E.**, April.
Methods of speed control.—**Trans. Inst. Elec. E.**, April.
Methods of combining resistances.—**Elec. Rev.**, June 20, 27.
Divided multiple switchboards.—**West. Elec.**, June 20.

Paralleling alternators.—**West. Elec.**, June 20.
Lifting electromagnets.—**Elec. World**, June 13.
The new radiations, cathode rays and Roentgen rays.—**Scien. Amer.** Supplement, July 4.
Mietz and Weiss portable electric light plant.—**Iron Age**, May 28.
Safety devices in central stations and sub-stations.—**Elec. Rev.**, May 2, 9.
Multiple vs. independent operation of units and central stations.—**Elec. Rev.**, May 9.
The development and use of the small electric motor.—**Eng'ing. Mag.**, June, July.
Field coil formulas.—**Elec. World**, May 16.
The storage battery in transmission plants.—**Elec. World**, May 16.
Failure of direct-current dynamos to generate.—**Amer. Elec.**, May.
Life of storage batteries.—**West. Elec.**, June 13.
Dynamo-regulation testing.—**Eng. Cleve.**, July 1.

ENGINEERING AND FORTIFICATIONS.

Note on testing cables.—**Memories I. C.**, March.
Application of armored cement.—**Eng. Mil.**, March.
Construction and working of a standard railroad at the camp of Chalons, 1902.—**Genie M.**, May, June.
The Phodograph; an automatic topographical instrument.—**Genie M.**, May.
Armored beton.—**Genie M.**, May.
Armored cement for barrack fittings.—**R. Artig.**, April.
Equipment of the French bridge thains with new material.—**Kriegstech.**, 6, 1903.
Portable field bridge equipage for rapid constructions.—**Kriegstech.**,6, 1903.
New system of finishing concrete structures.—**Eng'ing News**, May 21.
Design and cost of slope walls.—**Eng'ing News**, June 11.
Experiments on the strengths of different makes of hoisting hooks.—**Eng'ing News**, June 25; **Iron Age**,, July 2.
The new Coast and Geodetic Survey precise level.—**Eng'ing News**, July 2.
The most useful engineering books.—**Amer. Mach.** June 18.
Enlargement of Antwerp.—**A. Belge**, March-April.
Field entrenchments.—**Ueberall**, 37, 1903.
Increasing the strength of the German fortifications of the upper Rhine.—**A. S. M. Zeit.**, May 23.
The fortifications of St. Petersburg.—**Sbornik**, May.
Remarks on field fortifications.—**Sbornik**, May.

ENGINES, BOILERS AND MECHANISM.

Some tests of boiler and furnace efficiencies.—**Eng'ing. News**, June 11; **Elec. Rev.**, June 13.
Fuel combustion and boiler efficiency.—**Amer. Manfr.**, June 11.
Some observations on gas engine ignition. **Amer. Manfr.**, May 21.
The gas engine.—**Eng. Cleve.**, May 15.
Gasket and insulation troubles in gas engines.—**Scien. Amer.**, May 16.
The Ostergren fuel oil engine.—**Scien. Amer.**, June 6.
A new oil engine.—**Amer. Manfr.**, June 25.
The Hornsby-Akroyd oil engine.—**Eng. and Min. Jour.**, May 30.
The Britannia oil engine.—**Eng'ing.**, June 10.
The Kynoch-Forward oil engine.—**Eng'ing.**, June 10.
The Mietz and Weiss kerosene engine.—**Eng. Cleve.**, July 1.

A simple kerosene engine.—**Scien. Amer.**, May 23.
The steam turbine.—**R. Maritt.**, March.
Recent progress in steam engines.—**Memoires I. C.**, April.
The Curtis steam turbine.—**Eng. Cleve.**, May 1; **Amer. Elec.**, May; **Elec. World**, May 23.
American steam engines for electric light and power service.—**Amer. Elec.**, June.
Corliss and other steam engines.—**Eng. Cleve.**, June 15.
Value of indicator diagrams in complicated engine diagnoses.—**Amer. Manfr.**, June 4.
Reid ball bearing.—**Iron Age**, June 4.
The safety valve.—**Amer. Manfr.**, May 28.

METALLURGY.

New armor-plate mill at Creusot.—**Amer. Manfr.**, May 21; **Eng'ing.**, May 1.
The continuous open-hearth process.—**Amer. Manfr.**, June 4, 11; **Eng'ing.**, May 15.
A modern iron foundry.—**Stahl u. Eisen**, June 1.
Malleable cast iron.—**Eng'ing. News**, June 11; **Iron Age**, June 11; **Amer. Manfr.**, June 25, July 2.
The color test in high carbon steels.—**Iron Age**, June 11.
Electric furnace methods of iron and steel production.—**Elec. Rev.**, June 6.
Some ideas on the theory of tempering steel.—**M. de Art.**, March, April, May.
Researches on nickel steel.—**Genie C.**, May 2, 9, 16.
Production of steel by electric furnaces —**Memoires I. C.**, March.
Hollow pressed axles.—**Scien. Amer.** Supplement, May 16; **Stahl u. Eisen**, May 15; **Eng'ing.**, May 15.
The electric furnace.—**Cas. Mag.**, June.
Steel works of Firminy (France).—**R. G. de Marina**, June.
Some new researches on nickel steels.—**Genie C.**, June 27.

MILITARY GEOGRAPHY.

The question of Morocco.—**R. Univ.**, May, June.
The harbor of London.—**Rundschau**, April.
The territory of Acre.—**R. Mil. Brazil**, April.
The Dortmund-Ems canal.—**Zeitschr. I. A. V.**, May 1.
Russia.—**U. Serv. Mag.**, June.
Projected canal from the Baltic to the Black Sea.—**Genie C.**, June 6.
The Siberian railroad and the Russian field of operations in Eastern Asia. —**Beiheft zum M. W.**, 4, 1903.
Question of a Central American canal.—**Seewesens**, VI, 1903.
Canal uniting the Atlantic and Mediterranean.—**Cercle**, June 13, 20, 27, July 4.
Port Arthur, Dalny and Vladivostock.—**Rundschau**, June.
On the military importance of a direct railway from Florence to Bologna. —**R. Artig.**, April.
New railways in southeast Africa.—**Amer. Manfr.**, June 4.
Dover harbor works.—**Eng'ing.**, June 12; **Eng.**, June 19, 26; **Scien. Amer.**, June 27.

MILITARY HISTORY.

History of the artillery.—**R. Univ.**, May, June.
Spanish domination in Algeria and Morocco.—**R. Univ.**, May.

Report of the commission on the selection and transport of war material from the Philippines.—**M. de Art.**, March, April, May.
Count Albrecht v. Roon, Royal Prussian Field Marshal.—**Beiheft zum M. W.**, 4, 1903: **Rundschau**, April.
Ziethen's diary of the campaign of 1815.—**Jahrbucher**, April.
De Ruyter.—**Rundschau**, April.
Expedition of a corps of Indian troops from Bombay to the Mediterranean, 1878.—**Rundschau**, April.
Recruiting in the Low Countries in 1681.—**U. Serv. Mag.**, April.
A chief of cossacks in the campaign of 1813.—**R. Cav.**, April, May, June.
The Somaliland expedition.—**A. and N. Gaz.**, May 16.
Events in Somaliland.—**Cercle**, May 2, 16.
Napoleon as a general.—**Jour. U. S. I. India**, April.
Napoleon, chief of the army.—**Cientifico**, March 15, April 1, May 1, 15.
The Thirty Years' war, 1618-1648.—**Exercito**, April, May.
A new contribution to the history of the war of 1815.—**Wochenblatt**, April 30.
The battle in the Froeschweiler forest, August 6, 1870.—**Wochenblatt**, May 2.
How Prussia prepared her revenge.—**R. Inf.**, May, June.
Campaign in China.—**R. Univ.**, June.
Washington at Valley Forge.—**U. Serv.**, June.
Letters from Somaliland.—**U. Serv. Mag.**, May.
Historical examples of sieges from the Franco-German war, 1870-71.—**Proc. R. A. I.**, March.
Studies on the South African war.—**R. M. Etrang.**, May, June.
The military aeronauts (balloonists) during the wars of the Revolution.—**Genie M.**, May.
Military insurrections in 1790, France.—**Cercle**, May 30.
Spanish-American war, 1898.—**Ueberall**, 37, 38, 39, 1903.
Affairs of Figuig (with maps).—**A. Marine**, June 14, 21.
French expedition against Figuig.—**Ueberall**, 40, 1903.
Campaigns against India from the West and through Afghanistan.—**Jour. R. U. S. I.**, May.
History of war and tactics.—**Wochenblatt**, May 5.
Expedition of the English against Denmark, 1801 and 1807.—**Wochenblatt**, May 7.
Various criticisms of the tactical events of the campaign of 1859.—**Wochenblatt**, May 7, 9.
Fight at Stormberg, December 10, 1899.—**Wochenblatt**, May 12.
Addenda to battle of Vionville-Mars-la-Tour.—**Wochenblatt**, May 14.
From the Spanish-American war.—**A. S. M. Zeit**, May 2.
Battle of Inkerman and the defence of Sebastopol.—**Sbornik**, April, May.
The war of 1877-78.—**Sbornik**, April, May.
Spanish-American war in the Philippines.—**R. Maritime**, May.
Glance at the South African war.—**R. M. Suisse**, June.
Retreat on Sedan.—**R. Cav.**, May, June.
Episode of the campaign of 1801.—**R. Mil. Portugal**, May 31, June 15.
Service of the military engineers in France during the reign of Louis XIV.—**Genie M.**, June.
Military and naval losses in the American Revolution.—**Penn. Mag.**, April.
An Elizabethan army.—**Scien. Amer.** Supplement, June 13.
The Imperial navy during the disturbances in China, 1900-1901.—**Rundschau**, May.

MILITARY SCHOOLS.

ORGANIZATION AND ADMINISTRATION.

General officers of the French army, 1902.—**Wochenblatt**, April 30.
The Belgian army.—**Ueberall**, 33, 1903.
The formation of a general staff, U. S.—**Wochenblatt**, May 2.
The British army, 1902.—**U. S. Gaz.**, May 30.
The canteen abroad.—**A. and N. Reg.**, June 13.
"Mobile men" (mounted infantry or cavalry?).—**A. and N. Gaz.**, June 6.
American cavalry.—**U. Serv.**, June.
Imperial defence and colonial responsibilities.—**U. Serv. Mag.**, May.
Importance of fortress warfare and the organization of engineers.—**R. M. Etrang**, May, June.
Organization of fortress artillery, Belgium.—**Belgique M**, May 17.
The English nation and its army.—**Cercle**, May 30, June 6.
New staff organization, Russian army.—**Cercle**, June 13.
English army considerations.—**Ueberall**, 36, 1903.
Organization of the nation for defence.—**Jour. R. U. S. I.**, May.
Service on lines of communication of the French mobile army.—**Wochenblatt**, May 5, 7, 9.
Re-organization of the Russian general staff.—**Wochenblatt**, May 16.
Changes in regulations of March 16, 1882, concerning administration of French army.—**Wochenblatt**, May 19.
New re-mount system for the Russian field artillery.—**Wochenblatt**, May 21.
Army commanders in piece and war.—**A. S. M. Zeit.**, April 25.
Re-organization of the military departments, Switzerland.—**A. S. M. Zeit**, May 30, June 6.
Organization of the Brazilian army.—**R. Mil. Brazil**, May.
Regulations for the staff, Argentine army.—**R. Mil. Brazil**, May.
The Servian army.—**U. S. Gaz.**, June 20; **Ueberall**, 39, 1903.
Fortress troops in peace time.—**Kriegstech**, 6, 1903.
Servian army.—**A. Marine**, June 28.
The coming general staff.—**Jour. M. S. I.**, July-August.
Our military judicial system.—**Jour. M. S. I.**, July-August.
Cavalry of the future.—**R. Cav.**, June.
The Turkish officer.—**U. S. Gaz.**, June 13.
The Japanese army.—**Ueberall**, 39, 1903.
Service and discipline on our warships.—**R. Marit. Brazil**, April, May.
How the efficiency of our fleet may be increased without new naval accessions.—**R. de Mar.**, April.
Work of the Admiralty staff for 1900-01.—**Wochenblatt**, May 7.
Promotion of naval officers.—**R. Marit. Brazil**, May.
Law of re-organization of naval service.—**R. de Mar.**, March.
Contribution to the study of the question of engineers.—**Marine F.**, April 15, May 15.
English naval budget 1903-04.—**Rundschau**, April; **Seewesens**, VI, 1903.
The Indian defence squadron.—**U. S. Gaz.**, May 2.
Australian naval defense.—**Rev. Austral.**, April.
Great Britain's naval supremacy.—**Cas. Mag.**, June.
The struggle for sea power.—**A. and N. Gaz.**, May 16.
Organization of naval reserves.—**R. G. de Marina**, May, June.
Report of the English manning committee.—**Rundschau**, May.
Final settlement of the French naval budget, 1903.—**Rundschau**, May.
The Royal naval reserve.—**U. Serv. Mag.**, June.
Colonies and English naval expenses.—**A. Marine**, May 24.

Two rival navies (U. S. and Germany).—**Yacht,** May 30.
Proposed naval general staff, U. S.—**A. and N. Jour.,** June 13; **A. and N. Reg.,** June 13.
Naval officers (memorandum on their appointment, instruction and assignment, etc.)—**Boletin,** February-March.
Australia and naval defence.—**U. Serv. Mag.,** May.
The control and administration of the navy.—**R. Maritime,** April, May.
New English naval training.—**Ueberall,** 37, 1903.
The German naval engineer.—**U. S. Gaz.,** June 13; **Eng'ing,** June 5.
Naval administration.—**A. and N. Gaz.,** May 30; **Eng'ing.,** June 12.
The problem of engineers.—**Naval Inst.,** June.
Naval intelligence during war.—**Naval Inst.,** June.
The need of a building program for our navy.—**Naval Inst.,** June.
Engineering efficiency in the navy.—**A. and N. Jour.,** June 27.

SMALL-ARMS AND EQUIPMENTS.

Modern cartridge loading.—**Arms and Expl.,** May.
The lance in war.—**A. and N. Gaz.,** April 25.
The sword—lance.—**Jour. U. S. I. India,** April.
The new uniform and equipment of the Norwegian infantry.—**Ueberall,** 33, 1903.
Telescopic sights.—**Arms and Expl.,** June 2.
The modern express rifle.—**Arms and Expl.,** June 2.
Uniform and equipment reform in the Swiss infantry.—**Beilage, A. S. M. Zeit.,** 2, 1903.
Considerations on automatic weapons.—**A. Belge,** March-April.
The extended use of Mauser guns and Maxim machine guns.—**Ueberall,** 38, 1903.
Repeating pistols.—**M. de Art,** May.
Equipment of the sapper.—**R. M. Suisse,** June.
Suppression of the lance in the English army.—**Cercle,** June 27.
Battle sights.—**Kriegstech,** 6, 1903.
The army uniform and its protection.—**Jour. M. S. I.,** July-August.
Automatic repeating rifle.—**S. and Fish.,** May 21.
British army rifles.—**S. and Fish.,** May 14.
German fire-arms.—**S. and Fish.,** May 14.
Revolver sights.—**S. and Fish.,** June 4.
New Springfield magazine rifle.—**Scien. Amer.,** June 6.
Lance sword and carbine.—**A. and N. Gaz.,** May 30.
Some aspects of the new British and Springfield rifles.—**S. and Fish.,** June 25.
The target of the future.—**Can. Gaz.,** June, 2, 16.

STRATEGY AND TACTICS.

Capability of defense of the Russian western frontier.—**Jahrbucher,** April.
Question of Morocco from a German point of view.—**Marine F.,** April 15.
Strategic positions of England in the Caribbean sea.—**Marine F.,** April 15.
Strategy and tactics in mountain ranges.—**U. Serv. Mag.,** April, May, June.
Strategical deployment of the Germans in 1870.—**R. Cav.,** April.
Strategical importance of Bizerte (with map).—**A. Marine,** May 10.
The value of fortified positions in field warfare.—**Wochenblatt,** May 2, 5.
Persia and the Anglo-Russian duel.—**Marine F.,** May 15.
A new military station in Alsace-Lorraine.—**Ueberall,** 38, 1903.

Skirmishing.—**U. Serv. Mag.**, May.
Tactical problems.—**Belgique M.**, May 31, June 14.
Military technique and tactics.—**Kriegstech.**, 6, 1903.
An old problem and its solution (supply of ammunition in battle).—**Jour. M. S. I.**, July-August.
Cavalry divisions and field batteries with shields.—**Ueberall**, 39, 1903.
Superiority of fire.—**A. S. M. Zeit.**, June 20.
On infantry fire.—**A. S. M. Zeit.**, June 27.
Naval tactics.—**R. G. de Marina**, May, June.
Russian views on submarine warfare.—**Eng.**, May 15.
Fire control in warships.—**A. and N. Gaz.**, June 6.
Tactics of the German navy.—**Yacht**, June 20.
Notes on naval military art.—**R. de Mar.**, April.
Disembarkations.—**Wochenblatt**, May 19.

SUBMARINES, TORPEDO BOATS AND WARSHIPS.

The French submarines in 1903.—**Yacht**, May 9.
American submarines: the Adder and the Mocassin.—**R. Maritime**, April.
On the use of submarines.—**R. Maritt.**, April-May.
Submarines.—**R. Marit. Brazil**, May.
Submarine war engines.—**Iron Age**, May 7.
Submarines—peace, war and exploration.—**Mar. Rev.**, May 21.
Torpedo boat destroyer Rapiere.—**Yacht**, June 20.
U. S torpedo boat destroyers Truxton, Whipple and Worden.—**A. S. N. Engrs.**, May.
The German 4th class cruiser Frauenlob.—**Yacht**, April 11.
Naval scouts.—**U. Serv. Mag.**, April.
Relative importance of offensive and defensive qualities in men-of-war.—**Page's Mag.**, May.
Launch of Argentine cruiser Moreno.—**Scien. Amer.** Supplement, May 9.
Battleship Henri IV.—**Yacht**, May 9.
English battleship Commonwealth.—**Yacht** May 30.
Naval notes on construction and armament.—**Page's Mag.**, May, June.
Description of the turrrets for 24-cm. guns of the Princess Asturias type of cruisers.—**R. G. de Marina**, April, May, June.
Advances made in American warships during the last twelve years.—**R. G. de Marina**, June.
The warship of the future.—**Boletin**, April.
Gun power in warships.—**Seewesens**, VI. 1903.
Battleship Charles Martel.—**Seewesens**, VII, 1903.
Coast-defense battleship Indomptable.—**Yacht**, June 13.
German battleship Zaehringen —**Yacht**, June 20.
Strength and composition of a modern fleet.—**Sbornik**, April.
Russian school ship Ocean.—**Schiffbau**, June 23.
Armor protection of battleships.—**A. Marine**, June 28, July 5.
Comparison of the German battleship Wettin with the Maine.—**Scien. Amer.**, June 13.
H. M. S. Commonwealth.—**Eng.**, May 22, 29.
Proposed armament for type battleship U. S. Navy, with suggestions on armor protection.—**Naval Inst.**, June.
Spanish armored cruiser Cardenal Cisneros.—**Eng.**, June 5.

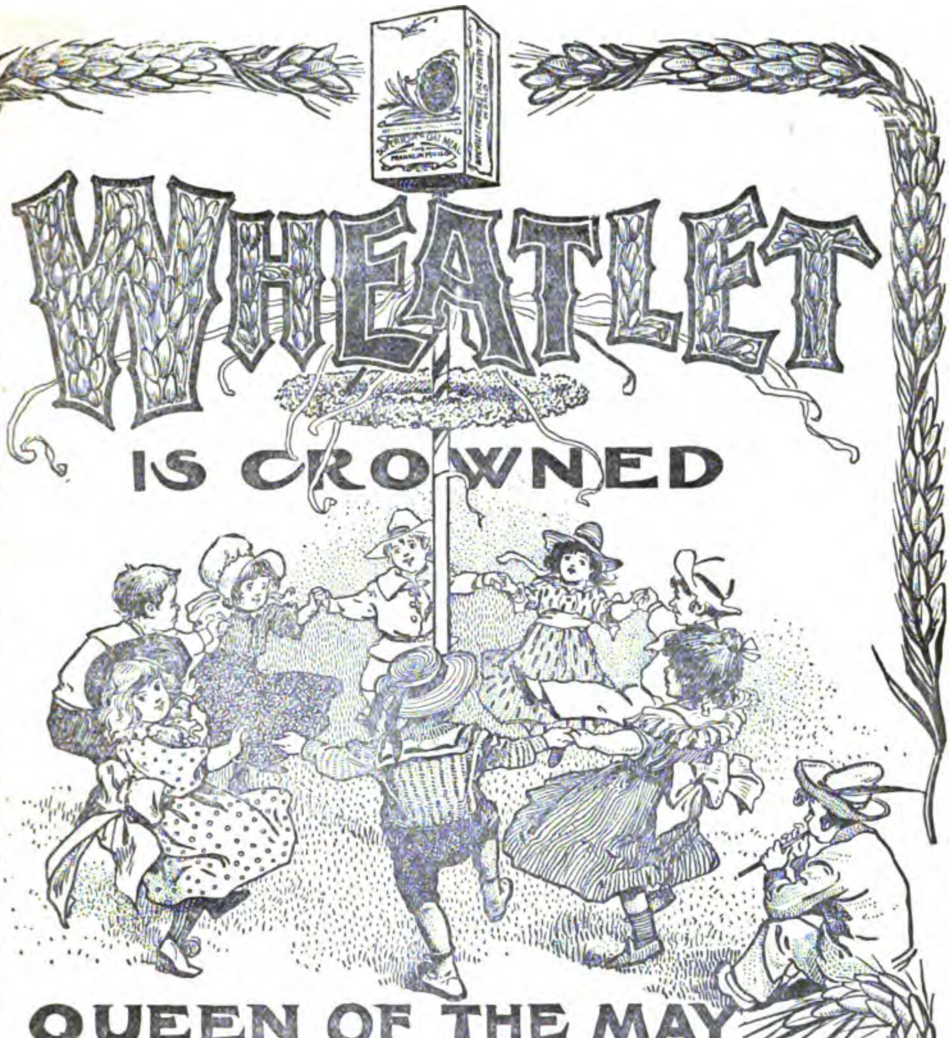
CORRECTIONS.

Whole number 61, May-June, 1903, (vol. XIX., No.3) :—

Page 307, 3rd paragraph, 2d line. "Five ranges" should read "six ranges," and the numbers in the parenthesis should then read "500, 1000, 1500, 2000, 2500, 3000 yards."

Whole number 62, July-August, 1903.

Page 55. 6th line from bottom of page. "mobilized" shoull read "immobilized."



There's more vitality lost in development of heat energy to digest "all ready-cooked foods" than analysis shows they contain, and you pay the same price for only twelve ounces as you do for two full pounds of

Absolutely the most strength-giving cereal on the market. Children crave its deliciousness.

Know what you eat by sending postal, with grocer's name, for copy U. S. Gov't official cereal analysis, free.

The Franklin Mills Company,

"All the Wheat that's Fit to Eat."

729 Franklin Square, **LOCKPORT, N. Y.**

OCEAN VIEW

THE ATLANTIC CITY OF THE SOUTH

Nine miles from the City of Norfolk, 20 minutes from Old Point.
Boat leaves Old Point 20 minutes after the [illegible]

BOATING! BATHING!! FISHING!!!

Varied Amusements.

HIGH CLASS ATTRACTIONS IN CASINO.

BAND CONCERTS. DANCING.

OCEAN VIEW HOTEL.

EXCELLENT CUISINE.

NORFOLK'S STORES CATER TO ARMY OFFICERS.

[illegible]

STOCK

CHINA, GLASSWARE,

LAMPS, BRIC-A-BRAC,

[illegible]

SILVERWARE

AND CUTLERY.

DINNER SETS,
TOILET SETS

[illegible] BELOW COST [illegible]

[illegible]

NEW STOCK.

JOHNSTON'S,

[illegible]

NORFOLK, VA.

Take a Sea Trip

[illegible]

COMFORT, PLEASURE, and RECREATION

Merchants and Miners Trans. Co.

"QUEEN OF SEA ROUTES"

[illegible]

SEPTEMBER–OCTOBER.

Vol. XX. No. 2. Whole No. 63.

[illegible]

JOURNAL

OF THE

UNITED STATES ARTILLERY

[illegible]

ARTILLERY BOARD.

FORT MONROE, VA.
ARTILLERY SCHOOL PRESS.
[illegible]

[illegible]

The **JOURNAL OF THE UNITED STATES ARTILLERY** is published, as a bi-monthly, at Fort Monroe, Virginia, under the direction of the Artillery Board.

MANAGER AND EDITOR.

Captain ANDREW HERO, JR., Artillery Corps.

Subscription	$2.50
For countries in the postal union	$3.00
Single numbers	$0.50

All remittances should be made payable to **Journal of the U. S. Artillery.** These and communications relating to the editorial management should be addressed **Editor Journal U. S. Artillery, Fort Monroe, Virginia.**

AGENTS.

NEW YORK — *Dyrsen & Pfeiffer*, successors to
F. W. Christern, 254, 5th Avenue.

LONDON — *B. F. Stevens & Brown*, 4 Trafalgar Square.

ADVERTISING DEPARTMENT.

All communications in regard to advertising should be addressed to **Mr. Frank St. Clair, Box 799, Norfolk, Va.,** who has complete charge of this department.

HARVARD COLLEGE LIBRARY
OCT 30 1913
CAMBRIDGE, MASS.

JOURNAL
OF THE
UNITED STATES ARTILLERY.

VOL. XX. NO. 2. SEPTEMBER—OCTOBER 1903. WHOLE NO. 63.

STABILITY TESTS FOR NITROCELLULOSE AND NITROCELLULOSE POWDERS.

BY ALBERT P. SY, M.S.
ASSISTANT CHEMIST, ORDNANCE DEPARTMENT, U. S. ARMY.
Frankford Arsenal.

Stability tests, sometimes also called "heat tests," are applied to explosives to determine their keeping qualities, or chemical stability. The manufacturer also uses some stability tests, during manufacture, to determine if his product has been thoroughly purified.

That the stability of an explosive is of the utmost importance must be apparent, and it explains why government and explosives chemists have been and are making an exhaustive study of the methods for stability testing. Although a great deal of work has been done in this direction, yet the best methods in use today are still far from ideal. The fault lies in the fact that the general cause or causes of instability of explosives have not been established.*

In the early stages of nitro-explosives manufacture, instability was frequently caused by traces of nitrating acids left in the finished product. Today, with improved methods and apparatus, insufficient purification is not the most frequent cause of instability. But, even if purification be perfect, it has been found† that normal products, perfectly purified, may become unstable.

Among the known causes of instability are the following:

(1) Traces of nitrating acids left carelessly by the manufacturer. (Rare.)

* Luck & Cross. Jour. Soc. Chem. Ind., 1900, p. 642.

† Guttmann: Zeitschr. f. Angew. Ch. 1897, p. 233.

(2) Substances added to powders to increase stability sometimes have the reverse effect. For example, alkalies, added to powders for the purpose of neutralizing traces of nitrating acids or acids which might be formed from decomposition of an unstable powder, may cause saponification or decomposition of the nitrocellulose itself. The value of alkalies for increasing stability is a disputed point.* Saponification may be caused by water. A sample of pure nitroglycerin kept in distilled water has been known to develop acidity.†

(3) Local decomposition may be set up in a powder by careless treatment and handling.

(4) Exposure to higher than usual temperatures, during drying or storing.

(5) Cotton wool always contains, even after careful cleaning, small quantities of organic substances other than cellulose.‡ These are nitrated together with the cellulose, forming nitro-compounds which are quite unstable; they can not be removed by ordinary processes of washing or solution.§ These unstable compounds may cause decomposition of the nitrocellulose.

(6) Various investigators‖ hold that even a perfectly pure product may decompose slowly, spontaneously; the products of such decomposition may act catalytically and thus bring about complete decomposition. According to this view all nitrocelluloses are unstable, or their degree of stability is only relative, depending upon conditions.

(7) Spontaneous combustion of organic compounds is believed to be caused by intramolecular respiration or oxidation, and it seems likely that this might be the cause of spontaneous decompositions of nitrocellulose, even if it be perfectly pure. The nitrocellulose molecule is comparatively large and the atoms loosely held together which would favor decomposition brought about by internal oxidation. The difference in stableness of different nitrocelluloses could easily be explained by slight differences in composition, preparation, handling, and differences in physical properties.

It has been stated¶ that it does not follow that because two substances are stable, a mixture of the two will also be stable;

* Guttmann: Zeitschr. f. Angew. Ch. 1897, p. 233.

† Thomas: Zeitschr. f. Angew. Ch. 1899, p. 55.

‡ Abel: Trans. Roy. Soc., 1866, p. 307.

§ Luck & Cross: Jour. Soc. Ch. Ind., 1900, p. 642.

‖ Hoitsema: Zeitschr. f. Angew. Ch. 1899, p. 705. Luck & Cross: Jour Soc. Ch. Ind. 1900, p. 642.

¶ Guttmann: Zeitschr. f. Angew. Ch. 1897, p. 233.

e. g., a stable nitrocellulose and a stable nitroglycerin when mixed may produce an unstable mixture; in such cases, the mixture is undoubtedly more liable to internal oxidation than are the ingredients before mixing.

(8) It does not seem unlikely that denitrifying bacteria might start a decomposition of nitrocellulose, and preliminary experiments strongly indicate the probability of such decomposition. The possibility of bacteria causing a decomposition and consequently instability of nitrocellulose is conceded (private communications to the writer) by authorities on the subject of denitrifying bacteria. These experiments are to be continued at this laboratory.

Stability tests are always made on explosives at higher than ordinary temperatures of storage. This is done in order to shorten the time required for obtaining results, it having been determined by experiments that the stability of a powder or nitrocellulose decreases as the temperature to which it is exposed increases.* For each method of testing stability it is necessary to know the behavior of a good or standard powder with which to compare results obtained from other powders. On account of the great influence of slight variations in apparatus, reagents or manipulations in making stability tests, the results obtained by any one test, but by different operators, seldom agree.

Following is a brief description of the more important stability tests now in general use: four of these are used officially at this laboratory. None of these tests are entirely satisfactory, as will be seen later. There is also given a description of a new test, developed at this laboratory: this test has been applied to a large number of powders, and has given entirely satisfactory results.

THE POTASSIUM-IODIDE STARCH, OR ABEL TEST. †

This is the oldest and most extensively used stability test for finished products, as well as a purity test used by the manufacturer. It is one of the official tests of the Ordnance Department, U. S. Army, prescribed‡ and made as follows: The sample is prepared by cutting into slices 0.02 inch thick, and then exposed to the air for at least 12 hours.§.

* Sy: Jour. Am. Ch. Soc., June, 1903, p. 562.

† Trans. Roy. Soc., 1865, p. 269.

‡ "Standard Methods of Chemical Tests of Nitrocellulose, etc." Ord. Dept., U. S. Army.

§ Preliminary experiments indicate that better results can be obtained by this test if the samples are prepared by turning off thin shavings in a lathe and exposing to air for 24 hours. In the Navy Department, the samples are prepared by shaving the powder with glass, producing very thin shavings, which are then exposed to 45° C for 48 hours, and then put in a moisture box over night.

In testing nitrocellulose, air-dried samples are taken. 1.3 gram is placed in a test tube (6 x ½ inch) which is then closed by a cork carrying a glass rod, the latter having a hook of platinum wire fused in at the lower end (see fig. 7, A). On this hook there is suspended a strip of KI-starch paper, moistened to one-half its length with a 50 per cent glycerin solution. The position of the test paper in the tube is so adjusted that the line dividing the dry and wet portions of the paper is on a level with the lower edge of the film of moisture expelled from the explosive and deposited on the inside of the tube. The tube is immersed in a in a bath, the temperature of which is regulated to 65.5° C (±1°) for nitrocellulose, and to 100° C (±1°) for smokeless powders (nitrocellulose powders). The bath (see fig. 1) consists of an open water bath in which there is placed a copper vessel containing water or glycerin; the copper vessel has a cover consisting of three perforated and parallel disks about one inch apart. The holes in the upper and middle disk are just large enough to admit the test tubes, while those in the lower disk are smaller. This arrangement serves to hold the tubes all at the same level and in a vertical position and is an improvement over the old form of apparatus usually used in this test.

When the bath has reached the required temperature the tubes with the samples are immersed, and the test begins at this moment; it ends at the appearance of a brown line on the test paper at the juncture of the dry and wet portions. For a good nitrocellulose this discoloration must not take place in less than forty minutes (at 65.5° C) and not less than ten minutes (at 100° C) for a good nitrocellulose powder. Powders containing nitroglycerin should stand this test for twenty minutes (at 65.5° C). The discoloration of the test paper is due to the action of free iodine on the starch, the iodine being liberated from the KI by impurities, or products of decomposition* volatilized from the explosive.

This test as described, or with some slight modifications, is more extensively used than any other. However, it is of most value to the manufacturer, since by careful application of the test he can determine whether his products are thoroughly purified, and the test could be called a "purity test" more appropriately than a "stability test". When applied to finished products, this test has many weak points, as follows:

(1) It shows, in cases of decomposition of the sample during the test, only the beginning and not the continuation of the decomposition.†

---

* Principally nitrogen oxides and acids.

† Will: Mittheilungen a. d. Centralstelle f. wissenschaft. Untersuch. No. II, Dec., 1900.

FIG. 1. Apparatus for KI-Starch Test.

(2) Traces of unstable nitro-compounds (other than nitrocellulose) would show a product in which they are found by this test to be bad; yet these traces of comparatively unstable compounds might not cause a decomposition of the explosive if kept under ordinary conditions. And, considering that there is no indication as to the effect of these traces of unstable compounds, this test does not indicate the keeping qualities of the explosive.

(3) In cases of nitrocellulose powders, this test is affected by the solvents used in making the powders.

(4) The weakest point of this test is that it can be masked by a number of substances which are sometimes added to the explosive for this purpose. Mercury salts, especially mercuric chloride, are most frequently used for this purpose.* According to Thomas,† $HgCl_2$ is reduced to Hg which unites with the oxides of nitrogen, preventing volatilization of the latter, and consequently retards the action on the test paper. A test paper which shows discoloration is readily bleached when exposed to vapors of mercury. Samples of nitrocellulose have been received at this laboratory, which contained traces of metallic mercury which had been added as such, or had been reduced from a mercury salt.

Amines, *e. g.*, urea, have been added to powders in order to mask or lengthen the stability test.‡ Amines react with nitrous fumes as follows:

$$R.\ NH_2 + HONO = R\cdot OH + N_2 + H_2O.$$

Small quantities of alkalies or carbonates are sometimes added to neutralize remaining traces of nitrating acids, and also to combine with nitrous fumes resulting from decomposition.§

Other substances used to mask stability are‖ acetic ether, acetone, oils, vaseline, aniline.

(5) The test is affected by the condition of the sample,¶ size of grains or pieces, whether freshly prepared for testing or exposed to air, and by moisture content.

* "The presence, in a powder, of mercuric chloride, or alkali, or any other substance which might in any way mask or interfere with the heat test (KI-starch) will be sufficient to cause its rejection." Standard Methods of Chem. Tests, Ordnance Dept., U. S. Army.

† Zeitschr. f. Angew. Chem., 1898, p. 1027.

‡ Hoitsema: Zeitschr. f. Angew. Chem., 1899, p. 705.

§ The value of alkalies or carbonates for increasing stability is a disputed point. Guttmann, (Zeitschr. f. Angew. Chem., 1897, p. 233) discourages this practice, contending that the real decomposition of a nitrocellulose soon develops more acid than can be neutralized by the small amount of added alkali. Under some conditions, alkalies saponify and decompose nitro-compounds.

‖ Guttmann: Zeitschr. f. Angew. Chem., 1897, p. 233.

¶ Guttmann: Zeitschr. f. Angew. Chem., 1897, p. 265, found that it required 8½ minutes to heat ground cordite from 12° to 69½° C.

(6) Slight differences in test papers greatly affect the results of this test.* The test papers used by the Ordnance Department are made in large quantities by Eimer & Amend, of New York, according to specifications, thereby insuring greater uniformity than if made at different laboratories in small quantities. Manufacturers who have contracts with the government are supplied with these test papers.

(7) The personal equation of the operator enters as a factor in causing variations. It is no easy matter to decide just when there is "the first appearance of a brown line" on the test paper, or just when the line is of the same intensity as a standard.

From what has been said, it must be apparent that this test has too many weak points to make it a reliable one. The Ordnance Department condemns no powder on results of this test alone.

THE ZINC-IODIDE STARCH TEST.

This is a modification of the test just described, using zinc iodide instead of potassium iodide, and a temperature of 80° C.

Zinc iodide is more sensitive than potassium iodide,† and also acts as a preservative of the test paper. However, a greater sensitiveness is in no way an improvement of the KI-starch test, and results obtained at this laboratory show that it is no more reliable than the original, having all the weak points of the latter.

THE GUTTMANN DIPHENYLAMIN TEST.‡

Instead of using potassium or zinc iodide test papers, Guttmann recommended a paper moistened with a solution of diphenylamin in sulphuric acid. He claimed for his test the following advantages over the KI-starch test:

(1) Not as sensitive.

(2) Test papers more easily prepared.

(3) Masking substances do not interfere as much.

The temperature used is 70° C, and nitrous fumes turn the colorless paper to a greenish-yellow and finally blue.

Thomas says§ the diphenylamin test is unsatisfactory; it may be masked by adding diphenylamin to the explosive to be tested. Guttmann himself admits that the blue color sometimes fails to appear. Moisture in the sample affects the test. Thomas as well as others failed to get a sharp end reaction. The test was

* Cullen: Jour. Soc. Chem. Ind., 1901, p. 8.

† Guttmann, in "Ch. Tech. Untersuchungsmethoden" Lunge, II p. 492, says zinc iodide test paper is about ⅓ more sensitive than potassium iodide paper.

‡ Zeitschr. f. Angew. Chem., 1897, p. 233. Jour. Soc. Chem. Ind., 1897. p. 283.

§ Zeitschr. f. Angew. Chem., 1898, p. 1027.

tried at this laboratory but gave unsatisfactory results and was discontinued. Thomas, Aspinwall,* Spica,† found sufficient objections, after trial, to discard it. Major Nathan says‡ the test fails when testing volatile explosives, such as nitroglycerin, the latter being decomposed by the sulphuric acid on the test paper.

THE HESS TEST.§

Hess heated nitrocellulose to 70° C in a tube, and, by means of a current of air, the volatile products of decomposition are carried into a dilute solution of KI-starch. Five observations are made: four colorimetric readings on the KI-starch solution, and the time required for explosion of the sample. This test shows the beginning, and roughly and for a short time also how decomposition proceeds. The KI-starch solution, like the KI-starch papers, is far too sensitive, and has the weak points mentioned under the "KI-starch test".

THE HOITSEMA TEST.‖

Another test in which an attempt is made to show the progress as well as beginning of decomposition. The explosive is heated for fifteen minutes at a constant temperature, and then, by means of a current of carbon dioxide, the volatile products of decomposition are passed through glass wool moistened with Guttmann's diphenylamin solution. The operation is repeated, lowering the temperature 10° each time until a temperature is found at which no decomposition takes place, *i. e.*, at which no products of decomposition are formed which give a color reaction with the diphenylamin.

This test is subject to most of the objections mentioned under the previous tests, especially the Guttmann test. As far as the writer knows it is not in use in this country.

THE EXPLOSION TEST.

For this test 0.1 gram of the explosive is placed in a strong, wide test tube (see fig. 7 D) which is then lightly corked and placed in a paraffin bath at 100° C. The bath (see fig. 2) is stirred and heated so that the temperature rises 5° a minute until the sample explodes: the temperature at which this takes place is noted.

* Jour. Soc. Ch. Ind., May 31, 1902.

† Rivista, August, 1899.

‡ Jour. Soc. Ch. Ind., 1901, p. 10.

§ Dingler Polyt. Jour. 234, p. 43.

‖ Zeitschr. f. Angew. Chem., 1899, p. 705.

A good nitrocellulose should not explode under 186° C.
A good nitrocellulose powder should not explode under 177° C.
A good nitroglycerin powder should not explode under 170° C.

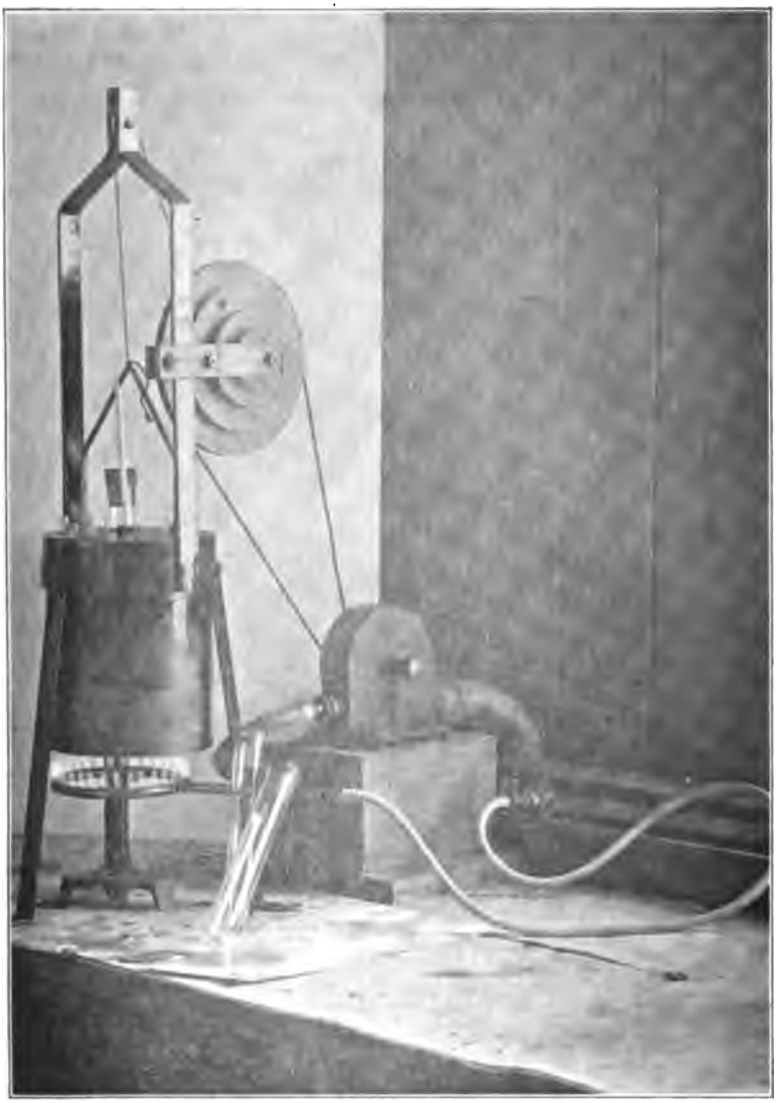


FIG. 2. Apparatus for Explosion Test.

Experience shows that this test is reliable when the explosive is either very good or very bad, and is only a rough guide as to stability. Variations in conducting the test give widely differing explosion points, especially if the temperature is raised at a different rate than 5° a minute.

THE THOMAS TEST.*

The sample is heated in a glass-stoppered tube, in an oil bath, for eight hours daily. A good nitroglycerin powder should stand four days heating at 94-96° C, without developing brown fumes (N_2O_4); a good nitrocellulose and nitrocellulose powder should not show fumes before three days, at a temperature of 99-101° C.

These temperatures are too low to produce a decomposition which may be accurately observed by the appearance of brown fumes; it is difficult sometimes to say just when brown fumes appear. Moisture and volatiles in the sample affect the result. Aspinwall† objects to the length of time (sometimes over twenty days) required to obtain results.

THE 135° C. GERMAN TEST.

2.5 grams of the sample to be tested are placed in a strong test tube (see fig. 7 C); a piece of blue litmus paper is put into the tube about one-half inch above the explosive. The tube is lightly corked and placed into a bath (see fig. 3) at 135° C.

Three observations are made: (1) reddening (complete) of the litmus paper, (2) appearance of brown fumes (N_2O_4) and (3) explosion of the sample. Stable explosives should stand the test as follows:

	Litmus red	N_2O_4	No explo. in
Nitrocellulose	:30	:45	5:00
Nitrocellulose powder	1:15	2:00	5:00
Nitroglycerin powder	:30	:45	5:00

To make the results of this test as valuable as possible, all three observations must be carefully studied and compared with those obtained from known good powders.

The temperature 135° is usually considered too high for stability testing, as it may cause decomposition not always dependent upon the stability of the explosive. Sometimes it is impossible to say just when the litmus paper is red, or when brown fumes are present, and two operators may vary thirty minutes in their observations. Different makes of litmus papers give widely varying results. The test papers used by the Ordnance Department are made by Einer & Amend, according to specifications, of as nearly uniform quality and sensitiveness as possible.

* Zeitschr. f. Angew. Chem., 1898, p. 1027.

† Jour. Soc. Ch. Ind., May 31, 1902.

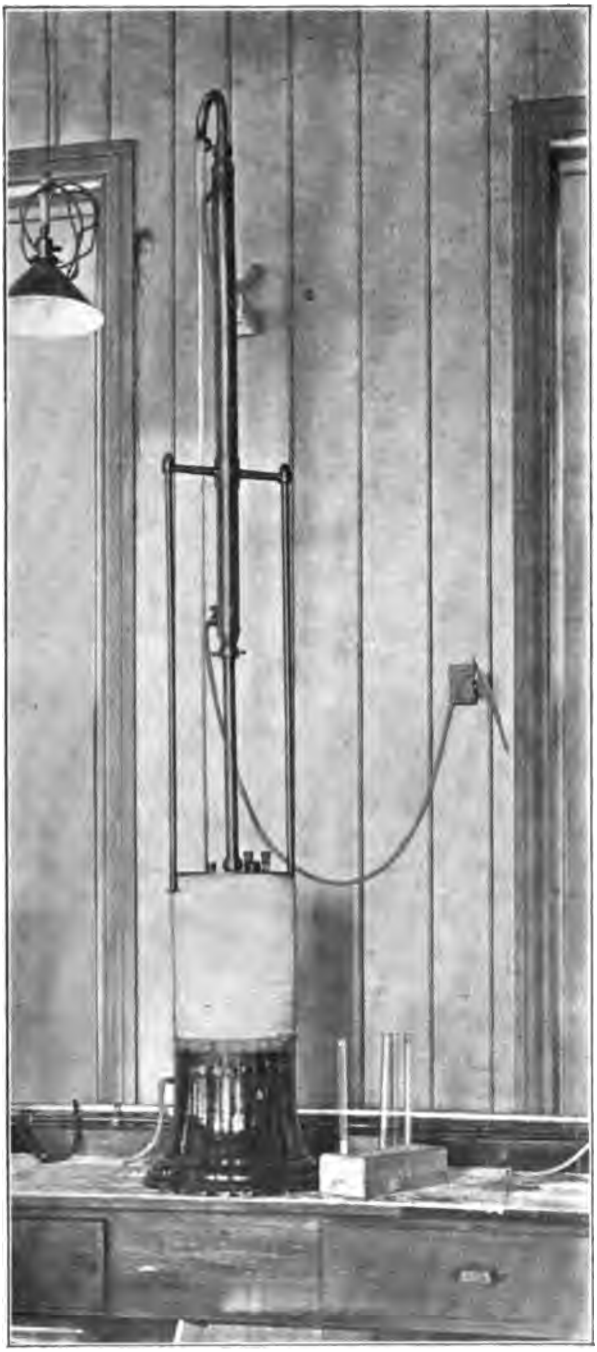


FIG. 3. Apparatus for German 135° C. Test.

By keeping all conditions as nearly uniform as possible and observing precautions mentioned, this test is one of the best of its kind.

THE VIEILLE TEST (110° C).

Ten grams of the explosive are placed in a strong glass tube (see fig. 7 B), a piece of blue litmus paper is placed above the sample and the tube closed air tight; the tube is then heated in an air bath* at 110° C (see fig. 4) until the litmus paper is completely reddened. The time required for this reddening is noted, the bottle removed and opened; this operation is repeated daily, using a clean bottle and fresh

FIG. 4. Apparatus for Vieille Test.

test paper, until the time required to redden the paper is one hour or less. These daily times are added and the total (accumulated time) should not be less than

30 hours for large grain powders,
20 hours for small grain powders (5 inch or less),
10 hours for nitrocellulose.

* A special air bath is used to heat the samples to 110° C; for description and illustration see Sy: Jour. Franklin Inst., March, 1903.

This test is not applicable to nitroglycerin powders. In common with all other heat tests where blue litmus paper is used, it shows only acid products of decomposition. It is practically impossible to get all the bottles equally tightly closed, and on this account there are variations in time, since pressure is an important factor in decomposition—the greater the pressure the less the stability time. The personal equation of the observer in reading the reddening of the paper, and different makes of test paper give rise to variations. At this laboratory (Ordnance Department, U. S. Army) the test papers used are the same as those described under the "135° C. Test".

THE WILL TEST.*

Nitrocellulose is decomposed by heating to 135° C, and by means of a current of CO_2, the products of decomposition are carried into a reduction tube containing a heated spiral of copper gauze; here the nitrogen compounds are reduced to nitrogen gas which is measured over sodium hydrate solution. The nitrogen is measured at regular intervals, and the rate of evolution is taken as an index of the decomposition. A nitrocellulose which by this test gives off equal quantities of nitrogen in equal intervals of time is considered by Will to be in "the limit state of purification," and therefore as stable as possible. An unstable nitrocellulose—one not in the "limit state" (Grenzzustand)—suffers, at first, an accelerated decomposition, which sooner or later becomes uniform.

Will's test was thoroughly tried by Mr. C. P. Beistle, of the Frankford Arsenal laboratory, no expense nor time being spared in setting up the rather elaborate apparatus required, and in conducting the test. The results obtained were unsatisfactory and failed to distinguish a bad from a good nitrocellulose, and the test was abandoned. This test, as well as modifications of it, have been investigated in several laboratories in this country, but in all cases eventually discarded as impracticable.

The following reasons are given as the cause of unsatisfactory results:

(1) 135° C is too high a temperature for stability-testing purposes.

(2) Decomposition is measured only by the nitrogen evolved.

(3) From Professor Will's experiments and diagrams it is not at all clear where to draw the line between a stable and an unstable product.

---

* Mittheilungen a. d. Centralstelle f. Wissenschaft. Untersuch. December, 1900, Neu Babelsberg. Also abstr. in Jour. Soc. Ch. Ind., June 30, 1900.

(4) The statement is made in Professor Will's report that for a certain nitrocellulose, heated for thirty hours and losing one-fourth its original nitrogen, the evolution of nitrogen in equal intervals of time was identical; while in another place it is stated that 10 grams of nitrocellulose gave four times the amount of nitrogen that was given off by 2.5 grams. This latter statement is correct, judging from our own experiments, but it contradicts the former, since the amount of unchanged nitrocellulose in the former experiment is constantly decreasing.

(5) It is practically impossible to buy or make CO_2 which is free from air; and as it is difficult to pass CO_2 through the apparatus at a uniform rate, the air-content of the gas gives rise to serious errors and if the current is too rapid it may cool the sample, and it, the CO_2, will not be completely absorbed by the sodium hydrate solution; if too slow, the gases of decomposition are not carried away fast enough, which may affect the decomposition, as stated by Professor Will.

(6) If the reduction tube and copper spirals are not hot enough, or the CO_2 passed too fast, some of the products of decomposition may escape reduction.

(7) Unstable products are liable to explode which might cause considerable annoyance both to the operator and the apparatus.

THE NEW TEST, 115° C.

From one to four whole pieces of powder are weighed on a watch glass and heated for eight hours in an air bath regulated to 115° C (+ or − 0.5°); the sample is then taken out, allowed to cool in a desiccator and weighed. This is repeated for six days, at the end of which time the total loss of a powder must not exceed 8 per cent.

A specially constructed air bath is used for obtaining a uniform temperature. The apparatus, shown in figs. 5 and 6, consists of a doubled-walled, sheet copper oven like the water ovens in general use, except that the new oven has the inner bottom slightly V-shaped (fig. 6, d): this effectively prevents bumping. Between the walls the oven is filled (about two-thirds full) with a mixture of xylol and toluol in such proportion that when the mixture boils, the air in the oven has a temperature of 115° C. A reflux condenser prevents the evaporation of the xylol-toluol.

In developing the new test a great deal of experimental work was necessary (credit is due Captain Dunn for suggestions and aid in this work). The points to be decided were: 1. Does decomposition increase as the temperature increases? 2. Does a bad powder decompose more rapidly than a good one? 3. Which is the most suitable temperature for the new test?

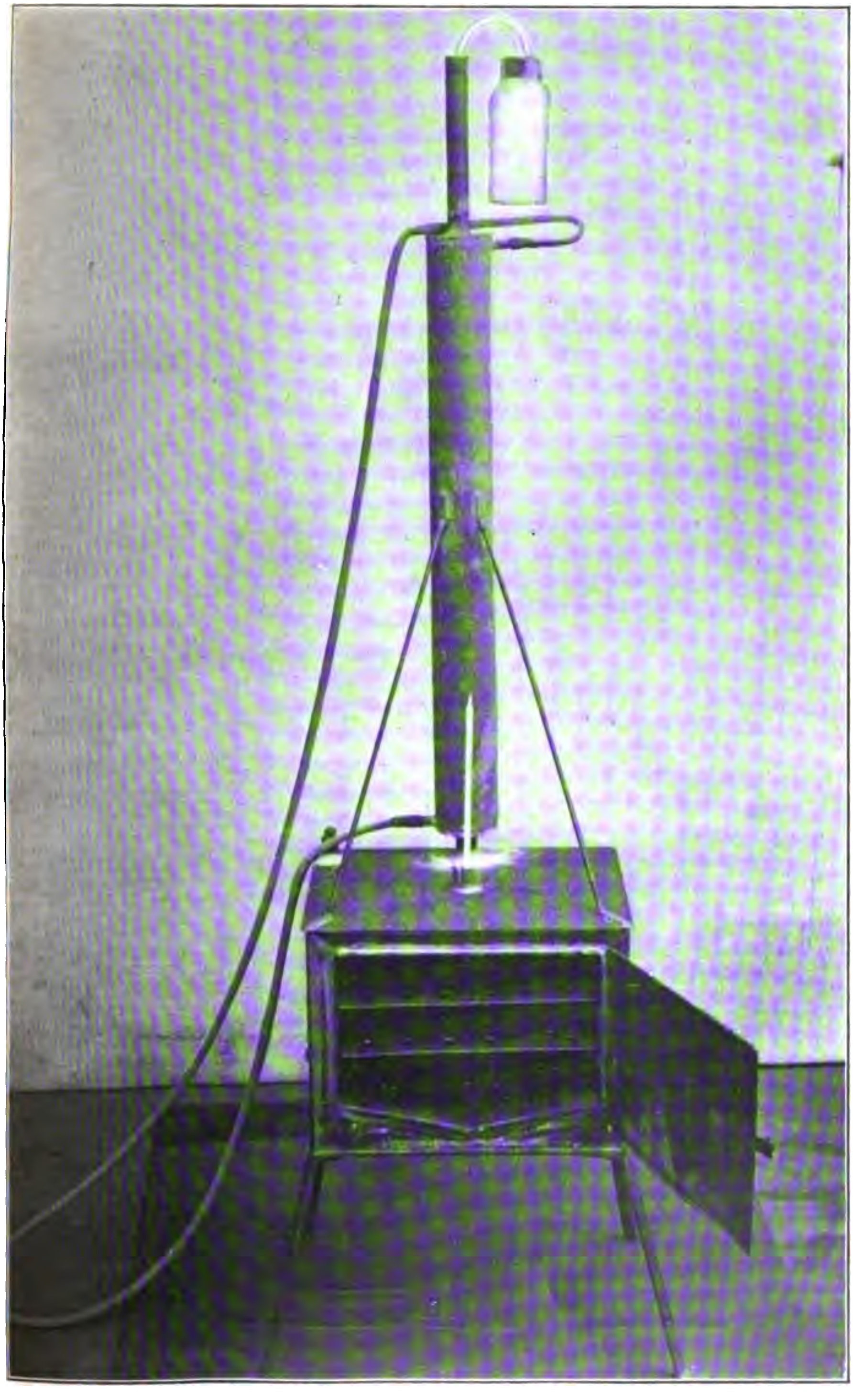


FIG. 5. Oven for New 115° Test.

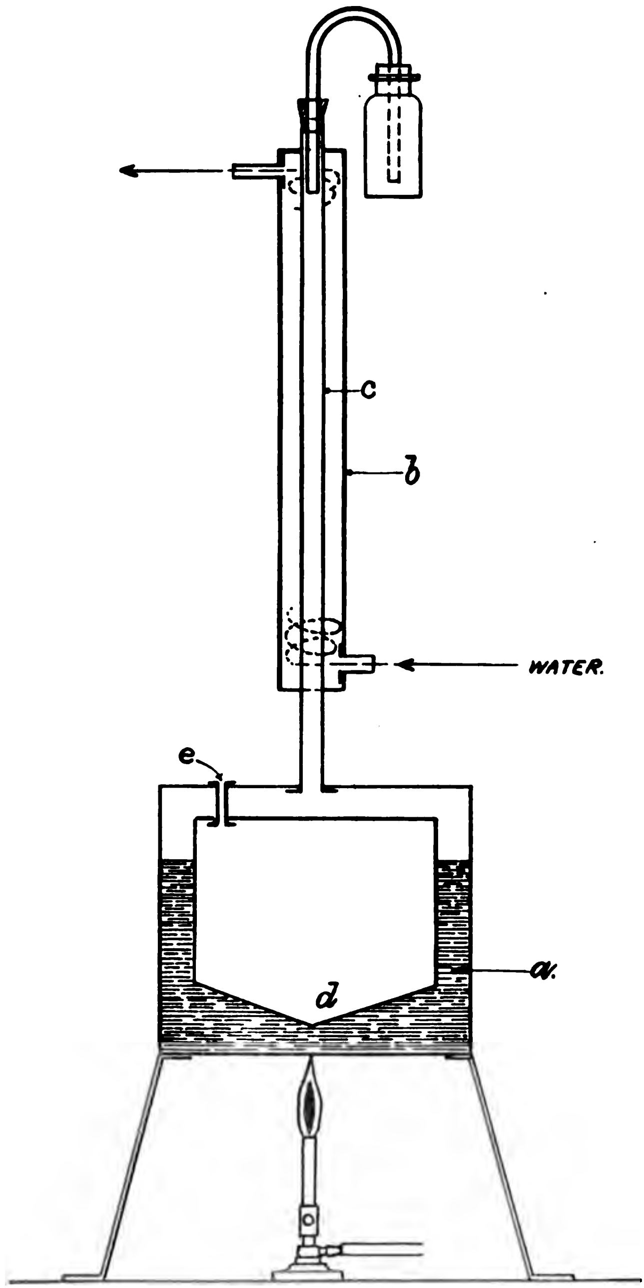
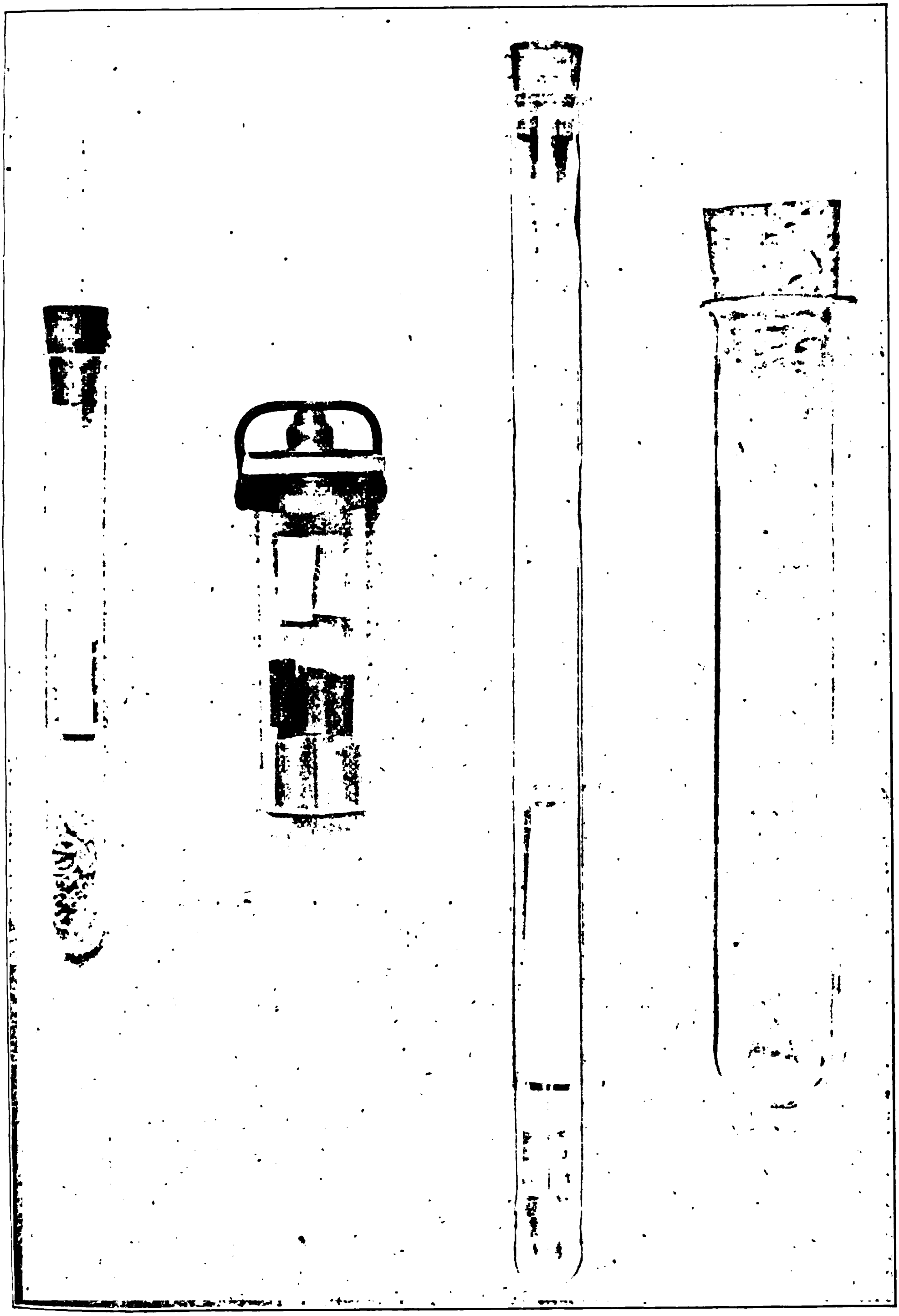


Fig. 6. Oven for New 115° C. Test.



A B C D

Fig. 7. A. Arrangement of tube and sample for KI-starch test.
B. Arrangement of tube and sample for Vieille test.
C. Arrangement of tube for German 135° C test.
D. Arrangement of tube for Explosion test.

Decomposition increases with the temperature; this is shown in figs. 8 and 9, showing the loss in weight of powders Nos. 179 and 391 respectively when subjected to different temperatures. Experiments soon showed that a bad powder decomposes much more rapidly than a good one. As may be seen from figs. 8 and 9, decomposition at 100° C is very slow; at 110° it increases but requires too much time to show a decided difference between good and bad powders. At 115° decomposition is still further increased and big differences are shown between good and powders in a reasonably short time, see figs. 11, 12 and 13. In fig. 11, powders 265, 293 and 391 are bad; in fig. 12, Nos. 803, 344 and 546 F.A. are bad; in fig. 13, Nos. 4-25, 405, 406 and 326 are bad. All other powders shown are good.

Experiments were made at 120°; at this temperature powders decompose more rapidly than at 115°, but the difference between a good and a bad powder is not as great, all powders decomposing more or less rapidly.

Although it is desirable to shorten the time of a test, yet it is undoubtedly of greater value the nearer the temperature approaches that of ordinary conditions of storage and handling.

The effect of size of grain on the decomposition is shown in fig. 14. Powders 922, 924 and 926 were made from the same nitrocellulose and as nearly alike as possible except in size, being for 8, 10 and 12-in. guns respectively. Decomposition increases but very slightly with size of grain, probably due partly to a slightly higher content of moisture and volatiles, and partly to internal pressure of products of decomposition from the larger grains. Powders 391 and 546 F.A., fig. 14, are bad and are shown for comparison with the good powders 922, 924 and 926.*

Experiments were made to shorten the time of the new test by sealing the samples in tin boxes and thus effecting decomposition under pressure and determining the combined effect of heat and pressure.

The weighed samples were sealed up (soldered) in small tin boxes and then exposed to 80° and 100° C., opened at regular intervals and weighed. At 80° decomposition is slow but considerably greater than if heated in the open. At 100° (sealed) decomposition proceeds quite rapidly, being almost as great as at 115° in the open. The difference between a good (577) and a bad powder (391) at 100°, sealed and open, is shown in fig. 15. The effect of pressure is the same as an increase of temperature. Further experiments are to be made along this line of testing.

* For further data see "Jour. Am. Chem. Soc.," June, 1903.

After applying the new test to a large number of powders it was found to give more reliable results than any other test now in use. It has the following advantages:

(1) The powder is tested in its *natural condition*, the same in which it is stored or used.

(2) It shows *all* products of decomposition; the older tests show only *acid products*, or only nitrogen as in the Will test.

(3) It shows the decomposition of *nitro-compounds other* than nitrocellulose which are often present in a powder, and also shows the *effect of this decomposition* on the powder itself.

(4) It shows the effect on the stability of a powder of added substances (for masking stability); the effect of volatiles: handling and working which may set up local decompositions; traces of nitrating acids; decomposition due to saponification by water, alkalies, carbonates, etc.

(5) It shows *quantitatively* the progress of *all* decomposition.

(6) The test itself as well as the apparatus used is simple and not subject to variations like the old tests.

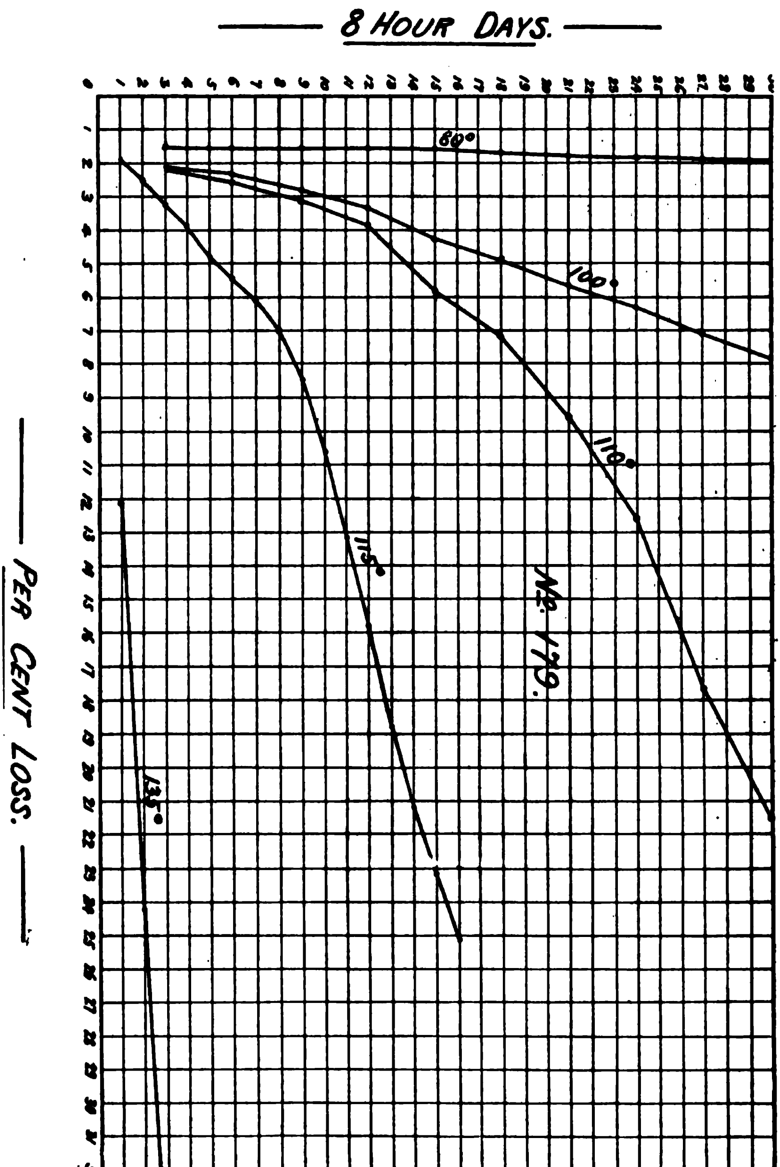


Fig. 8.

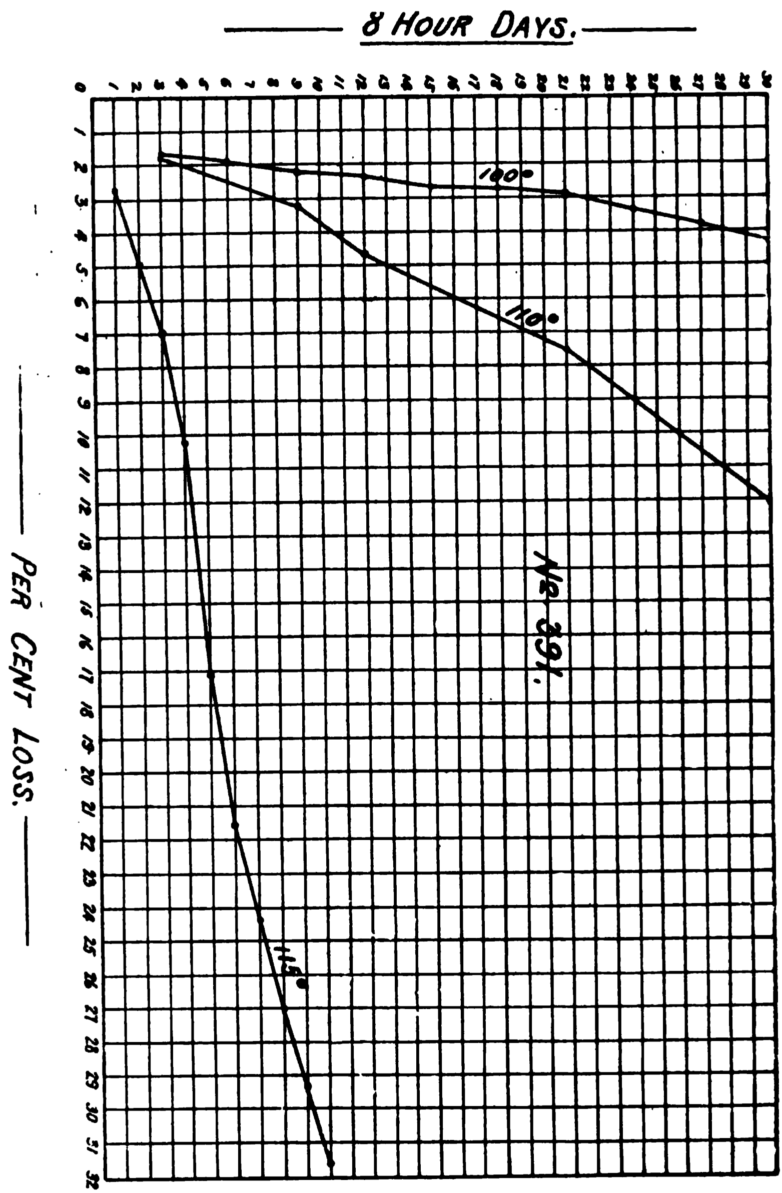
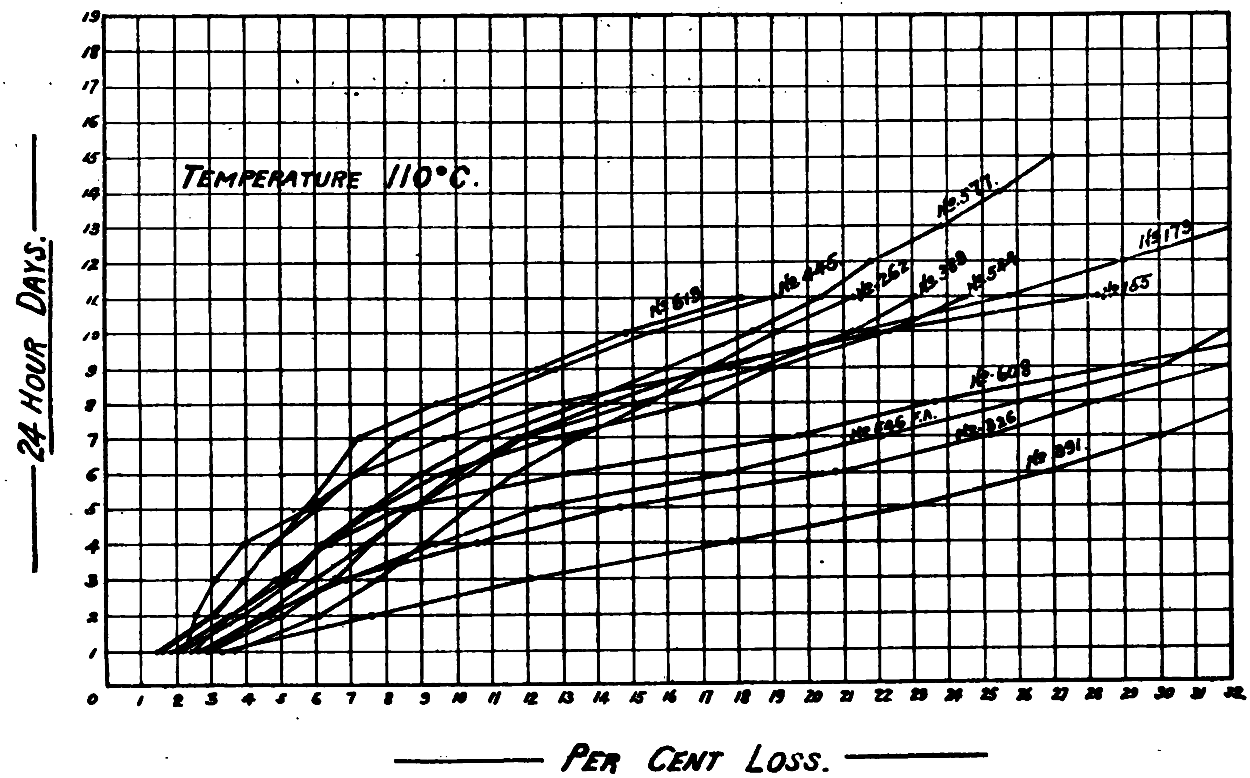


FIG. 9.

FIG. 10.



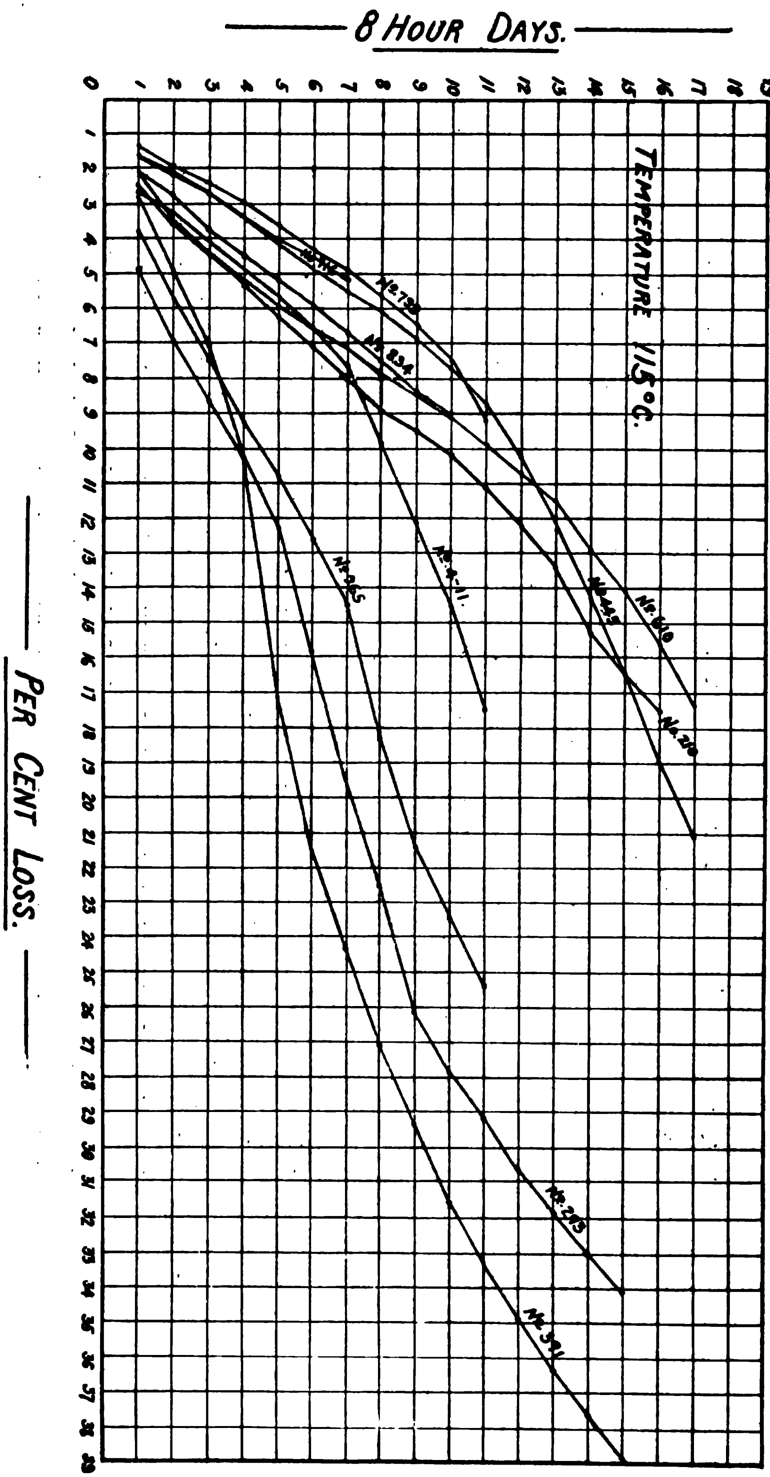


FIG. 11.

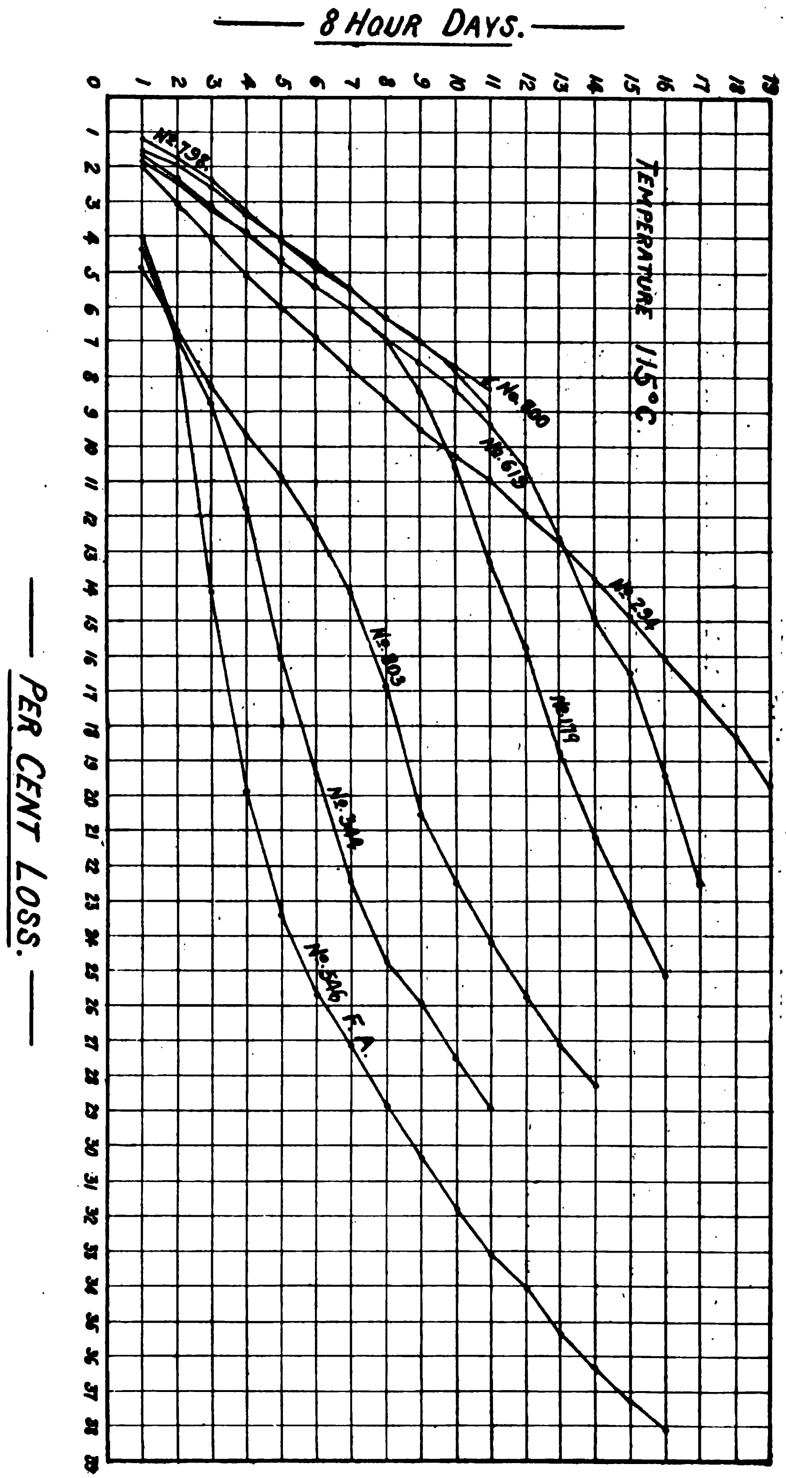

8 HOUR DAYS.
PER CENT LOSS.
TEMPERATURE 115°C.
No. 798.
No. 800
No. 615
No. 294
No. 803
No. 179
No. 344
No. 546 F.A.

FIG. 12.

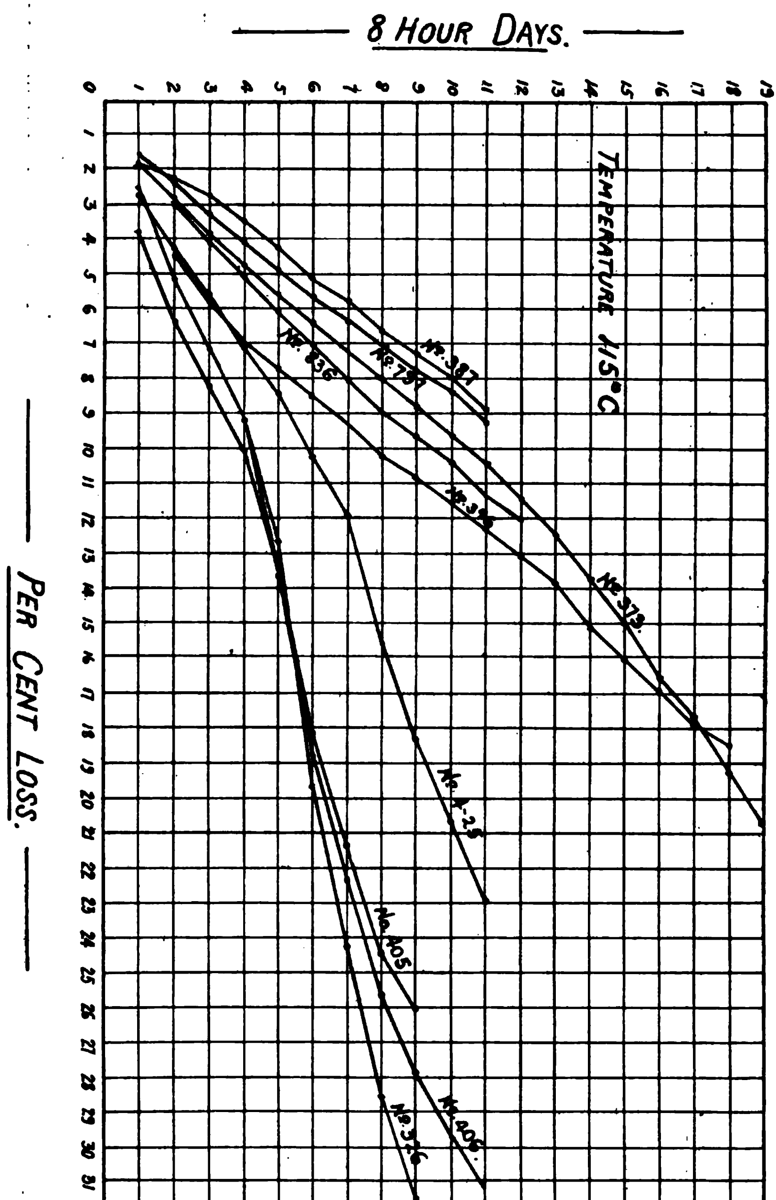

8 HOUR DAYS.
PER CENT LOSS.
TEMPERATURE 115°C
No. 387
No. 737
No. 836
No. 373
No. A-25
No. 405
No. 406
No. 376

FIG. 13.

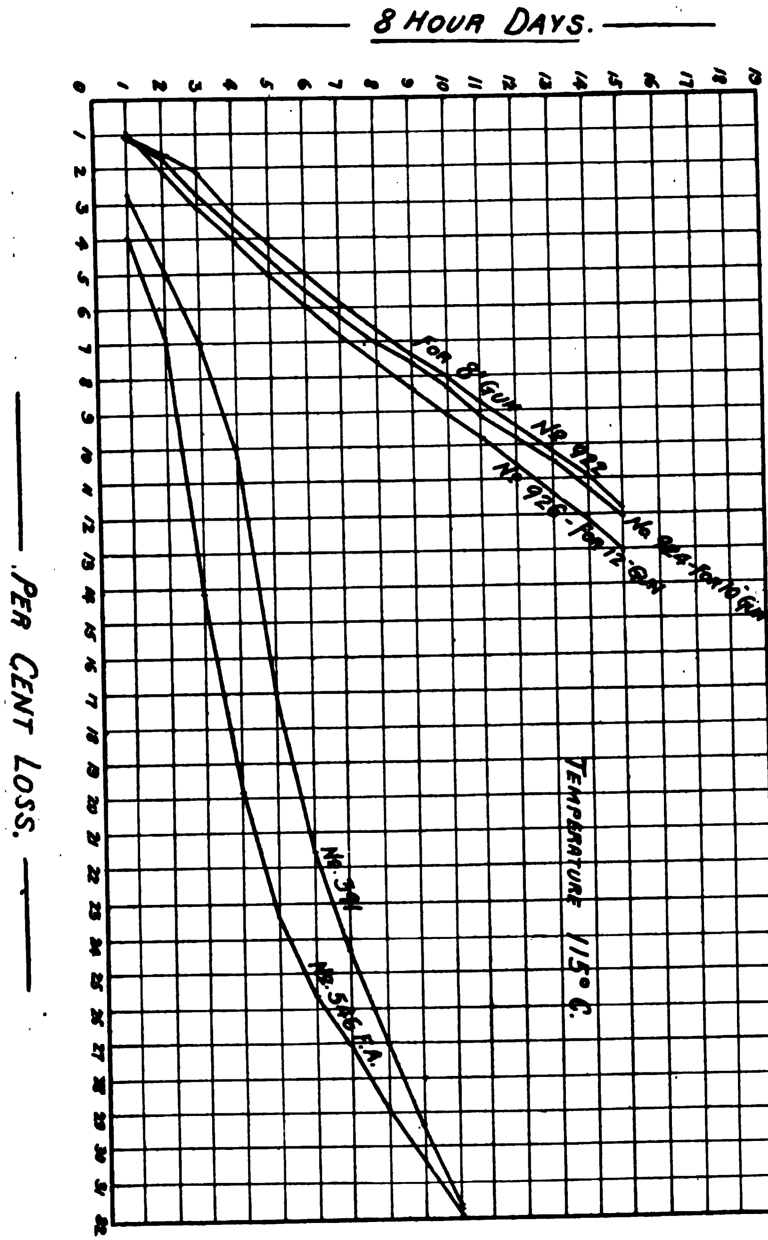

8 HOUR DAYS.
PER CENT LOSS.
TEMPERATURE 115° C.
FOR 8" GUN No. 922
No. 926 - FOR 12" GUN
No. 924 - FOR 10" GUN
No. 341
No. 546 F.A.

FIG. 11.

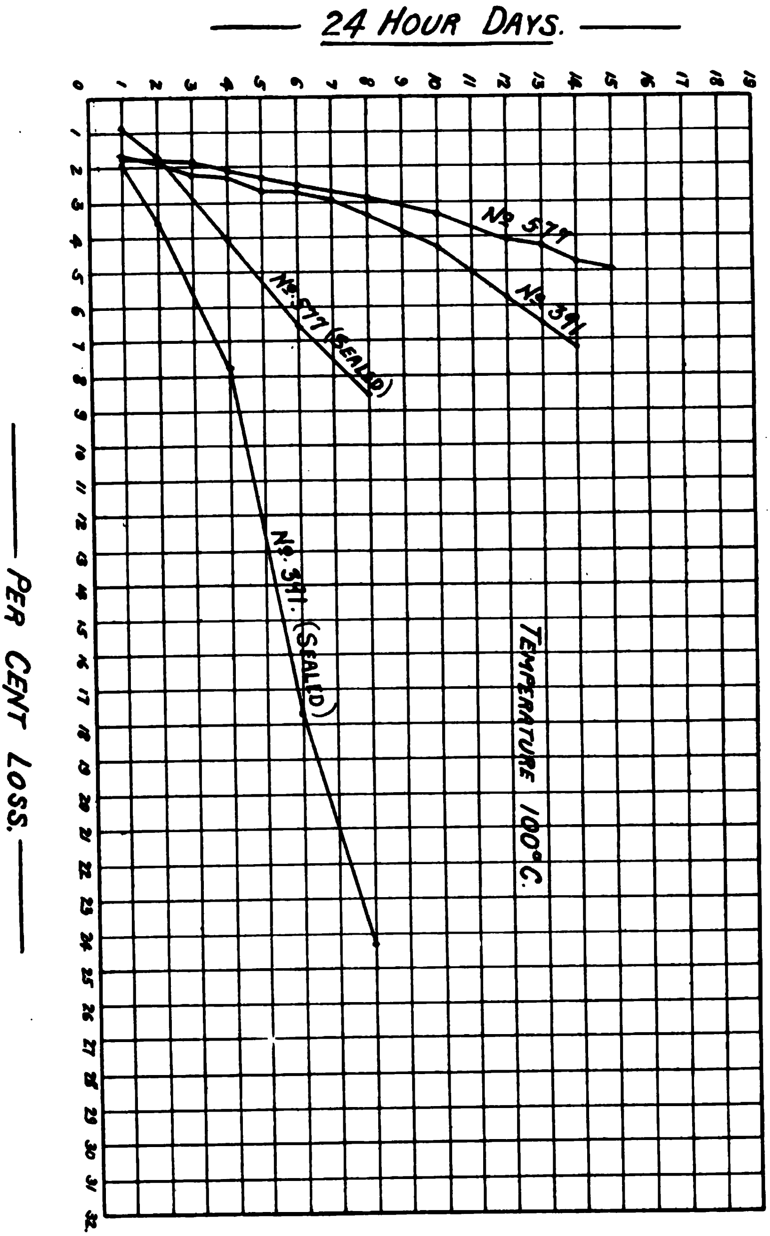

24 HOUR DAYS.
PER CENT LOSS.
No. 579
No. 391
No. 577 (SEALED)
No. 391. (SEALED)
TEMPERATURE 100° C.

Fig. 15.

REPORT ON ARTILLERY PRACTICE AT FORT MONROE, VIRGINIA.

By Major E. M. WEAVER, Artillery Corps.

This practice took place on July 22d, 1903, as a part of the course of instruction in the Department of Artillery, Chemistry and Explosives.

In submitting this report I desire to invite attention to certain features of the practice which seem worthy of note.

The special allowance of ammunition expended in this practice was authorized "for practice in *fire control* and direction."

Our regular artillery practice is by battery. The *fire command*, as a unit, is not involved therein. It has seemed that this kind of practice excludes an important feature of the real work of the line of batteries in action; that the concentration and dispersion of the fire of a number of batteries; the assignment of targets to batteries; the picking up of targets by batteries; the following and keeping on targets *assigned;* the shifting promptly at the command of the fire commander from target assigned to another,—in short the *fire command* features of coast artillery in action are not included in our present system of artillery practice.

In 1902, and 1901, *fire control* was introduced in the class firing to some extent, the "control" features being limited to assigning the *bow*, *stern* or *midship* section of a single ship target to the batteries respectively. The success of these firings led the instructor this year to attempt something closer to actual conditions.

Permission of the Commandant of the Artillery School was obtained to have the targets towed at "angles of presentment" that would give a greater rate of change of range than has been the custom in recent practice. A course was laid down which in one circuit of the tug covered the *short*, *mid* and *long* ranges prescribed in General Orders, No. 100; that is from less than 4500 yards to greater than 7500 yards. The angle of presentment to the line of works was such that all batteries could fire at any of the ranges with safety to the tug.

The scheme was to simulate the attack of the works by a squadron of four battleships moving in the circuit laid down. Each target* was given the name of a ship and had distinctive

* The type of target used was of the pyramidal form, as described in my report of 1901. The names assigned were 1. République, 2. Renown, 3. Borodino, 4. Mikasa.

flags or streamers that enabled the fire commander to designate the target to any battery commander by its ship name.

The four targets were towed in "line ahead" (what ashore we call *column* formation). The leading target was 300 yards from the tug; the others 100 yards apart.

Overs and shorts were taken from the tug by the usual T scale method. The readings were taken for the leading target and corrections made for other targets. As this work on the tug is the most important and novel, some details of the manner in which it was conducted may be of value. The personnel of the tug party consisted of:

1. One officer with glasses to watch the shore batteries and call out instantly the name of the battery that fired.
2. The recorder; an intelligent enlisted man, (who should be a rapid writer and quick in his movements) having a watch in hand that is adjusted to the fire command time, and a a table arranged as follows:

No. of Shot	Battery Letter*	Time of fire			Over +	Short —	Remarks
		h	m	s			

3. One officer to use the T-scale and call out the overs and shorts, instantly; *e.g.*, "plus 50," "minus 20," to be entered by the recorder.

No. 1 should stand scanning constantly the line of batteries of the fire command. No. 2 should stand by him with T-scale in hand. The recorder should stand between the two. At the flash of the gun ashore No. 1 should call out the battery, No. 2 should stand ready to read the splash. The recorder should enter the serial number of the shot, the letter of the battery, the minute and second of the flash as soon as called by No. 1, and stand ready to enter the over or short. As soon as the projectile strikes, the over or short should be called out by No. 3 and entered by No. 2.

Although several batteries were firing at the same time it was rare that there was not sufficient interval between the flashes and splashes to distinguish between the latter. When flashes

* For expedition in entering in record each battery may have a letter designation.

and splashes came close together in time, the splashes were credited to batteries in the order of striking and the order of firing, the first splash to the first flash, second splash to second flash, etc. In the rare cases when it would be impossible to thus differentiate, the record should bracket the two batteries and the over or short would be assigned by comparison with the records ashore or by lot.

At each battery a "safety officer" is required, who has supreme control over all matters pertaining to the safety of the range. He may hold up any order of the fire commander, and the firing at any instant, when, in his opinion, safety demands it.

Near by the safety officer a "time keeper" should be stationed. He may be an intelligent enlisted man. He should keep a record like the following:

No. in F.C. series	No. in battery series	Time of fire*			Tactical No. of gun	Remarks
		h	m	s		

In the first column will be entered the serial number of any shot in the *fire command series*. In the second, the number in the *battery series*. In the third will be entered the hour, minute and second of the flash. In the fourth, the tactical number of the gun.

The first and third columns serve to connect tug record of overs and shorts with the battery's firing; the second serves to connect the deflection record with overs and shorts of the tug record.

Deflections are taken at each battery by an azimuth instrument.

In this practice the fire command consisted of the following batteries.†

1. *Battery A*‡: B.L. Rifles; Manning Body: 118th Company, Coast Artillery.
2. *Battery B*: B. L. Rifles; Manning Body: 35th Company, Coast Artillery.

* The watch required to be adjusted to the fire command time.

† A much larger F.C. than is customary.

‡ The armament of the batteries and calibres of guns are not published.—ED.

3. *Battery C:* B. L. Rifles; Manning Body: 13th Company, Coast Artillery.
4. *Battery D:* B. L. Rifles; Manning Body: 69th Company, Coast Artillery.
5. *Battery E:* B. L. Rifles; Manning Body: 73rd Company, Coast Artillery.
6. *Battery F:* B. L. Rifles; Manning Body: 73rd Company, Coast Artillery.
7. *Battery G:* R. F. Guns; Manning Body: 6th Company, Coast Artillery.
8. *Battery H:* R. F. Guns; Manning Body: 73rd Company, Coast Artillery.
9. *Battery K:* B. L. Mortars; manned by the 58th Company, Coast Artillery, and by the 41st Company, Coast Artillery. Only one mortar in each A and C pits used.

Battery H was not included in the fire control practice.

The batteries were manned by the enlisted men regularly assigned to them. The positions of *battery commander*, *battery officer* and *range officer* were filled by student officers.

The practice took place on Wednesday, July 22. The morning was occupied in firing the trial shots from the large calibre guns and mortars. One trial shot for each series of five authorized.

The regular practice began in the afternoon at 2:28 o'clock. It terminated at 4:20 o'clock.* During the practice there were fired sixty-nine rounds, as follows:

Battery A	fired	4	rounds.
Battery B	"	8	"
Battery C	"	8	"
Battery D	"	9	"
Battery F	"	8	"
Battery E	"	4	"
Battery G	"	20	"
*Battery K**	"	8	"
	Total	69	"

These were fired on two circuits of the targets, in obedience to instructions of the fire commander, as follows:

* Of this time about thirty minutes were occupied in actual firing. The mortars are not included in the time statements. They had to wait for the target to get in the zone.

FIRST CIRCUIT OF TUG.

1. *Battery G* fired three rounds at the Mikasa.
   The fire was then shifted by order of the fire commander to the Renown. Four shots were fired at the Renown and cease firing was ordered.*
2. *Battery K* was ordered to fire at the Mikasa as soon as within range (charges for only *one* zone about 6500 to 8000 yards). Two rounds were fired.
3. *Battery A* was ordered to fire two rounds at the Mikasa.
4. *Battery B* was ordered to fire four rounds at the Mikasa.
5. *Battery C* was ordered to fire four rounds at the République.
6. *Battery D* was ordered to fire two rounds at the République and later shifted and fired two more rounds at the Mikasa.
7. *Battery F* was ordered to fire four rounds at the Borodino, shifted after firing two rounds to the Renown.
8. *Battery E* was ordered to fire two rounds at the Mikasa.

Except the rounds of the 4.7-inch R. F. guns, this first firing was all at ranges of about 5500 yards from the batteries increas- to about 7000 yards for the mortars. Allowing time out for the turning of the targets, eleven minutes were occupied in executing the orders of the fire commander. The mortars were able to get in only two shots as the target did not get into their zone until just before the tug turned to make the second run.

SECOND CIRCUIT OF TUG.†

1. *Battery A* was ordered to fire two shots at the République, the order was afterward changed to direct the fire on the Mikasa.
2. *Battery B* was ordered to fire one round at the Borodino and later three shots at the République.
3. *Battery C* was ordered to fire one round at the Renown and later three at the République.
4. *Battery D* was ordered to fire two rounds at the Renown and later three rounds at the République.
5. *Battery F* was ordered to fire two rounds on the Mikasa and two at the République.
6. *Battery F* was ordered to fire two rounds at the République.
7. *Battery G* was ordered to fire its remaining shots (13) at the République.

* First shot, 2:28, 7th shot 2:31, total time, 3′. After the series with R. F. guns the tug turned. Big gun firing on first run: 1st shot, 2:57, last shot, 3:08, total time, 11′.

† Time for guns, 1st shot, 4:00, last shot, 4:21, total time, 21′.

8. *Battery K* was ordered to fire their remaining shots when the Mikasa was in the zone.*

The mortars had to wait for some time, after the guns had used all ammunition, for the target to get into the one zone within which they could fire.

The large guns and the R. F. guns responded promptly to all orders, whether these were to commence firing at a specified target, to shift the fire to another ship target or to cease firing. The action for the guns was over in a very few minutes. The shots from the guns were all put in, in a run of about 1400 yards, about twenty minutes of time (making allowance for "time out").

The fire control features of the practice, the transmission of orders of the fire commander, the receipt of these orders at the batteries, the execution of them by the battery commanders was very satisfactory. It is very pleasing to note the satisfactory working of the communications, because heretofore much difficulty has been experienced in this division. The very great improvement is attributed partly to the watchful care of Captain H. C. Davis and his assistants, in charge of the electric installation, and partly to the fact that the observers and telephone men and plotting board men had been working together for five months; it was practically a permanent detail, which, it may, perhaps, be said, is a requisite for high class work in this division.

Officers of the class in their reports to the instructor speak in high terms of the plotting room work at all the batteries. Indeed the promptness with which the orders of the fire commander were executed is a positive test of the efficiency of the telephone men. The excellent shooting of the batteries is a test of the plotting, predicting, indicator board work, setting of deflection and range scales, and, indeed the general fire discipline of the command.

The result of the practice of the several batteries may be tabulated as follows, considering the large calibre guns only:

Company.	No. of round.	Range, yards.	Over, yards.	Short, yards.	Right yards.	Left yards.	Hits.
118th	1	5290		30		4	½
	2	5340	50		7		1
	3	4540	20		15†		½
	4	4500	0	0	3		1
				Per cent (3/4) = 75			

* Time for mortars, 1st 5:02, last, 5:11, total time, 9′.

† The sight standard shifted in firing and caused this or a portion of this error.

Company.	No. of Round.	Range, yards.	Over, yards.	Short, yards.	Right, yards.	Left, yards.	Hits.
35th	1	5280		37		10	½
	2	5302		105	0	0	
	3	5410	75		10		1
	4	5360	15			9	1
	5	4920	81†		2		½
	6	4890	0		6		1
	7	5140	67		9		1
	8	5190		7	7		1
				Per cent (6/8) = 75			
13th	1	4720		100	4		
	2	5440	10			4	1
	3	5920	135			9	
	4	5360	0	0	12		1
	5	5445	0	0	0	0	1
	6	5540	195		27		
	7	4980	25		27		½
	8	5300	125		0	0	
				Per cent $\left(\frac{3.5}{8}\right)$ = 43.8			
69th	1	5467		150	27		
	2	5560	135		0	0‡	
	3	4964	0	0	0	0	1
	4	5205	38		0	0	1
	5	5165	75		0	0	½
	6	5492	38		0	0	1
	7	5550	135		0	0	
	8	5015	11		0	0	1
	9	5232	91		0	0	½
				Per cent (5/9) = 55.5			
73d	1	5410	100			14	½
	2	5575	55			2	1
	3	5270	0	0		6	1
	4	5290	175§		0	0	
				Per cent $\left(\frac{2.5}{4}\right)$ = 62.5			
73d	1	5700	Lost			11	
	2	5825		75	23		
	3	4790		10	0	0	1
	4	4810	10		0	0	1
	5	4785		15‖		2	½
	6	5390	90			7	½
	7	5500	200			15	
	8	4940	40			10	1
				Per cent (4/7) = 57			

† Contrary to instructions an attempt was made here to correct for "observed" errors of range; the "observations" were, as usual, misleading.

‡ These deflections which are quite remarkable were taken with an azimuth instrument by Captain E. W. Hubbard, Artillery Corps. He reports them all so small he could not measure them

§ The recoil on this shot was excessive; indicating an abnormal velocity.

‖ This shot would have struck 3 yards, 9 feet, short of the broadside. It might well be the most important of the whole series in action and yet it is not counted, under our rules, on the broadside.

These results may be summarized as follows:

Shots fired by the B.L. rifles in practice:		41.
Total time occupied in firing these		32 min.
Per cent of hits:	118th Company	75
	35th Company	75
	13th Company	43
	69th Company	55
	73rd Company	62
	73rd Company	57
Average per cent of hits		61+
Average range, about		5300 yards.

Full service charges of smokeless powder.

The firing of the mortars was not satisfactory as to range. The battery commanders had given close study to all elements bearing on good practice, and it may be taken as a matter of no doubt that all preparatory work was properly attended to and that the pieces were correctly laid.

Before the practice a "compression test"* was made of all powder used. All gave high tests of 50 per cent or over except the powders used in the mortars and in the 8-inch B.L. rifle. These powders were made in 1901, by the same manufacturer, and gave low compression tests, 40 per cent and under, appearing to vary considerably with the several grains, the following being the results of five tests.

1. 42 per cent; 2. 38.1 per cent; 3. 42.8 per cent; 4. 31.8 per cent; 5. 40.9 per cent.

From my position in the fire commander's tower I could see the fall of the shots plainly and the ranges were very variable; the overs of the mortars were as follows:

1. + 500 Off the T-scale, estimated.
2. + 700 "
3. + 375 "
4. + 500 "

The battery commander took his powder at normal velocity.

At the 8-inch B.L. rifle two trial shots were permitted because the first one gave such an excessive range, + 290. The second one confirmed the first with an over of + 305. Correction was made for this and good practice resulted.

---

* Captain Dunn of the Ordnance Department has found that smokeless powders vary their pressures with storage. The *physical* characteristics of the powder appear to be involved in these variations. He has proposed a compression test in which he cuts a grain of powder to the length of its diameter and subjects it to compression along the axis of the grain. The compression is continued until a small crack develops on the side. Good powders should stand a compression of above 40 per cent. Below 40 per cent powders give excessive pressures for regular service charges. This powder was made in 1901.

The firing appears to support Captain Dunn's theory. I am of the opinion that the excessive and variable ranges of the mortars are due to the changes that have taken place in this powder in storage, causing an increase of pressure and variable rate of burning in the piece with consequent excessive and variable range errors with correct laying.

I would suggest that these compression tests be made regularly before firing. It appears to be a very important matter. Perhaps Captain Dunn has developed other facts bearing on it in his more recent experiments

The R.F. gun-firing was done by student officers acting as gunners. The firing was uniform but the ranges too great to score hits on a 15-foot freeboard. Such shots would be terribly effective in the superstructure of ships and it is a question whether they should not be given some value for that region on a vertical target. It requires practice to *know* what *kind* of a sight to hold, fine or coarse, when an open sight is used, such as is provided for the 4.7-inch gun. It would seem that these guns might be provided with telescopic sights. The same guns in the English service have telescopic sights, and one is provided for our 15-pounders.

I would respectfully renew the suggestion offered in my last year's report, that *our regular artillery practice include fire control or fire command practice* as distinguished from fire direction or battery practice prescribed by General Orders No. 100, exclusively. Three series of five shots each are prescribed by General Orders No. 100. It would seem that *one* of these series might be a *fire control series* instead of a *fire direction series*, and that such a modification would be beneficial in its effects on the service; especially is it desirable that our fire commanders have an opportunity to exercise their war functions as well as the battery commanders.

There is one new feature in connection with the post's equipment which should be noted in a special way. One of the batteries (35th Company, Coast Artillery), *had its own base line.* The fire commander was able to assign any one of the four targets to this battery and it could at once take it up independently and hold it as long as ordered. The other batteries have not yet their own horizontal base position finding systems installed, and it made it very awkward in the fire control practice. The fire commander's position finder could work on only one target, and those batteries assigned to other targets than that the fire commander's observers were following, were obliged to estimate the range difference, based on the knowledge that the targets were a known distance apart. By all means, the H.P.F. system, for each battery, should be installed and put in operation as soon as possible.

The success of the 5-month observers, noted above, confirms all that has been said in previous reports as to the importance of *permanence* in this division of work. It would, in my opinion, give still better results if *a manning body of officers and men were definitely and permanently assigned to such a distinct and important class of material and to its service.*

I desire to commend the work of the tug party during this firing. It had a new and difficult duty to perform. The targets were always on the field of fire at the time appointed for the practice and precisely as planned. The party recorded all of the shots fired, eighty altogether, and with the exception of one or two shots falling at the targets at about the same time, there was no doubt about their record; these doubts disappeared on comparing their record with those taken at the batteries.

AN ELEVATION SCALE FOR SEACOAST GUNS.

By Captain HENRY C. DAVIS, Artillery Corps.

As the information on which a seacoast gun is set in elevation comes to the platform expressed in yards, it is desirable to have scales for setting this elevation graduated in yards.

A scale so graduated is good for but one muzzle velocity, and as this is not constant, each change in velocity requires a change of scale. This may be accomplished by shifting the strip on which the scale is drawn, or by shifting the index along the scale so that the proper elevation for a given range may be obtained by setting off the given range on the elevating bar or wheel.

If, however, the velocity changes materially and the range required is quite different from that for which the scale was adjusted by shifting, the error is too great to be disregarded. For mid ranges a fair adjustment may be obtained, but the error is still present and becomes quite apparent for long and short ranges.

This may be seen by examining the proposed scale in the following way: Consider the range 4000 yards and a M.V. of 2300 f.s. Suppose the M.V. reduced to 2275 f.s. Measure the vertical *linear* distance between the points where the 4000 yard range line cuts the vertical lines marked with these two velocities. Make a similar measurement at the 10000 yard range line and observe that we shall have failed to shift the scale by about 100 yards if we have adjusted for 4000 yards. A similar comparison shows an error of 25 yards at 1000 yards. This latter would not material for low sites, but the former is a good deal of an error to remain after an attempt at correction.

Nothing will be gained by "allowances" made by the gunner, for then we immediately leave the field of accuracy and would as well not adjust the scale at all. The only thing left is to change the scale as soon as the velocity changes materially, as for instance, for a variation of 10 f.s., thus requiring 11 separate scales for a variation of 100 f.s.

To make it possible to change the scales for changes in velocity continuously and not by ten jumps as above, and also to avoid the mechanical trouble involved in changing the strips of brass on which the scale is stamped, the arrangement shown in the accompanying drawing is suggested.

The left hand graduations are the elevations in degrees taken from the elevation scale of a 12-inch B.L.R., mounted at Fort Monroe. The five vertical lines are drawn at equal distances apart and so spaced that the whole diagram is the width of the brass surface on which the elevations in degrees are now marked. Points corresponding to the elevation for the different ranges and for the velocities indicated at the top of the line, are plotted on each vertical line. Lines joining the different points corresponding to the same range give the range lines and the elevations as continuous functions of the muzzle velocity. These lines in this case differed from right lines by but two tenths of a minute in elevation for the M.V. 2250 f.s., and so were plotted as such.

To set the scale for any given velocity, within the limits for which the scale is made, loosen the set screw and turn the translating screw till the arrow on top of the index marks the desired velocity directly or by interpolation. The set screw is then tightened to prevent a change from shock. The elevation for any range and for the velocity set off may now be given by elevating the gun till the index reads the proper range line.

To set the scale and find the velocity from data obtained from a trial shot, set off on the range scale any convenient elevation, fire the gun and observe the actual range. Correct the observed range for atmospheric conditions, and without changing the elevation, turn the translating screw till the index reads this corrected range. The range scale is then set for the proper velocity, which may, if desired, be read on the horizontal scale.

A scale entirely similar to this may be applied to the elevating wheel. In both cases the index will be on the side of the scale which lends itself best for attachment to the carriage, the graduations being on the side of the scale opposite to that occupied by the index. It will be observed that the scale of degrees is not a scale of equal parts, but must be laid off to suit the elevating apparatus of each gun before the graduations in yards can be put on.

The advantage claimed for this scale is that, being once put on, its use avoids the necessity of putting on other scales, giving a continuous correction, rather than by jumps, for changes in velocity. The change is also more easily made than where new scales have to be substituted for the old.

The scale here given does not take into consideration the height of the gun. This was omitted by oversight, but its addition would in no way change the general appearance or usefulness. The

effect would be to shift the yard graduations with respect to the degree graduations.

Several guns at Fort Monroe are already equipped with extemporized elevation scales graduated in yards. These, under the recent order changing the weight of powder in the charge, and hence the muzzle velocity, will all have to be changed; whereas, if the guns had been equipped with scales as shown in the diagram, no change other than shifting the index would have been necessary.

In preparing data for this drawing valuable suggestions were received from Captain Bartlett, Artillery Corps. The drawing was made by Mr. Charles A. Junken. The scale as represented is about five-sevenths actual size.

EXAMINATIONS FOR GUNNERS.

By Captain ROBERT E. WYLLIE, Artillery Corps.

"The object of this examination is to ascertain in each company the qualified gunners." This is quoted from General Orders, No. 100, A.G. O., 1903, but only the immediate object of a gunners' examination is there given. By the Act of February 2d, 1901, increased pay was allowed to gunners, in order to promote the efficiency of the Artillery. Therefore, to carry the matter back to its foundation, the object of the gunners' examinations is to increase the efficiency of the service, and, bearing this fact in mind, I wish to bring up some points in regard to these examinations as at present conducted.

Let us assume that a company is assigned to any battery for service, it is evidently the duty of the company commander to place his personnel in the highest state of efficiency and to be ready at any time for actual service with the material placed at his disposal. In order to effect that object, he must train his men in the use and care of the guns and carriages, all instruments, charts, means of communication, in fact every thing pertaining to his battery. It must all be manned, and if it is to be operated efficiently the men must have a thorough knowledge of it all; but on the other hand it is useless for the company commander to give instruction on instruments and other material which are not needed for the service of the battery. It is not only useless, but a positive detriment, since it tends to load the minds of the men with information of which they can make no practical use, and any attempt to teach the average enlisted man how to use an instrument, such as a sight or quadrant, for instance, is futile unless he can have experience with it. The correct and rapid use of the instrument at the piece is the kind of knowledge that is required, and that can be obtained only by actual use; anything else is only "cramming" and is forgotten as soon as the examination is over, and the time spent in giving the instruction is wasted, time which could have been employed to much greater advantage. If then any of the prescribed subjects contain matter foreign to the battery to which his company is assigned, the company commander has to take his choice of two paths; either to give his men special instruction in such subjects, to the detriment of his regular work, so that they can qualify as gunners and get the extra pay, which might be designated as his duty to his men; or, keeping in mind the efficiency of his battery, to refuse to spare for any other purpose any time which should be devoted to the service of that battery, which would be his duty to the government. This latter is evidently the prime consideration, and therefore the enlisted man fails for want of the necessary instruction. If he takes the first path, then the result of the examination will be to decrease the efficiency of the service, rather than to increase it, thus running counter to the real object of the examination.

Now for the different subjects to which this could apply. At a mortar battery, sights are unknown, and Case I. and Case II. do not apply; at gun batteries the quadrant is never used.

At almost every post there will be found certain departures from the commonly accepted methods, a more simple scheme for determining one thing, or greater accuracy in finding another, being usually based on ideas which have occured to the officers there; as an example, the drift scale for the mortars, described by the late Major C. L. Best, Artillery Corps, in No. 56 of the JOURNAL, is more rapid and convenient for mortars than a gun commander's range scale; if therefore, a battery is provided with that device, the men should be examined on it and not on the range scale,—for a company commander to teach his men both is a waste of time; similarly, range strips on the elevating wheels of guns, by means of which the elevation is given in yards of range, is certainly much to be prefered to a gun commander's range scale, yet the men are supposed to be "crammed" on the use of the latter.

Various other similar cases could be mentioned, and in all such, candidates should be examined on the instruments and methods actually used at the battery instead of on the ordinary devices.

From the wording of the order (No. 100) it would appear that the men are required to know the weights of the charges and the muzzle velocities for all guns in the service, the weights of all projectiles employed, and what portions of warships can be effectively attacked at various ranges by any gun which may be designated. Now what earthly good does it do a man who is assigned, we will say, to a 10-inch battery to know that a 4.7-inch gun fires a projectile weighing 45 pounds, with a muzzle velocity of 1786 f.s. and powder charge of 13 lbs. 10 oz. of "Pebble", or 2570 f.s. if a charge of 8 lbs. 2½ oz. of "Cordite" is used. With the "Cordite" charge at 1000 yards and less, he can penetrate the 8-inch turrets and after conning towers of the New Jersey, Rhode Island and Maine, the casemates of the Alabama, the 8-inch gun turrets and 6-inch casemates of the California; at 2000 yards the belt at bow and stern of all the United States vessels can be penetrated, the shields for 4-inch guns on the Iowa, sponsons for 6-inch guns on the Indiana, bulkheads of the California, and so on for other ranges and vessels.

All this is for the 4.7-inch gun of 45 calibres only, but there is also a 4.7-inch gun of 40 calibres, with different charges, weights, velocities and penetrations to be learned. Such knowledge is very useful for a gunner at a 4.7-inch gun, but its value to a man at a 10-inch battery seems somewhat dubious; if the 4.7-inch gunner knows it all thoroughly, and has it at his finger ends, both he and his company commander are to be congratulated, the former on his excellent memory and the latter on his perseverance, but to expect the 10-inch gunner to know it also, is to expect the impossible. But the 4.7-inch is only one gun, and there are over half a dozen others to be learned in the same manner.

In the aiming and laying of guns, where is any advantage gained in having a gunner at a mortar battery expert in the use of sights? He never needs them, why should he be troubled with them? If his mortars are of steel, why should he be required to know the charges and velocities for a cast-iron mortar and *vice versa*? If his battery be equipped with D.P.F. only and does not use the horizontal base system, why need he have any knowledge whatsoever of the latter?

It is simply throwing away valuable time when a company commander undertakes to teach his men subjects which they do not have to use. On the other hand no examination is prescribed in such an important branch of the battery service as the communications. The men must be instructed in the use and operation and, to a certain extent, in the adjustment of telephones and telautographs. Both fire direction and fire control would be impossible if they were not, hence why should not that subject be included? I think most artillery officers will agree that there is no one element of the battery service which is so frequently out of order and useless,—usually, too, just at the time when most needed—as the communications, and a great deal of such trouble would be avoided if the men assigned to such duties knew more about their instruments. I have more than once known communication to be stopped, simply because one of the telephone men moved the battery switch from its contact, he did'nt know any better; the hook switch too is frequently left down after the receiver is taken up, and then every body says the telephones are no good. A telephone or telautograph man needs training as much as a gunner does, he should know enough about his instrument to be able to discover any ordinary fault, he should be trained to talk intelligently through a phone, and he should receive credit for such knowledge in the gunner's examination.

The Type "A" Lewis D.P.F. is used by the men, but is not in the examination; the time interval bell is sometimes out of adjustment, and if no officer is present to put it right, vessel tracking must be abandoned unless the men have the requisite knowledge, why is that omitted? To sum up, everything which the men have to use and operate in the particular battery to which they are assigned, should be embraced in the examination and everything else omitted.

Again, rapidity in the use of instruments should be a factor. No matter how accurately a gun may be laid or a target plotted, if it is not done on time, it might as well have been left undone; speed is just as essential in the artillery as accuracy, and a quick man is of far more value than a slow one and should receive credit for it.

This is written with the idea of setting forth what are, in my opinion, the weak points of the present system of examinations, a system which has remained, to a large extent, unchanged in its principal features during recent years. In the days before the Spanish War, when the 8-inch converted rifle and the 15-inch smooth-bore were practically our only weapons, the subjects for an examination could be easily defined, since the same instruments were used, the same methods of plotting employed, and target practice was conducted in the same way for one kind of a gun as for another; then again, companies in those days were not usually assigned to any particular battery of guns, but were drilled and had target practice at all guns at the post, consequently the examinations for different companies could be absolutely uniform. Conditions however have changed greatly, and such is no longer the case. It may be said in general that each battery differs from every other in some particular, which the men manning it must be acquainted with, and with a three year enlistment, there is plenty for the men to learn around their own battery without attempting to master others as well. If a man has a good knowledge of his own gun, with its necessary range finding and communication appliances, he will be of more practical value to the service than if he has a veneer of the entire field of gunnery, and it would seem to me that if gunners' examination were conducted on that principle, the spirit of the Act of Congress would be more nearly complied with than it is at present.

BATTLE FIRING OF A BATTERY OF RAPID-FIRE GUNS OF THE ROUMANIAN ARTILLERY.*

On May 1st, 1903, there was held at the polygon of Dadiloff near Bucharest, in the presence of His Majesty the King of Roumania, some firing practice under battle conditions by a battery of rapid-fire field artillery of the Roumanian army. Now that our field artillery is to be armed with this modern rapid-fire material with controlled recoil, the results of such firings as are here presented possess the greatest interest, and even more so in this case because, to our knowledge, up to this time there have not been published complete results of firings executed according to the new methods.

These results show the effects that can be obtained with the new artillery, and demonstrate that the introduction of this material will necessarily lead to great modifications in the present methods of fire. This period of transformation will be, accordingly, a period of deep study and work for the field artillery, one in which it should learn to know thoroughly the capabilities of the new guns, and should master the new methods of employing them in order that it may fully derive from this material all the advantages possessed thereby.

The battery consisted of four rapid-fire 75 mm. Krupp guns, with shields, and four armored caissons, which, as shown in Plate I., were placed close beside the pieces when in the firing position. The guns were provided with Major Ghenea's telescopic sight, (see Plate II.).

The personnel of the battery had received three month's instruction.

The battery commander received, in the first instance, an order to open fire on a battalion in line of columns at mid-range (2,-600 m.). The target consisted of 4 companies in columns of sections, represented by 1040 standing figures.

After the reconnaissance of the target, the choice of the method of fire and of the auxiliary aiming point, the measure of the breadth (front) of the objective, and the determination of the lateral allowance for each piece, the battery commander executed his ranging fire by salvo for the purpose of determining a fork of 200 m., and then passed to the fire for effect—progressive fire with sweeping—which was completed in 52 seconds. 420 men of the battalion were hit. (See Plate III.).

* From the "Revue Militaire Suisse". July 1903, and "Kriegstechnische Zeitschrift", 7, 1903.

The following table gives the details of the firing:

Table I.

No. of the Salvo.	Commands of the Battery Commander.	Range.	Observation of fire.	Remarks.
1	Battalion on the march, 2600. Point of aim: tree by itself to the right. 1st piece, allowance 17, others at intervals of 28 plus. Corrector 25. From the right, by battery.	2600	Short, height of burst low.	1st piece, 17. 2nd piece, 45. 3rd piece, 73. 4th piece, 101.
2	2800	2800	Over, normal height of burst (hauteur-type.)	
3	2600	2600	Short, normal height of burst.	Salvo of control.
4	2500. Progressive fire with sweeping. Corrector 50.	2500, 2600, 2700, 2800 } Each piece three rounds with sweeping. Total, 48 rounds in 52 seconds.		Each piece changes its direction by one turn of the traversing hand wheel (8/1000) to the left after the 1st and 2nd round of the 1st range and to the right after 1 and 2 at the 2nd range, and so on; so that the 12 shots of one gun may be shown thus: 1 2 3 — 2500 m 6 5 4 — 2600 m 7 8 9 — 2700 m 12 11 10 — 2800 m > 20 m <

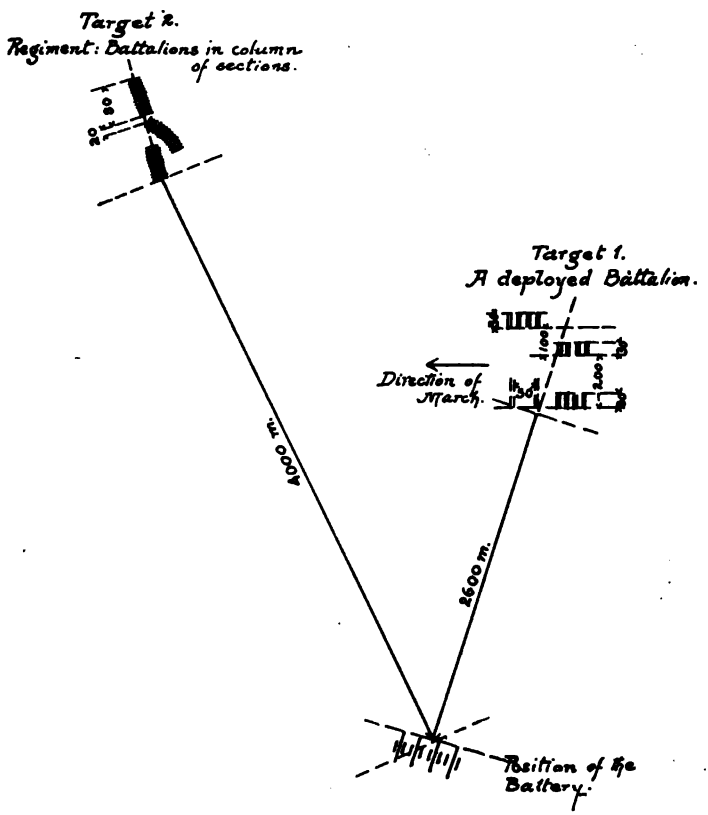


Fig. 1.—Sketch of positions of targets and battery of R.F. field artillery.

As the battery commander was familiar with the polygon, the regulation of fire, as well as the various steps in the preparation for fire, which was all executed according to the French regulations, do not offer any particular interest. On the other hand, the fact that with this method of fire a decisive result can be obtained in such a short length of time is of the greatest importance. The perfect instruction of the cannoneers—gun-layers, fuze-cutters and ammunition servers—also the immobility of the carriage in firing, and the type of laying apparatus played an important part in obtaining this result.

The Ghenea sight enables the gun layer to make changes of range during the return of the piece in battery, by lightly turning the elevation screw which is just in front of him, and that without taking his eye off the level, the bubble of which he brings to its central position as soon as the forward movement of the gun is finished. With the ordinary sight, changing the range elevation while the gun is in motion is impossible. It takes more time, is more difficult and would necessitate the layer's leaning forward in order to read the graduations. The regulations, moreover, prescribe that he should lean back when the gun is fired, so that if the carriage recoils a little,—which is not altogether imposible—he may not be struck by the sighting apparatus. The loss of time involved is a minimum, half a minute, perhaps, for a series. But seconds count, and all possible advantage should be taken of rapidity of action.

"Sweeping" is obtained by turns of the handwheel of the traversing apparatus. The center of gravity of the gun and of the cradle passing very nearly through the pivot of the cradle, this handwheel turns very easily. One turn corresponds to $\frac{8}{1000}$ of the range. Hence at average battle ranges, a zone 300 m. in breadth can readily be covered without break of continuity by successive changes of one turn of the handwheel.

The distribution of the fire was good. In this connection, from the point of view of rapidity of fire, attention may be called to the importance and advantage of having a sight with azimuth disk for use with an auxiliary aiming point and for the proper distribution of fire. In fact, the value of the "ligne de mire independante" is so great that no rapid-fire field gun can be made to render its maximum of efficiency without embodying this principle of laying.

Table 2.

		HITS.				
		Penetrated targets.	Imprints.	Bullets remaining in targets.	Fragments.	Total.
1st Company.	1. Section.	212	29	4	5	250
	2. "	18	10	1	—	29
	3. "	20	8	2	1	31
	4. "	88	13	5	3	109
2nd Company.	1. Section.	125	15	6	—	146
	2. "	113	17	7	—	137
	3. "	36	10	2	2	50
	4. "	31	15	1	—	47
3rd Company.	1. Section.	24	15	5	1	45
	2. "	18	26	5	—	49
	3. "	30	26	6	2	64
	4. "	40	27	8	2	77
4th Company.	1. Section.	10	11	—	1	22
	2. "	19	18	3	5	45
	3. "	23	13	4	—	40
	4. "	6	5	—	1	12

Total 1153

The effect of the fire was distributed fairly equally over the whole target. The table below shows the number of men hit:

Table 3.

	1st company.	2nd company.	3rd company.	4th company.
1st section	54 out of 65	51 out of 65	17 out of 65	8 out of 65
2nd section	14 " " 65	47 " " 65	15 " " 65	19 " " 65
3rd section	17 " " 65	28 " " 65	26 " " 65	19 " " 65
4th section	45 " " 65	22 " " 65	31 " " 65	7 " " 65
	130 out of 260	148 out of 260	89 out of 260	53 out of 260

total 420 out of 1040.

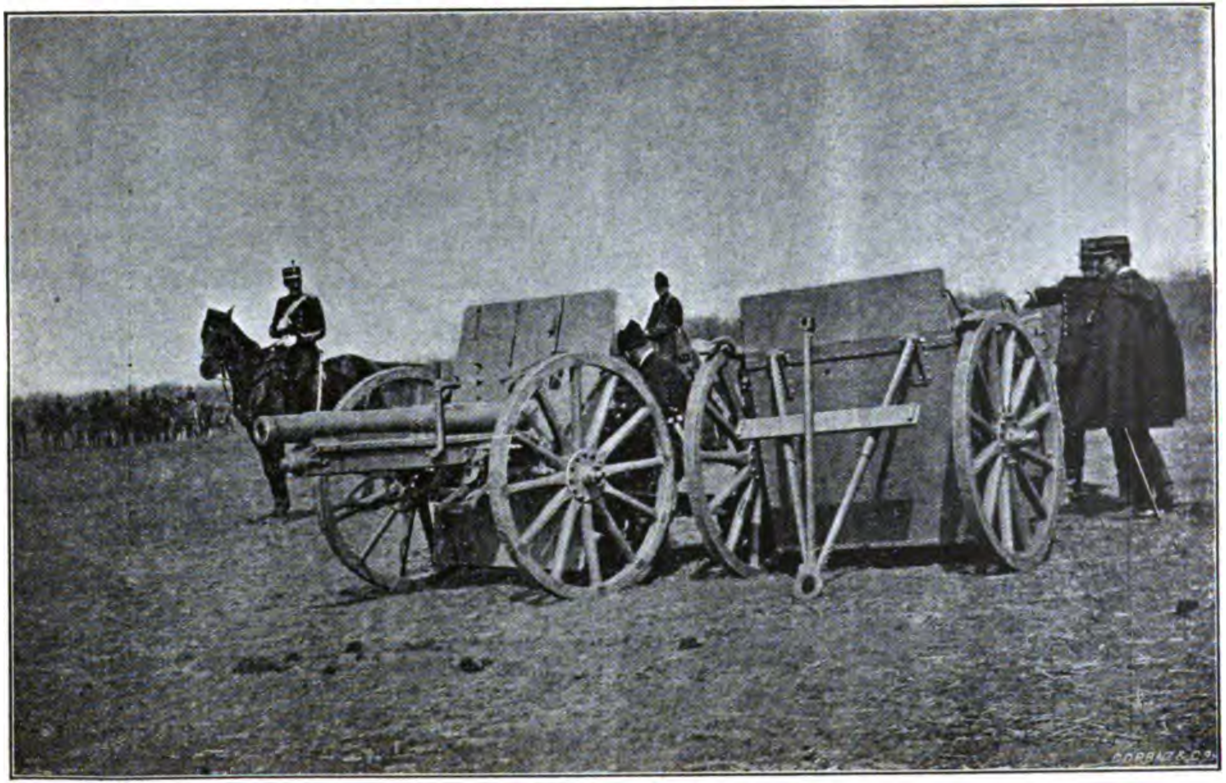


PLATE I. — Krupp 75 mm. R. F. Field Gun. — Roumanian Army.

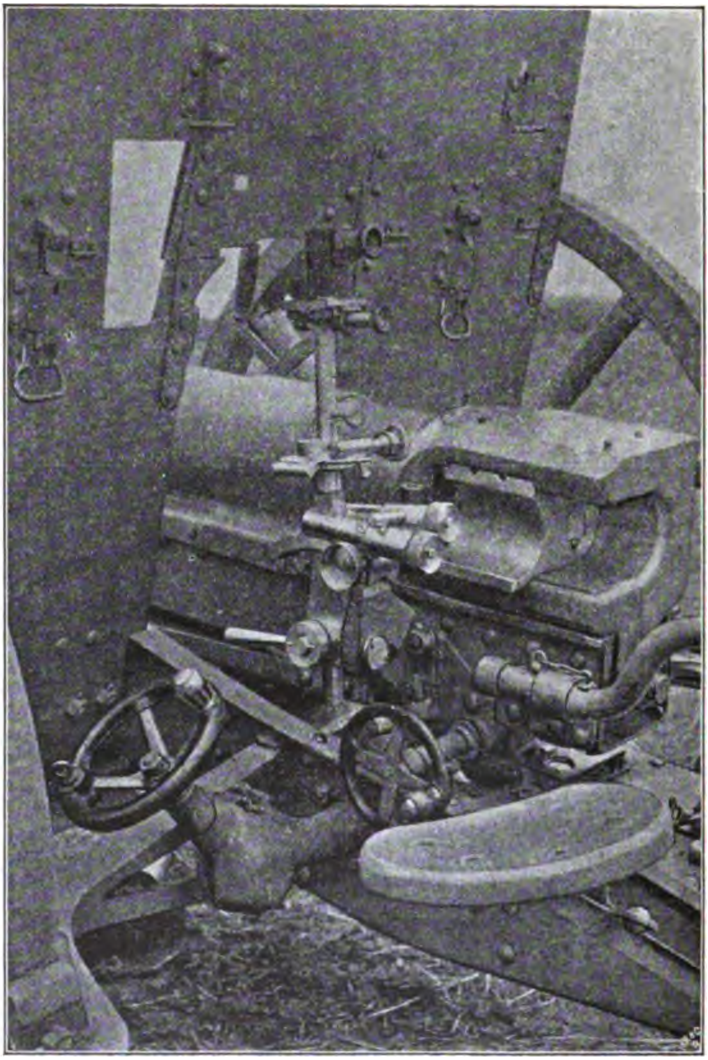


PLATE II. — Krupp 75 mm. R. F. Field Gun with Ghenea Sight.

ssif avec fa
gne de colonn

III. Compagn

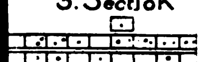
1. Section

15–Fix : 5–Ecl

2. Section

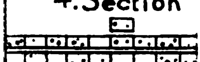
–Fix : 5– Ecl : (

3. Section



Fix : 6 — Ecl : 2

4. Section



7–Fix : 8–Ecl : 2

With the method of fire used in this trial, a surface of 120,000 sq. m. was covered by bullets. Some of the the bullets passed above the target in consequence of the dispersion in range, and some fell in front. Morever the three ranging salvos should have caused some hits. Finally, on account of the formation of the battalion, it is very probable that a certain number of bullets must have passed through two targets. Hence the density of the hits obtained can not be determined absolutely, As an approximate result, it may be said the vertical surface of the target was 826 sq. m.; the number of effective hits, 715; deducting 25% for bullets that pierced two targets, there remain 536 hits, which gives a density of 0.65. In actual service, it seems probable that the same number of hits can be counted upon, for men instinctively dispersing and opening out at the first fire of shrapnel would increase the extent of the target they offered.

The second problem of the battery commander was to fire at long range at a deploying regiment of infantry in three lines, battalions in column of sections. Each section was represented by a screen or target of the proper dimensions.

In view of the great depth of the target progressive fire was indicated; on the other hand its lack of breadth rendered sweeping unnecessary and useless.

After the regulation of fire—three salvos with low-bursting time fuze—the battery executed progressive fire twice, as a result of which in 2 × 40 seconds it obtained a total of 3681 hits. (See Table 5.)

The details of the firing are given in the following table:

Table 4.

No. of the Salvo.	Commands of the battery commander.	Range.	Observation of fire.	Remarks
1	Regiment in column, 3700. Point of aim: tree to the right. 1st piece, 1542 others at intervals of 4 plus. Corrector 25. From the right, by battery.	3700	Short, height of burst good.	
2	3900	3900	Over, height of burst good.	
3	3700	3700	Short, same.	Salvo of control.

Table 4. Continued.

No. of the Salvo.	Commands of the battery commander.	Range.	Observation of fire.	Remarks
4	3600. Progressive fire. Corrector 50.	3500, 3600, 3700, 3800 } 2 rounds per piece at each range; total 32 rounds in 40 seconds.		
5	3600. Progressive fire. Corrector 50.	Same, in 40 seconds.		

The hits were well distributed over the target. In the total area of 32,000 sq. m., 17150 shrapnel bullets fell, or 2 bullets to each sq. m. of vertical target. The total vertical area of the targets was about 2,600 sq. m. Hence there should have been 5,200 hits. There were only 3681, of which 2423 went through the target. Considering the position of the target and the direction of fire, probably ⅓ of the bullets went through two targets, so deducting ⅓ there remain 1615 effective hits, or .62 per sq. m., in other words, about every second man would be struck. This small number of hits can be accounted for by the fact that some of the rounds fired at the elevation 3500 were short, burst on striking and hence produced no effect.

Table 5.

			HITS.				
			Penetrated targets.	Imprints.	Bullets remaining in targets.	Fragments.	Total.
I. Battalion.	1st. Co.	1st section.	122	1	1	5	129
		2nd "	108	—	—	4	112
		3rd "	96	4	—	—	100
		4th "	162	2	1	2	167
	2nd. Co.	1st "	100	8	—	1	109
		2nd "	92	5	1	—	98
		3rd "	88	5	—	—	93
		4th "	76	7	1	—	84
	3rd. Co.	1st "	59	5	—	1	65
		2nd "	60	1	—	1	62
		3rd "	91	3	—	—	94
		4th "	95	8	—	—	103
	4th. Co.	1st "	50	4	—	1	55
		2nd "	59	1	1	—	61
		3rd "	67	8	—	—	75
		4th "	64	8	1	1	74
							1481

Table 5. Continued.

			HITS.				
			Penetrated targets.	Imprints.	Bullets remaining in targets.	Fragments.	Total.
II. Battalion.	1st. Co.	1st section.	40	13	—	1	54
		2nd "	30	6	—	2	38
		3rd "	39	9	—	3	51
		4th "	142	6	—	1	149
	2nd. Co.	1st "	15	14	1	1	31
		2nd "	145	8	2	1	156
		3rd "	106	15	1	2	124
		4th "	116	15	—	—	131
	3rd. Co.	1st "	53	7	1	—	61
		2nd "	18	9	3	2	32
		3rd "	29	8	—	1	38
		4th "	151	21	2	1	175
	4th. Co.	1st "	29	7	1	2	39
		2nd "					
		3rd "	The target fell down.				
		4th "					
							1079
III. Battalion.	1st. Co.	1st section.					103
		2nd "					113
		3rd "					106
		4th "					74
	2nd. Co.	1st "					100
		2nd "					82
		3rd "					79
		4th "					57
	3rd. Co.	1st "					67
		2nd "					50
		3rd "					68
		4th "					55
	4th. Co.	1st "					58
		2nd "					43
		3rd "					36
		4th "					29
							1121
							Total 3681

Another firing executed later on this same polygon serves as a further example of the practical application of the properties of rapid-fire field guns. The supposition was as follows:

An advance guard composed of a battalion of infantry and one rapid-fire battery on issuing from a wood encountered a position occupied by three battalions and three batteries each of four guns of the old model. The rapid-fire guns accompanied by their caissons went into battery at the edge of the forest and opened fire individually against the batteries and the infantry. Only a single piece really fired. This gun opened fire with low-bursting time fuze against one of the batteries of four pieces and regulated its fire for a fork of 100 m. (2,400–2,500), firing several series of two successive rounds. (Fire with a single elevation, French règlement.) It then fired twelve rounds at the short limit of the fork with sweeping in such a manner as to cover the intervals of the target. The ranging fire lasted 1½ minutes; the fire for effect, 1 minute. All the cannoneers of the battery fired at were hit, in all by 69 bullets.

These three firings show what may be expected of the rapid-fire material, and how the rapidity of its fire, its immobility in firing, and its facilities for rapid and accurate laying can be utilized to overwhelm an enemy in a minimum amount of time.

There seems to be no doubt that all the Powers now re-arming their field artillery with these new guns will have to adopt methods of fire similar to those of the French, and cast away old principles if they desire to realize to the full extent all the advantages which the modern material possesses.

Assuming the probability of raids by a Foreign Naval Power what are the best preparations to repel them so far as the construction, armament, and organization of our Coast Defenses are concerned?

EXTRACTS FROM ESSAYS BY CAPTAIN C. G. VEREKER, R.A., "DUNCAN" GOLD MEDALLIST, 1903, AND CAPTAIN C. S. S. CURTEIS, R.G.A., "DUNCAN" SILVER MEDALLIST, 1903.

Proceedings of the Royal Artillery Institution, April-June, 1903.

The class of attack to which each place is most exposed must vary according to its geographical position, its proximity to an enemy's ports or torpedo boat stations, and the probability of an enemy being in temporary command of distant seas.

In the heading of this essay, we assume the probability of raids by a foreign naval power. Most people agree that torpedo boat attacks are likely to take place during the earliest stages of a war, and even in some cases before war is officially declared. At this period it is probable that the reserve ships would be mobilizing and squadrons collecting and preparing for sea, and the moral result of a successful raid would be very great. An energetic enemy would spare no trouble in carrying it out and would not hesitate to sacrifice a few torpedo boats when even one getting through the defenses might do incalculable harm.

The different classes of coast defenses and the form of raid to which each is most liable can be summarized as follows:—

	CLASS OF DEFENSES.	MOST PROBABLE FORM OF RAID.
A.	Fortresses at home	By torpedo boats.
B.	Fortresses and coaling stations abroad	By torpedo boats (if within reach of an enemy's port). By strong force, if command of sea temporarily lost.
C.	Harbors of refuge at home.	By cruisers or torpedo boats and pinnaces carried by cruisers.

As each port should be so armed and organized as to be best prepared to meet the most probable attack, it will be convenient to discuss each separately and in the above order.

A. FORTRESSES AT HOME.

Defense against torpedo boat raids.

In order to divorce our thoughts from preconceived notions and existing works, it will be well, for the sake of discussion, to take an ideal case of a harbor with a narrow entrance to be defended against this class of attack, and to examine the various means of defense which might be available, and the most suitable organization. We may then be better able to see in what way existing works and schemes of defense might be improved.

Booms.—A boom or obstruction of some kind across the channel is essential if we are to be at all sure of preventing torpedo boats getting through.

No matter how good the gun defense and the lighting arrangements, if the boats only attack in sufficient numbers some are certain to get past, and if unimpeded, could run clear into the harbor.

It scarcely comes into the subject of this essay to discuss the various forms of booms, but the ones now in use should, we think, be quite good enough to achieve their purpose of at all events impeding or delaying torpedo boats.

The position of the boom necessarily affects the position of the guns and lights, and though it would usually be placed at the narrowest part of the entrance, other considerations might make it necessary to put it elsewhere and to employ a longer boom, or narrow the channel by breakwaters or the erection of "dolphins," permanently closing part of the shallower waters.

Mines.—Mines are not as a rule employed in defense against torpedo-boats, they have other and more important work to do in acting as a deterrent to the attack of larger ships, and should not be fired on the chance of sinking such a small and fast moving target as a torpedo boat, thus leaving a blank in the mine field. But there is one contingency which we must keep in view and which may make the employment of mines in narrow waters very necessary in the near future, and that is the possibility of being attacked by submarine torpedo boats. Such an attack could not be repelled by gun fire, a boom, unless specially constructed, would be of little use in preventing their entering a harbor, and mines may prove to be the best weapon of defense against them.

Electric Lights.—The arrangement of the electric lights is one of the most important factors in a successful defense and one of the most difficult to decide upon. The present recognized method is to have an illuminated area in front of the boom, and advanced lights termed "sentry beams" and "search lights" through which boats must pass before they reach the narrower waters near the boom. All things considered, this appears the best arrangement, as timely warning of the approach of boats can be given, and they come under close range fire as soon as they enter the illuminated area.

The scheme so often adopted of having guns and lights on both sides of the channel is, however, not always satisfactory, though some times necessary owing to the breadth of the entrance.

In the ideal case under consideration, it would be better to keep all the lights as far as possible on one side, thus giving a complete belt of light in front of the boom without any of the

TYPICAL DEFENSE AGAINST TORPEDO BOAT RAID.

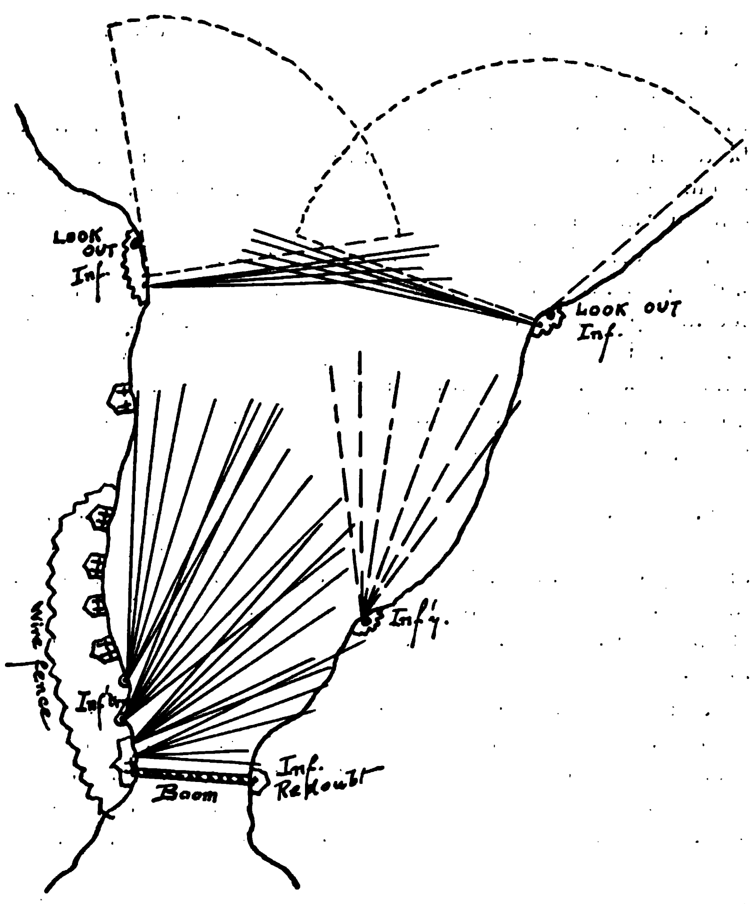


Figure 1.

beams crossing each other. The most advanced of these beams should be able to light up the water close to the shore to prevent any chance of "creeping," and if it were found that the lights would not illuminate the far shore sufficiently clearly, a beam might be placed as shown by dotted lines in the accompanying sketch, to light up that side of the entrance.

The beam nearest the boom should be capable of being turned upon it, to light it up in case of an attempt at destruction, but as a rule the boom should be left in darkness.

By such an arrangement of the lights, besides doing away with crossing, we make it more difficult for an approaching boat to judge where the entrance to the harbor actually lies, facilitate the protection of the lights against an attempt at destruction by small landing parties and enable the generating plant to be kept in one place.

In the case of sentry beams, however, this will not often be feasible, and we shall have lights on either side. As these are to enable timely warning to be given of the approach of boats, they should be placed as far out as possible. They should always be duplicated, in case of a break down, or of its being necessary to change carbons, and the spare lights used to search the water outside the sentry beams.

All electric lights should be situated sufficiently close to the water to prevent there being much "dead water." Their protection against an enemy's fire is now practically assured by the introduction of the "parabola ellipse" reflector, which enables them to be placed behind armor in which only a small aperture 3 feet high and 2½ to 8 inches wide, according to the angle of divergence, is necessary.

* * * * * *

The siting of the fixed beams depends on the sites selected for guns and mine fields. They may exist for both, or for guns alone. Each pair of lights should, if possible, be rather on the inner side of the batteries for which it is intended, and on a slightly lower level,as previously stated, as objects in the beam are more plainly visible from above it.

As regards the beams themselves, it cannot be too strongly urged that they should combine power with dispersion ; the former is sometimes sacrificed to the later. Rather than sacrifice power, the number of lights should be increased. The lights should be sufficient in number, or their power and dispersion increased sufficiently, to allow the whole channel within effective range of the guns to be fully illuminated. Otherwise the full fire effect is not obtained. This is merely a matter of calculation, and the nearer the channel, the greater the dispersion required. For instance, suppose a battery of 12-pounders with its mean line of fire at right angles to a channel 800 yards distant, and down the center of a pair of fixed beams with the usual 60° dispersion. A vessel on entering and leaving the beam will only be 900 yards from the battery, which, given light, could open fire with effect at 1,200 to 1,500 yards.

As far as possible on the outer side of the defenses should be a look-out post, in direct communication with all Q.F. batteries, and near it powerful sentry beams which should be solely employed in searching the approaches, with a view to giving as early an alarm as possible of any attack to the defense.

After the attacking torpedo vessels had passed the look-out post, these beams would probably have to be used as an exceptional case to aid the fire of the heavy guns of the outer batteries in keeping the covering fleet at a distance.

* * * * * *

Guns and Works.—The 12-pdr. Q.F., is an excellent all round gun for this class of defense; it is sufficiently powerful to sink a boat if it hits it and has a good rate of fire.

It is, however, quite possible that an enemy would send in some larger or heavier vessel with the object of smashing the boom to clear the way for the torpedo boats, and although submarine mines might succeed in stopping or sinking it, it is necessary to include in the defense, some heavier guns capable of dealing with such a case. A group of two 6-inch Mark VII. guns situated well away from the boom should answer the purpose.

All the guns should be placed on one side of the entrance when possible. This would simplify the lighting arrangements as before explained, enable an effective scheme for the distribution of fire to be devised, facilitate the rapid transmission of warning or orders, and the protection of the guns from a land attack, and do away with all chances of the bad moral effect which would result from shots from a battery on one side of the channel ricochetting into one on the other side, a contingency which has now to be met by "stopping" the guns, thus limiting their effective arc of fire.

Two is the greatest number of guns which can be efficiently looked after by one officer, who, besides having to direct his fire, must attend to the supply of ammunition and the replacement of casualties, &c.; all guns should therefore be arranged in groups of two, each group being perfectly self-contained and independent of all others.

These groups should be at least 50 to 100 yards apart to prevent confusion of orders and the effects of "blast" and "flash" on the laying of other guns.

The guns should be placed above and in front of the lights, with the exception of one group for the close defense of the boom. The best height above water at which they should be placed must, to a great extent, depend upon the conformation and nature of the coast line. The flatter the trajectory the better should be the chance of hitting at close range, and for this reason they should be placed as close to the water as possible; but, on the other hand, it is necessary for the efficient use of auto-sights, to have a certain amount of height, and we can say that about 40 feet above the sea should be their normal position, which will give accuracy with auto-sights up to about 1600 yards.

The high siting of guns may sometimes give what is called "dead water," upon which they cannot be depressed if the banks are steep and deep water comes close to the shore. In such a case it will be necessary to have one group close to the water's edge for the special purpose of covering this "dead water" area and prevent "creeping" by torpedo boats.

As the batteries are not intended to withstand a heavy fire, they will not require any great amount of protection, and as they will be used chiefly at night, they should be of very simple construction. There should be no lifts from the magazines to to the gun floor, and steps should be avoided as much as possible. Ample recesses should be built around the emplacements to hold all the ammunition likely to be required in action. Special attention should be paid for the sleeping accommodation for the detachments, as if they do not get good rest during the day they cannot be alert and up to the strain of continuous night work. There should also be small shelters by each gun so that a few men may always be in readiness to open fire the moment the alarm is given.

All batteries should have a slight infantry parapet in rear and should be entirely surrounded by an unclimbable fence to prevent any chance of their being rushed. If commanded by high ground within about 1800 yards which might be occupied by a landing party, they should have a parados or a high wooden palisade to screen the detachments from rifle bullets. They should, also, if necessary, be made with a strong traverse on the sea flank, to protect them from enfilade fire by a ship assisting the torpedo boats. This traverse would, also, to a certain extent, prevent "blast" from interfering with other groups.

Organization.—As a torpedo boat raid is the one we must be best prepared to meet, and as it may take place before mobilization has been completed, it is important that everything should be done in peace time to keep the defense ready for immediate action.

To obtain absolute efficiency, the defense against torpedo boats should be considered quite separately in all general schemes of defense. All the light Q.F. guns and the electric lights should be controlled by one officer, who would organize the defense in peace time, train the men in their work, and command them in war. He should have under his orders at peace manning, and on war mobilization, not only the R.G.A. to work the guns, and the R.E. to work the lights, but also any infantry told off for the special protection of lights and batteries, and men told off to lay and work the boom.

This officer, whom we could call the Fire Commander for torpedo boat defense, should, of course, belong to the R.G.A.

Though nominally under the orders of the Fortress or Section Commander, he should be given an absolutely free hand and held personally responsible for the preparation, training and organization of this part of the defense. This individual responsibility is absolutely necessary to ensure efficiency, and the principle has been recognized by the independence now given to G.G.C's. in charge of light Q.F. guns.

In action, the Fire Commander would in no way control or interfere with the fire of the lighter guns, though he might keep the direction of the heavier quick-firers, previously mentioned as forming part of the defense, in his own hands. His main duty would be the obtaining and transmitting of information to his batteries, and their protection against an attack from the land side.

For the purposes of communication, he would be telephonically connected with the Fortress or Section Commander, with the port war signal stations and with his advanced lookout parties.

The latter, in order to be able to give the earliest intimation of an attack, should be placed outside the sentry beams, and on sighting approaching boats or seeing them in the beams, would at once give warning by ringing a bell, the circuit of which, passing through the Fire Commander's post and the various batteries, would give the alarm simultaneously.

The system of firing rockets by lookout parties is not advisable, as it gives warning to the enemy that they have been sighted.

In some cases the Navy may have boats outside the defenses, which may be able to communicate information, but the desirability of this is a vexed question which we shall not discuss.

The Fire Commander should also be in touch, through the Fortress or Section Commander, with the land front outposts and the lookouts at the various possible landing places.

It is more than probable that small parties will land and attempt to destroy the lights or silence the guns in conjunction with the boat attack. The protection of landing places, and the action of the infantry comes more under the general defense of the fortress, but, as in spite of all precautions, a few men may creep through unobserved, the "torpedo boat defense" must possess an independent organization for its own protection at close quarters. Here again is an advantage of having all the guns and lights possible on one side.

The batteries should be able to protect themselves by carbine or machine gun fire ; the electric light emplacements and engine rooms, &c., should be surrounded by parapets and unclimbable fences, and have a small guard of infantry, and possibly Maxim guns if at all isolated ; the boom should be protected by a small work or loopholed wall at each end, the men in charge of the boom being reinforced, if necessary, by a few rifles *(see diagram)*.

It may be said that a great many of these precautions are quite unnecessary, but we maintain that the importance of these raids will be so great in a maritime war that an enemy will use every device possible, fair or unfair, to ensure their success, and we cannot take too great a care of our guns and men to go into details too thoroughly.

B. FORTRESSES AND COALING STATIONS ABROAD.

These, if within range of a torpedo boat raid, are as liable to this form of attack as our home fortresses, and the foregoing remarks as regards the preparation to meet it apply equally.

But they must also be prepared for a raid on a much larger scale, especially the smaller and more distant and isolated coaling stations, and should be armed and organized accordingly.

Mines.—Mines and Brennan torpedoes are likely to play a very important part in the defense and in preventing ships coming in to close range, but space does not allow a discussion of their merits as we are in an essay more particularly concerned with the artillery defense.

Electric Lights.—These must of course be established for the protection of all defended harbors at night, whether the harbor be exposed to a regular torpedo boat raid or not, as an enemy may send in boats and pinnaces during dark to reconnoitre, to countermine, or for other purposes.

The general remarks on the placing of lights already made in *A* hold good, except that instead of having a lighted area in front of a boom, the inner lights would be arranged to light up the mine fields.

The outer searchlights would have an important work to do in preventing an enemy's ship getting in close to the works unobserved, for, although it is agreed by most authorities that ships are unlikely to attack at night, it is nevertheless extremely probable that they will make use of the darkness to get in as near as possible, in order to open fire on the batteries at close range at dawn, instead of steaming in, in broad daylight, exposed for 8,000 yards or so to a far more accurate fire than any they can return.

Existing lights would appear unequal to lighting up even large vessels at anything over 2,000 to 3,000 yards except under very favorable conditions and it may, in some cases, be found advantageous to send out vessels fitted with searchlights to assist the defenders in discovering the approach of ships.

Guns.—We do not require many guns in coast batteries, but what we have should be the very best and highest velocity ones available. Modern ships are very strongly armored and unless we can penetrate their armor we cannot effectually cripple them, although by a rapid fire at the upper structures we may make them draw off.

Quick-firing is very important, especially with the lighter guns which may have but a small and fast moving target exposed for a very short time, or may be opposed to the lighter guns of ships at close range, when speed in firing will be essential.

With the heavier guns, a rapid rate of fire may also be necessary. It is the opinion of many naval officers that if ships engage forts, they will attempt to steam in at full speed to close range and then anchor, when the larger number of lighter guns they carry, and their better armor protection, may give them an advantage over the open shore batteries, which will be overwhelmed by a superior volume of rapid fire.

It may therefore be imperative for batteries to try and stop ships before they can get to close range, and fire will have to be opened at about 10,000 yards and gradually increased in rapidity as the range shortens and accurate laying with auto-sights, with which presumably all modern guns will be fitted, becomes possible.

To enable an accurate fire to be opened at these extreme ranges the guns must have a high initial velocity.

The projectiles from the heaviest guns should be capable of penetrating the belt armor of modern vessels at, at least, 2,000 yards, and those from medium guns should be able to pierce the armor of, and destroy, the secondary armament.

Works.—The introduction of high velocity guns and high explosive shell on ships sealed the doom of the elaborate granite forts, tightly packed with muzzle loaders, which figured so prominently in our coast defenses, and the tendency now is to keep to works of simple trace, made as inconspicuous as possible and armed with a few good guns.

Owing to the long range now obtainable from guns, the batteries need no longer be kept close to the water's edge, but can, if necessary, be withdrawn and placed on higher ground.

The adoption of automatic sights has made it important that guns should be mounted as much above the sea as possible, and where no high ground is available, an artificial mound is raised, or the old forts are made use of as a substructure on the top of which modern ordnance can be placed.

Besides the greater accuracy in laying, range-finding, and observation, obtainable from high sites, they possess every advantage for the heavier guns; these become less liable to be hit by an enemy's projectiles, as ships cannot come in to very close range or their shell would pass over the batteries without doing damage, and at long range their fire is not likely to be very effective.

At any but very close ranges, coast defense guns possess an enormous advantage over ships owing to their firing from a stable platform.

The latest works built afford, for the most part, good protection to the guns and detachments, but we still do not appear to recognize the importance of protecting the executive officers and the communications. One sometimes sees the battery commander and his range-finders with practically no cover at all, telephone wires exposed, and dials in the open where they could not remain five minutes under fire.

On board ship the executive officer is in an armored conning tower, sometimes as strongly armored as any part of the ship, his means of communication are close by him and the wires, etc., are led away in armored tubes.

Are not these precautions equally necessary on shore? Although the B. C. and his staff are nowadays no longer so indispensable as heretofore, and the guns can, if necessary, be fought just as well without them at close range, the effective direction of fire in the preliminary stages of an engagement still depends entirely upon them, and as long as they are found to be necessary they should be protected.

We therefore think that the B.C's post should consist of an armored emplacement or cupola placed in the most commanding position in rear of the center of his guns, where he could see what was going on, observe his fire and pass his orders without delay. His D.R.F. instruments should be close by him, as it is no longer necessary to place them on the flanks, owing to the introduction of smokeless powder; the instruments themselves should be of an "overhead" type, in order that they and the detachment working them may be safe. All telephone wires, speaking tubes, etc., should run direct into and from the B.C.'s post and when not buried at least a yard deep should be carried in steel pipes; all range indicator dials of the present clock faced pattern and "figures" should be relegated to the scrap heap and reliable electric range dials and order dials introduced, so that the whole of the communications may be under cover.

Another point requiring consideration when constructing new works, is the nature of ground used on the outer slopes. This, if of a crumbly nature, causes clouds of dust to obscure the view of the guns even at peace practice, and when thrown about by the bursting of an enemy's high explosive shell, might make it quite impossible to carry on direct fire at all; if shingly, it may make things quite uncomfortable for the gun numbers in action, though this would be the lesser of the two evils. A heavy soil well bound together by surface roots or grass would appear the most suitable for the purpose, but would rarely be available at foreign stations.

The drill book recognizes that at close range, owing to dust and smoke from the enemy's bursting shell, it may be impossible to lay the guns over the sights, and to meet this eventuality it has been found necessary to retain position-finders, placed some distance away from the batteries, so that the guns may be fought by Case III. from under cover. The cells for these instruments will require very careful screening, more so than is sometimes the case at present, in order that an enemy may be unable to ascertain their position even at a short distance, as otherwise he will no doubt do what he can to render them untenable.

The ammunition supply to guns is a very important detail to attend to. It is pretty well recognized that it would, in these days of rapid fire, be inadvisable to attempt to supply guns in action direct from the magazines by lifts, but that all the ammunition likely to be required will have to be previously brought up and placed handy in recesses near the guns. It is therefore necessary that these recesses should afford ample room for the storage of a plentiful supply, be easily get-at-able, and be well protected from an enemy's fire.

Batteries should be well defended on the land side, for whatever the action of the ships, there can be no doubt that if the destruction or capture of the works is aimed at, landing parties will play a very prominent part, and their success or failure will probably decide the ultimate result of the raid. Every battery should be a self-contained fortress, if at all isolated, and its safety should not depend entirely upon the advanced infantry; it should have a good infantry parapet, be surrounded by unclimbable fences, entanglements, abattis, and other obstacles, have a clear field of fire, defiladed by a parados or by traverses if the interior or the guns can be commanded by high ground, and in fact be made as impregnable as modern fortification can make it.

Organization.—The reduction of the number and types of guns used, and the introduction of auto-sights will very greatly affect the organization for defense.

This must be as simple as possible and the main object kept in view must be decentralisation of responsibility and the encouragement of individual initiative.

There must be one supreme head of the defenses on both the sea and land fronts, but section commanders and fire commanders should be reduced to a minimum, and battery and gun group commanders should be prepared to act upon their own responsibility without waiting for orders from higher authority, for, under modern conditions, there will be little time to spare between the sighting of an enemy and the opening of fire. All orders as to selection of targets and distribution of fire should be arranged in peace time and frequently rehearsed so that when the attack takes place each individual may understand exactly what is required of him and act without hesitation.

In any case the higher commands must gradually become of less importance as ships approach the batteries, until, when these are within effective auto-sight range, we may expect to find each gun acting independently and correcting its own fire. It is absolutely impossible for a B.C. or G.G.C. to make himself heard, or to pass orders, if three or four Q.F. guns are firing with any rapidity, and it is to be hoped that this may before long be recognised by our drill books, and that our men may be trained in the observation and correction of fire of each gun by its gun captain and layer whenever auto-sights are used. This system has already been tried at practice and found to work very well; it will however, entail a much higher standard of intelligence on the part of our N. C. O's and men, more care in the selection of gun-layers, and a thorough knowledge of the guns and mounting in use.

* * * * * *

Gunners should be given that work for which they are best suited physically. Q. F. gun drill requires men with a quick, active physique, not necessarily big men, but hard, wiry men of middle weight, who can move quickly and can last. Fat and clumsy men are utterly out of place. Selection of men of suitable physique has much to do with the maintenance of a high rate of fire.

When gunners are first called upon to defeat an enemy's raid, with the alternative, in the event of failure, of perhaps millions of dollars worth of *matériel* lost to the nation, the all important man will be the gun-layer. He will be at his gun waiting, see a torpedo vessel enter the beam perhaps at over 20 knots an hour, and have to stop that boat while it is under his fire, perhaps for one or two minutes only, if that in some cases. What conditions can be more calculated to upset a man's nerves, to make him in fact lay his gun less accurately than usual? Some men have a natural genius for gun laying, are always sure of themselves, have a marvellous control over elevating and traversing numbers, and always keep cool. We see it in the tests to which we put them in peace time, when they consistently lay a gun accurately in about half the time the average layer takes. Yet we let these men go when their time is up. We make no more effort to retain them than any ordinary man. We apparently go on the principle that we can always make such men, Yet, if we could keep them by making it worth their while to stay on in the service, we should have men who would get the highest rate of fire possible, given good drill, and get a hit every round. The value of such men in war time is exactly the value of the damage saved to the nation, and it is not exaggerating to say that there are such men, but they are comparatively few. The free board of a torpedo vessel is only about four feet, easy enough to hit in day-light, but given a dim, uncertain light and nerve breaking conditions, anyone, who knows how any error with an auto-sight is exaggerated, will fear for the result with the average gun-layer. It will be worth our while to pay these men the wages they would earn in civilian life to induce them to stay.

* * * * * *

Every gun has its own peculiarities, and it is just as necessary for a detachment to know their gun as for a sportsman to know his, or an infantryman his rifle. As at stations abroad, the men required to work the guns are, or ought to be, always on the spot, it could be easily arranged to have a number of them told off to each gun and to get them to look upon it as their own particular weapon, much as is done on board ship; they should be responsible for keeping it cleaned and in working order, for mounting and dismounting it when necessary, and should always keep to it at drill and use it at practice and in action.

In the same manner, the Specialists should have charge of their instruments and communications and should be capable of testing, adjusting, or repairing them.

If organized on these lines, the higher ranks would then have their duties in peace and war clearly defined. The G. G. C. would be in charge of his group of guns and their ammunition supply, the B.C. of his battery, its instruments, communications, etc., and the F.C. of his fire command; not on paper or occasionally when manning, but always, and absolutely, so long as serving in a station.

C. HARBORS OF REFUGE.

The defense of these calls for few further remarks. Most of what has already been said under *A* and *B* applies to some extent in this case.

Although it will rarely be feasible or desirable to close the entrance with a boom, there must be a good proportion of light Q.F. guns in the armament, and electric lights must be provided, in order to prevent raids by small boats during dark. The defense might be greatly assisted by a line of anchored barges or pontoons carrying quick-firing guns, if the entrance is at all broad, an illuminated area being established just in front of these, but any form of floating defense should be avoided if possible as it is likely to interfere with the freedom of fire of the land guns.

If larger vessels attack they will probably be cruisers or "commerce destroyers," and to meet these an armament of 6" gus should, as a rule, be good enough, with perhaps a few heavier guns to deal with a possible attack by armored cruisers or battleships and keep them out of bombarding range of the shipping.

These defenses are not intended to stand a determined attack, which, as already explained, is an extremely remote contingency, and there is no necessity for overdoing their armament, but the few guns provided must be the very best.

An attack by a landing party being extremely probable, as some harbors of refuge are somewhat isolated, and as a large force may not be available for their protection, the batteries, while made safe from a sudden rush by means of the usual parapet and unclimbable fence, must be further guarded by small infantry redoubts occupying any high ground within range of the rear of the batteries, and which might be occupied by the enemy with a view to keeping down the fire of the guns while the attack on the shipping in harbor is made. The landing places should also be guarded by small redoubts, which might with advantage be provided with one or two 4.7″ guns able to fire shrapnel shell at any boats attempting to land men.

No elaborate organization or chain of command is necessary, as, if attacked, there will be little doubt about what to do and how to do it, provided definite orders and instructions have been issued beforehand.

The garrison should consist in great part of local Militia and Volunteers, who will take a personal interest in the defense of their port and homes, will know the coast and surrounding country, and can be trained in peace at the work they will carry out in war, so that on mobilization there will be no delay, and the port will be placed in an efficient state of defense against raid before the declaration of war.

PROFESSIONAL NOTES.

ARTILLERY MATERIAL.

Smokeless Powders: Their History and Present Classification.

Although the manufacture of smokeless powder has lately made enormous progress, the subject is yet in the experimental stage. Both chemists and practical workers must still make great efforts to obtain the best possible results. The fact is not to be ignored that the powder mills of the United States produce daily from 12,000 to 18,000 pounds of smokeless powder, whose quality has been acknowledged satisfactory by the Army and Navy Departments. Certainly excellent results have been attained, but does this powder satisfy all the conditions resulting from prolonged storage and climatic changes? All that can be affirmed at present is that there is no proof for a negative answer.

Although the history of smokeless powder is doubtless familiar to the majority of chemists, it may nevertheless be useful to recall briefly different stages it has passed through before attaining its present development.

In 1832 Braconnot discovered while treating starch, woody fiber, and similar substances with concentrated nitric acid, that a very combustible body could be obtained, to which he gave the name of xylidine. These experiments were taken up and completed by Pelouze in 1838, and this savant likewise had recourse to paper as original material. Somewhat later, Dumas prepared, by means of paper, a substance that he named nitramidine and suggested that it be used for the manufacture of cartridges. But this substance was found uncertain and not very useful, and the researches had no practical result, when Schönbein, in 1845, announced the discovery of guncotton. In 1846 Boettger likewise stated that he had produced guncotton. Consequently these two inventors entered into partnership after having ascertained that their processes were identical. At about the end of 1846, Otto described a process for the manufacture of gun cotton, and in 1874, W. Knop, in Germany, and Taylor, in England, discovered that guncotton could be prepared from a mixture of nitric and sulphuric acids.

Then numerous experiments were made in different countries for the purpose of replacing ordinary powder with this new explosive. But it was very soon discovered that this was impossible. Frightful and inexplicable explosions occurred frequently, and this caused the general abandonment of the attempt. Nevertheless, in Austria, Baron von Lenke persisted, and in 1862 patented his processes in England. In 1865 Abel also took out a patent for an improvement, consisting essentially in reducing guncotton to the form of a paste, which allowed the elimination of every trace of acid and rendered it more stable.

The grinding and cutting up of the cellulose fiber in specially adapted apparatus, allowed the expulsion of free acid that it had retained by capillarity, and thus one cause of its instability was removed. This process, in use at the present time, has rendered possible the employment, more and more extended, of guncotton.

Nitro-glycerine was discovered by Sobrero, who, by the advice of Pelouze, had undertaken the study of the action of nitric acid on glycerine. Nevertheless, to Alfred Nobel belongs the honor of opening the way for the actual evolution of smokeless powder. After discovering explosive gelatine, he ascertained that, by means of a suitable solution, nitro-glycerine and guncotton could be mixed in varying proportions. He thus obtained a hard horny substance, which could be granulated and employed with perfect security as propelling power in cannon, a substance to which he gave the name ballistite.

The more recent history of smokeless powder dates from 1886, when Vielle prepared in France the B powder. The powder of Captain Schultz made its appearance about the same time. In 1882 Reid & Johnson had tested in England the powder C. E., which has been adopted for the artillery. The ballistite of Nobel was patented in 1888. Since that time numerous compositions have been proposed, of which, nevertheless, the majority have not been attended with the good results expected.

The term guncotton employed above to designate all the varieties of nitrated cellulose is not quite exact, since by this term is generally designated the most highly nitrated cellulose insoluble in alcohol-ether. Consequently the term nitro-cellulose will be employed as corresponding better with the facts and designating both the soluble and insoluble varieties.

The smokeless powders known at the present time can be assigned to three classes.

CLASS I.

The powders composed of nitro-cellulose, either with or without the addition of salts, capable of being freed from oxygen or inert organic substances.

This class comprises several sub-divisions, according to the degree of nitration and of the solubility of the nitro-cellulose.

(*a*) Powder composed of gun cotton (fulmi-cotton) trinitro-cellulose with 14.14 per cent of nitrogen, although in manufacture the proportion seldom exceeds 13.35 per cent. This powder is insoluble in a mixture of two parts of ether and one part of absolute alcohol and only contains a very small proportion, generally less than one per cent of soluble nitro-cellulose.

(*b*) Powders composed of a mixture of insoluble nitro-cellulose and of soluble nitro-cellulose.

(*c*) Powders composed of soluble nitro-cellulose.

These three sub-divisions can be varied infinitely by the addition of salts able to liberate free oxygen (commonly the alkaline nitrates), or inert organic matters (camphor, coloring substances, vegetable oils, mineral hydrocarbides and others).

CLASS II.

Powders containing nitro-glycerine in combination with nitro-cellulose.

This class may likewise be divided into sub-divisions according to the kind of nitro-cellulose employed and the presence or absence of oxygenized salts and of inert substances.

CLASS III.

Powders into whose composition enters picric acid, the picrates, or the nitro substituted products of the aromatic hydrocarbons in combination with one or several of the substances enumerated in classes I. and II.

Smokeless powders ought also to be differentiated according to their physical properties; that is, a distinction should be made between the powders called "bulk-loading," and those called "compact." The first have a low specific gravity and are manufactured in such a manner that they can be changed, charge for charge, like black powder; in other terms, that the same measure which serves for the black powder can be utilized to measure an equal volume of this class of smokeless powder, capable of producing volume for volume almost the same velocity and the same pressure. These powders are almost exclusively employed for fowling-pieces, with lead projectiles; that is, in cases where it is only desirable that the speed should be superior to that which a regular charge of black powder produces. The "compact" powders, on the contrary, have a high specific gravity, and are used from a preference in weight, provided the volume occupied by a full charge is only from a third to a half of the volume occupied by an equivalent charge of black powder. The smokeless powders for cannon are the compact powders whose specific gravity, varying between 1.58 and 1.67, approaches that of black powder.

All these productions have their merits and their defects, and the idea composition is yet to be found.

The manufacture of smokeless powder is quite a delicate operation, and to obtain satisfactory results certain indispensable conditions must be observed, of which the chief are enumerated below.

1. The powder must be chemically stable, and when submitted to a storage more or less prolonged, ought to show no sign of decomposition or of disorganization.

2. Exposed to the action of humidity, of heat, of cold, and climatic variations, it should undergo no change.

3. It should not be too sensitive to shock or friction.

4. It ought to be easy to manipulate and to be transported without danger.

5. Its gases arising from combustion should not have a disagreeable odor, nor have an injurious effect on the system.

6. It should be easily formed into grains of all sizes, and the shape of these should only be modified within very narrow limits.

7. It should be perfectly homogeneous.

8. It ought to possess the greatest possible ballistic power; it ought, in other words, to communicate to the projectile the greatest speed while giving the least possible pressure in the cannon.

Nitro-cellulose, soluble or insoluble, apparently lends itself better to the preparation of a smokeless powder, satisfying all the conditions. This substance enters into the composition of almost all the smokeless powders at present known, and the ballistic results obtained are very satisfactory, whether the nitro-cellulose is mixed with other substances, or employed in the form of a simple colloid of nitro-celloluse. The nitro-cellulose, in combination with nitro-glycerine, likewise gives very good results. This combination constitutes the English cordite, composed of 58 per cent nitro-glycerine, 37 per cent trinitro-cellulose, and of 5 per cent of vaseline.

But on the other hand, a certain number of compositions containing nitro-glycerine, in relatively slight proportions, in combination with nitro-cellulose, soluble or insoluble, have not given good results, and it is still unknown whether this is due to the composition, or to the granulation, or to both.

Nitro-glycerine, constituting a chemically stable combination, seems to be best adapted to the preparation of smokeless powder. The action of nitric acid on glycerine

$$C_3H_5O_3H_3 + 3\ HNO_3 = C_3H_5O_3\ (NO_2)_3 + 3\ H_2O$$

produces a compound which, purified by repeated washings, is homogeneous and stable.

Nitro-cellulose, although perfectly stable, cannot be considered as a chemically definite compound. It consists of a mixture of nitro-celluloses in different degrees of nitration. As regards the structure of the cellulosic fiber, it has been impossible to obtain the theoretical results, by nitrating with a mixture of nitric and sulphuric acids.

The product designated trinitro-cellulose

$$C_6H_{10}O_5 + 3\ HNO_3 = C_6H_7O_5\ (NO_2)_3 + 3\ H_2O$$

exhibits in the nitrometer 14.14 per cent of nitrogen, while practically only 13.35 to 13.65 per cent is obtained. The difference is due to the presence of cellulose not transformed, and perhaps also to the presence of very small quantities of lower nitrates. The soluble nitro-celluloses, whose employment is so extensive in the manufacture of smokeless powders, consist undoubtedly of a mixture of nitro-celluloses of different degrees of nitration, and for this reason they do not seem to be as suitable as a definite and homogeneous chemical combination.

Another disadvantage attending the employment of nitro-cellulose is due to its high price, which is much greater than that of nitro-glycerine.

It is interesting to note that Eder has prepared a nitro-cellulose soluble in etherized alcohol, which he calls penta-nitro-cellulose.

$C_{12}H_5O_5\ (ONO_2)_5 = 12.75$ per cent of nitrogen and which seems to be the most soluble of all known nitro-celluloses. Nevertheless M. Aspinall has quite recently prepared a soluble nitro-cellulose, showing 12.91 per cent of nitrogen by the nitrometer. —*Scientific American Supplement*, July 25, 1903.

BALLISTICS: ARMOR AND PENETRATION.

The Theory and Practice of Armor Attack.

Since Captain Tressider brought forward his formula for the perforation of wrought iron it has been accepted in this country as the standard formula for that class of plate, and although wrought iron is a thing of the past, it still serves as a basis from which we can arrive at the relative values of the various kinds and thicknesses of steel plates.

The formula in question is in the ordinary English notation

$t^2 = \frac{w}{d} v^3 \times \frac{1}{\log.^{-1}\ 8.8410}$ and is very similar in form to those of Krupp and de Marre. It has been tested and found to give reliable values of t for velocities between 1500 f.s and 2400 f.s. When, however, we come to modern hard-faced steel armor there is no such general agreement between the various competing formulas.

Krupp is alone in making $t \propto v$, Davis makes $t \propto v^{\frac{4}{3}}$, and the Russian formula used by Vickers makes $t \propto v2.1$

The last mentioned is $t^{0.7} = \frac{w^{0.5}}{d^{0.75}} v \times \frac{1}{\log.^{-1}\ 3.1977}$, and is frankly empirical.

So probably is Davis' $t^{1.5} = \frac{w}{d} v^2 \times \frac{1}{\log.^{-1}\ 6.6900}$.

Krupp's $t^2 = \frac{w}{d} v^2 \times \frac{1}{\log.^{-1}\ 6.3532}$ is believed to be based on theoretical considerations as far as t and v are concerned, but their validity is at least doubtful. The dynamical problem involved in the punching of a hard-faced steel plate is an immensely difficult and complicated one, and in our present state of knowledge it is impossible to theorize usefully about it. We very much doubt whether any simple monomial formula will be found adequate over the whole range of t's and v's.

Krupp's formula gives very good results for plates of K.C. between 4-inch and 6-inch in thickness.

At 6-inch nearly all formulas agree in making the velocity necessary for a 6-inch uncapped shot to perforate somewhere about 2150—2200. To guard against misconception, we may as well state here that under the term perforation we include both punching and boring. Above 6-inch, more especially in the case of 12-inch plates attacked by 12-inch projectiles, Vickers' formula would appear to give truer values of v than Krupp's. But the fact is that we have too few data to go on to speak with any certainty in the matter; 6-inch plates are attacked with 6-inch projectiles, 9-inch plates with 9.2-inch, and 12-inch with 12-inch, and we can thus make very fairly certain of one point on the perforation curve of each gun; but that is all, and until at least three points can be found on each curve, all formulas must be looked upon with suspicion, and accurate prediction is impossible. Only by progressive experiments with different calibres of gun against a constant thickness of plate, and by the same gun against varying thicknesses of plate can this be done, and it is to be hoped that either the Government or some leading private firm, such as the Sir W. G. Armstrong, Whitworth and Co., or Vickers, Sons and Maxim, will attempt something of the sort.

One of the most striking things about these modern hard-faced tough steel plates, of which the Krupp cemented is one of the best and best known varieties, is the way in which they yield when overmatched by the attacking projectile. In the case of wrought iron or soft steel, the plate first bulged at the back, then a star-shaped or three-cornered tear appeared, and, finally, the corners were doubled back and the shot came through. Hard steel plates of homogeneous texture usually were broken up as much as a tile is when a weight is dropped on it. In the case of the soft material, perforation varied inversely as the diameter of the shot.

In the case of racking the effect produced was proportional to the impressed energy and quite independent of d. However, in these modern cemented plates neither effect is usually produced; the plate is neither bored, nor, as a rule, broken up, but a large disc, considerably greater in diameter than the d of the shot, is punched out of it. This behavior was occasionally noticeable in compound plates, which, however, usually yielded by fracture. The disc is slightly conical in shape, and it looks as though the plate bent back when struck and then gave way circumferentially. In a few cases a plug of about the same diameter as the shot is punched out, and concentric cracks are noticeable round the central hole. Such plates are probably rather wanting in hardness, although the opposite opinion is also held that this action is associated with relative inferiority of projectile.

The above remarks apply to the effect of uncapped shot. With capped shot a totally different effect is produced. A clean round hole is made through the plate, and there is usually rather less surface scaling. This difference in effect is undoubtedly due to the fact that the point of the projectile is protected and prevented from being splintered on the hard plate face, thus enabling the shot to do its work properly as a boring tool. In many cases the shot passes unbroken through the plate, which is never the case with the uncapped projectile.

It has been suggested also that the cap sets up a molecular vibration and weakens the plate locally, so that the point of the projectile has less work to do in getting into the plate. It is impossible at present to say whether this is so or not; but in any case it does not affect the first reason, which is quite sufficient in itself to account for the behavior of the capped shot.

We do not believe that any serious student of the subject attaches importance to the theory that the cap acts as a lubricant.

There are, however, limits to the capabilities of the cap. It is unquestionable that at 30 degrees the advantage conferred by the cap is nil, or almost nil, while it is almost equally certain that there is a velocity below which the cap is not only useless, but worse than useless. In the case of the 6-inch this velocity is probably somewhere between 1600 f.s. and 1800 f.s. No experimental results have been published showing advantage with striking velocities of less than 1800 f.s.

At about 1950 a 6-inch capped shot fired normally will get through a 6-inch K. C. plate, and at about 2800 it will get through a 12-inch plate. Plotting these on logarithmic paper, we find that the horizontal and vertical coordinates are approximately as 1 to 2, thus indicating that $t \propto v^2$, t being measured vertically. Continuing this curve until it meets Krupp's curve for 6-inch uncapped projectiles, we find they intersect at about 1800 f.s., while Vickers' curve meets it at between 1500 and 1600 f.s.; theory thus confirming, or, rather, being confirmed, by experiments.

Should, however, it turn out that in the case of uncapped projectiles $t \propto v^n$ where n is some power of v greater than $\frac{3}{2}$, it will not necessarily conflict with experimental results, as even if $t \propto v^2$ the cap would give no appreciable advantage over 1000 f.s., and as the ideal cap would vary in weight with the S.V. required, whereas the actual cap must necessarily be of a constant weight for all striking velocities, that alone would be sufficient to account for any discrepancy between theory and practice.

Another limitation of the cap is the fact that it can only give good results with a projectile which will not break up in or on the plate. This condition does not obtain except with A.P. shot. No A.P. shell has yet been got intact as far as we are aware, through a plate of even $\frac{2}{3}$ calibre, and at present, at any rate, the cap confers no advantage on this most important class of projectile. *A fortiori*, it is useless for pointed common shell.

There are indications at present, however, that a shell may be designed of less capacity than the present A.P. shell—probably $2\frac{1}{2}$ or 3 per cent as against 4 to 5 per cent—which will be able to do what is required, and to carry its burster through a plate of its own calibre. The heavier shell, in particular, such as the 9.2-inch aud 12-inch, which, with a 3 per cent capacity, could carry about 11 pounds and 25 pounds, respectively, of lyddite or other high explosive, would be of very great value, and would be suitable for employment with a cap. At an angle of 20 degrees such a 9.2-inch 380 shell could take its burster through about 9 inches of K.C. at a range of 3000 yards.

In America, during the comparative trial of the Gathman and United States army gun, a shell or shot of 2 per cent capacity, ($d = 12$, w 1000) containing 20 lbs. of high explosive, was put through a 12-inch Carnegie K.C. plate, with S.V. 1800 f.s., and detonated in rear. From the appearance of the hole, the shot was capped, though this was not stated. A second similar shell burst in the plate and cracked it badly, punching out a disc. It would be interesting to see if the experiment could be repeated over here. The American plate seems to have been rather inferior to our Krupp plates of equal thickness. —*Engineer*, July 17, 1903.

Armor Perforation Formulas.*

A COLLECTION WITH NOTES.

BY BREVET-MAJOR W. E. EDWARDS, R. A.

To those interested in the subject of armor and its attack, the following collection of armor perforation formulas may be of value.

They have been got together from various sources. British and foreign, in various forms and in various notations, some in metric and others in English units. They have been cast as far as possible into the same form (one suitable for logarithmic computation) and have been arranged in two columns, one in English and one in metric units, problems occurring as often in the latter units as in the former, and the labor of conversion being considerable. The following notation has been employed :—

ENGLISH UNITS.	METRIC UNITS.
t = thickness of armor, in inches.	s = thickness of armor in cm.
w = weight of projectile (A. P. shot) in pounds.	p = weight of projectile in kilos.
v = striking velocity in feet-sec.	v = same velocity in metres-sec.
d = diameter of projectile in inches.	a = diameter of projectile in cm.

N. B.—In continental notation E is also used to indicate thickness of plate perforable. Both S or E, and a, are frequently given in decimetres instead of in centimetres, and as it is a common fault with writers on the subject not to explain their units and notation, much confusion arises.

To avoid misconceptions, it may as well be stated here that both punching and boring are included in the term perforation.

Two diagrams are attached. One shows on a logarithmic chart the perforation of wrought iron by Orde Browne's, Maitland's, Tressider's, de Marre's and the Gâvre formulas for the 6'' gun with 100 lb. projectile at striking velocities between 1,000 and 3,000 feet per sec.

The second diagram, also on a logarithmic chart, shows the perforation of hard faced steel armor given by the U. S. Navy, Krupp's, and the modified Krupp, formulas, at the same striking velocities as in former diagram, for the following guns :—

12'' w = 850 lbs.
9.2'' w = 380 lbs.
7.5'' w = 200 lbs.
6'' w = 100 lbs.
4.7'' w = 45 lbs.

It will be noticed that the $\frac{w}{d^3}$ of these guns varies from 0.49 in the case of the 12'' and 9.2'' to 0.43 in the case of the 4.7'', yet there is no practical difference in the values of t for any of these guns, given by the Krupp formula $t^2 = \frac{wv^2}{d} \times \frac{1}{\log^{-1} 6.3532}$ or by the modified $t = \frac{vd}{2200}$ formula where $\frac{w}{d^3}$ is taken as constant and equal to 0.46.

The latter equation is so much simpler and easier to use than the former that it would seem unnecessary for practical purposes to employ the longer and more complex formula; more especially when we bear in mind the fact

* Proceedings Royal Artillery Institution, April-June, 1903.

that the class of armor for which it is intended varies so much in resisting power, even for plates of the same thickness, that no formula can give us more than an approximate estimate for t or v in any particular case.

The advantage of using logarithmic coordinates is that the graphs of all monomial formulas become straight lines and consequently only two points on each curve instead of half a dozen or more need be found. Also for the same formula, the curves for all calibres of gun are parallel.

Since however the resistance to perforation of hard faced steel armor varies so much both with the thickness and nature of the plate, it is as a general rule more advisable to find t by first finding the perforation into wrought iron (which is a material of fairly constant resisting power) by Tressider's or other suitable formula and then dividing by a suitable factor, which is frequently called the figure of merit of the plate, than to find straight away from such a formula as Krupp's or Davis'.

In the following table an attempt has been made to supply good average factors for plates of varying thickness and character, when attacked by projectiles of a calibre approximately equal to that of the plate. The F. M. of a plate probably falls off in proportion as $d > t$ but to what extent is not known with any certainty :—

Thickness of Plate.	K. C. [a] or Terni.	H. S.^{2} or K. N. C. [b]	H. S.$'$	S. or C.
4″ — 6″.	2.45	2.2	1.9	1.33
6″ — 8″.	2.6	2.4	2.1	"
8″ — 10″.	2.45	2.2	1.9	"
Over 10″.	2.3	2.0	1.7	"

(a) Not much K. C. armor of this thickness (under 6″) has been made.

(b) K. N. C. is very variable in its behaviour and no reliable factors can be given for it. However it may be taken as roughly equivalent to H. S.^{2}

Formulas showing the perforations of wrought-iron armor for the 6″ w = 100 lb. gun :—

de Marre $t^{0.65} = \dfrac{w^{0.5}v}{d^{0.75}} \times \dfrac{1}{\log^{-1} 2.9616}$

Tressider $t^2 = \dfrac{wv^3}{d} \times \dfrac{1}{\log^{-1} 8.8410}$

Krupp $t^2 = \dfrac{w^{1.5}v^3}{d^{2.5}} \times \dfrac{1}{\log^{-1} 8.6664}$

Gâvre $t^{0.7} = \dfrac{w^{0.5}v}{d^{0.75}} \times \dfrac{1}{\log^{-1} 2.9320}$

Orde Browne $t = \dfrac{vd}{1000}$

Maitland $t = \dfrac{v}{608.3}\sqrt{\dfrac{w}{d}} - 0.14d.$

[NOTE.—The formula and diagram showing the perforations of hard faced steel armor will be found on page 211.]

Diagram on logarithmic chart showing the perforations of wrought-iron armor given by the foregoing formulas for the 6″ w 100 lb. gun.

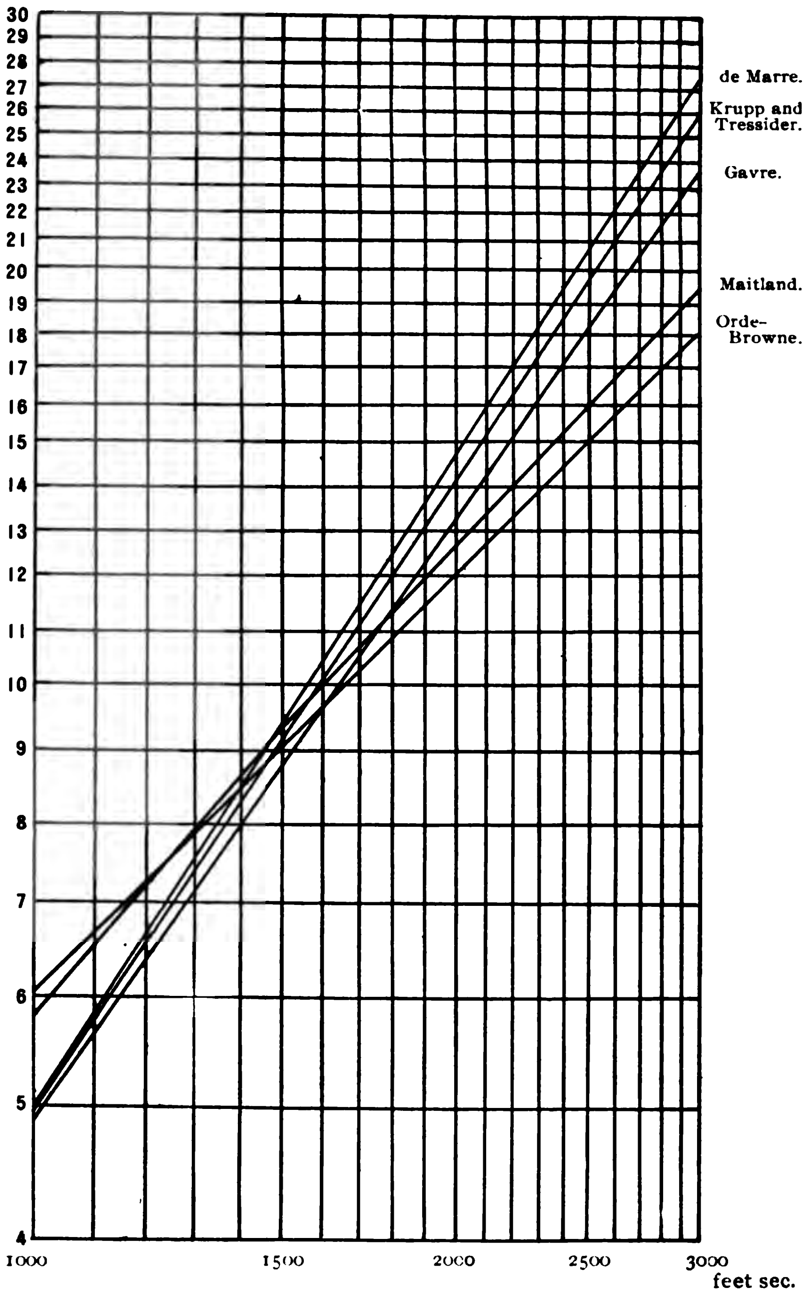
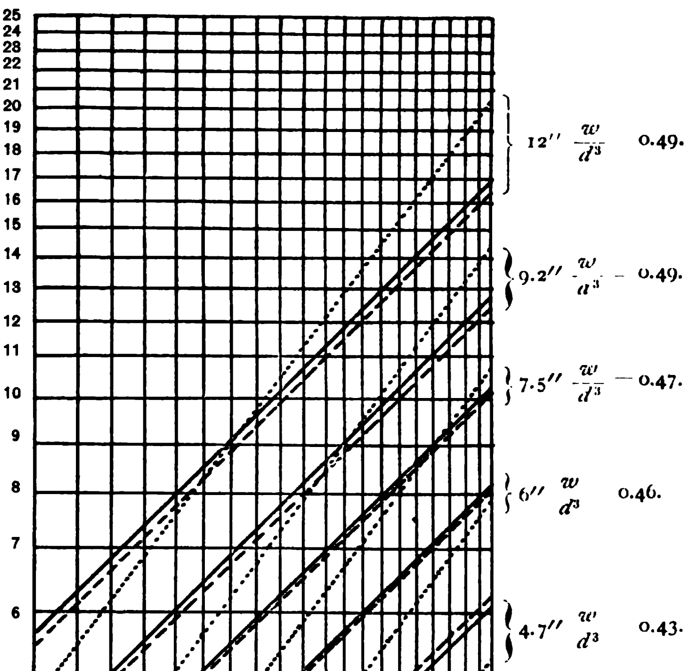


Diagram on logarithmic chart showing the perforations of hard faced steel armor given by the following formulas for various guns.

$t^{\frac{3}{2}} = \frac{wv^2}{d} \times \frac{1}{\log^{-1} 6.8354}$, U. S. Navy shown thus :— ....*

$t^2 = \frac{wv^2}{d} \times \frac{1}{\log^{-1} 6.3532}$, Krupp shown thus :— ▬▬▬▬▬▬

$t = \frac{vd}{2200}$ shown thus :— - - - - - - - - - -



* If possible the U. S. Navy curves would have been replaced by those given by Davis formula.

$t^{1.5} = \frac{w}{d} v^2 \times \frac{1}{\log^{-1} 6.6900}$

and those given by the Russian formula:—

$t^{0.7} = \frac{w^{0.5}}{d^{0.75}} v \times \frac{1}{\log^{-1} 3.1977}$

would have been added but this would have necessitated fresh blocks.—*W. E. E.*

W. I.	Wrought Iron.	H. S.[2]	Harveyed steel of later date, (end of 1897) Somtimes called Harvey nickel.
C.	Compound.	K. C.	Krupp cemented steel.
S.	Schneider steel.	K. N. C.	Krupp non-cemented steel.
H. S.[1]	Harveyed steel of early date.		

Name of Formula	Kind of Armor.	English Units and Notation.	Metric Units and Notation.	Remarks.
Maitland	W. I.	$t = \frac{v}{608.3} \times \sqrt{\frac{w}{d}} - 0.14d$	$s = \frac{v}{30.84} \times \sqrt{\frac{p}{a}} - 0.14a$	For striking velocities below 1,600 f. s.
Orde Browne	"	$t = \frac{vd}{1000}$	$s = \frac{va}{304.79}$	Rough Rule.
Tressider	"	$t^2 = \frac{wv^3}{d} \times \frac{1}{\log^{-1} 8.8410}$	$s^2 = \frac{pv^3}{a} \times \frac{1}{\log^{-1} 5.7352}$	For striking velocities over 1,600 f. s. The best W. I. Formula.
Krupp	"	$t^2 = \frac{w^{1.5}v^3}{d^{2.5}} \times \frac{1}{\log^{-1} 8.6664}$	$s^2 = \frac{p^{1.5}v^3}{a^{2.5}} \times \frac{1}{\log^{-1} 4.7817}$	Gives results almost identical with Tressiders' for same $\frac{w}{d^3}$
de Marre	"	$t^{0.65} = \frac{w^{0.5}v}{d^{0.75}} \times \frac{1}{\log^{-1} 2.9616}$	$s^{0.65} = \frac{p^{0.5}v}{a^{0.75}} \times \frac{1}{\log^{-1} 1.7072}$	Gives rather higher values to t than either of last two.
Gâvre	"	$t^{0.7} = \frac{w^{0.5}v}{d^{0.75}} \times \frac{1}{\log^{-1} 2.9320}$	$s^{0.7} = \frac{p^{0.5}v}{a^{0.75}} \times \frac{1}{\log^{-1} 1.6573}$	For chilled iron projectiles against unbacked W. I. plates. Also called de Marre's old W. I. formula.
"	S	$t^{0.7} = \frac{w^{0.5}v}{d^{0.75}} \times \frac{1}{\log^{-1} 3.0094}$	$s^{0.7} = \frac{p^{0.5}v}{a^{0.75}} \times \frac{1}{\log^{-1} 1.7347}$	For forged steel projectiles against mild steel plates. Also called de Marre's steel formula.
Davis	H.S.[2]	$t^{1.5} = \frac{wv^2}{d} \times \frac{1}{\log^{-1} 6.6900}$	$s^{1.5} = \frac{pv^2}{a} \times \frac{1}{\log^{-1} 4.3026}$	For American plates and projectiles, (1899 & 1900)
"	"	$t^{1.5} = \frac{wv^2}{d} \times \frac{1}{\log^{-1} 6.5061}$	$s^{1.6} = \frac{pv^2}{a} \times \frac{1}{\log^{-1} 4.0782}$	For same plates as above and capped projectiles. It does not appear to be reliable.*
" (U. S. Navy)	K.C.	$t^{1.5} = \frac{wv^2}{d} \times \frac{1}{\log^{-1} 6.8354}$	$s^{1.5} = \frac{pv^2}{a} \times \frac{1}{\log^{-1} 4.4481}$	For the latest American Krupped armor. Gives very high Fig. of Merit to the plates, especially against 6″ B. L.
Krupp	"	$t^2 = \frac{wv^2}{d} \times \frac{1}{\log^{-1} 6.3532}$	$s^2 = \frac{pv^2}{a} \times \frac{1}{\log^{-1} 3.7634}$	For K. C. plates of medium thickness. This formula gives best results for t between 4″ and 7″. If $\frac{w}{d^3}$ be taken as constant and equal to 0.46, the formula reduces to $t = \frac{vd}{2200}$ which is far handier and sufficiently accurate.
" (modified)	"	$t = \frac{vd}{2200}$	$s = \frac{va}{670.55}$	
A Russian	"	$t^{0.7} = \frac{w^{0.5}v}{d^{0.75}} \times \frac{1}{\log^{-1} 3.1977}$	$s = \frac{p^{0.5}v}{a^{0.74}} \times \frac{1}{\log^{-1} 1.9230}$	Of the same form as the two Gâvre formulas but with constant altered to suit K. C. It agrees very well with experimental results for plates 6″ and over and appears on the whole to be the best K. C. formula.†

* For Capped shot t appears to vary as v^2 but as only results with 6″ capped shots are available it is premature to construct a formula for general application.—*W. E. E.*

† I am indebted for the original form of this formula to Major Hon. A. Lambart late R. A., of Messrs. Vickers, Sons & Maxim.—*W. E. E.*

DRILL REGULATIONS. MANEUVERS AND PRACTICE.

Memorandum on the "System of Fire Direction for Guns and Mortars for Artillery District of Portland, 1903".

BY MAJOR W. E. BIRKHIMER, ARTILLERY CORPS.

Artillery Inspector Department of California.

1. The scheme is worked out in every detail. The painstaking care with which this has been done is highly creditable to the officers who spent their time in elaboration. It is this zeal in coast artillery work which, properly directed, will lead to hoped for results, and cause us to get up a scheme of fire direction that will enable us to land our projectiles on the hostile ships during battle.

2. But while this credit is due the elaborators of the plan now being commented upon, it is believed that it is to cumbersome for practical use.

3. There are too many human agencies and too many mechanical appliances in certain parts, viz: In the rapid fire work, in the various station houses, especially of battery commander.

4. Our aim must be in the direction of reducing the fire control and direction system to its simplest possible elements, the very reverse of the scheme now commented upon. We must not coop up any of our good men in the station houses unless they contribute materially to the accomplishment of practical, good results. Nor do we want instruments in connection with the fire control and direction scheme, the use of which do not bring about practically important results. And, in deciding whether a man or an instrument should enter the scheme, the matter to be looked at is not alone whether theoretically, some benefit will result; we must remember that their entrance complicates matters, a very objectionable matter unless compensated for by some resulting advantages; that it depletes the number of good men who can be utilized at the guns, a most important matter; and, further, that the errors that result from uncertainties about powders burning always alike, under seemingly similar circumstances, thereby causing considerable variations in ranges, so far outweigh in magnitude errors due to climatic phenomena for instance, and other like causes, that the latter cease to be not only of relative, but of real importance, and, therefore, the question well may be considered whether the observers and the instruments assigned to the taking cognizance thereof may not well be altogether omitted from the scheme of fire control and fire direction.

5. During our peace exercises, maneuvers, etc., it should be our aim to simplify the fire direction scheme as much as possible. When war comes it will be too late to proceed with the deliberation absolutely necessary to arrive at wise conclusions. But we can rest assured that, if we cannot devise a simple scheme, the enemy, if he be worthy of the name, will do it for us.

6. It is noticed that commissioned officers are sometimes transmitters of ballistic data over lines of communication (p. 18, scheme.) They cannot be spared for this work, which is that of properly trained enlisted men. Nor can officers be used as plottersand predicters (p. 41). Enlisted men must be taught to perform all these duties. Officers in action must be general supervisors and correctors of the course of affairs.

7. It is noticed that the reading meteorological instruments in mortar practice is enjoined. It was thought that the action of the Board for Mortar Prac-

tice in Maine in the fall of 1901, and approval thereof by the Board of Ordnance and Fortification, had put an end to this in our service.

8. There are 13 enlisted men in manning detail, battery commander's station (p. 15.) They will be in each others way. The confusion that will result from these men repeating each the data he must use when he receives said data, will make the station houses a babel. It is believed, instead of adding to the confusion resulting from said repetitions, that the greatest quiet should be enforced in the stations, and no sound made nor word spoken unless it be absolutely necessary for the correct progress of the station work. There is no place where fire discipline is more essential than in the station house.

9. It is believed that firing from rapid fire guns should be with the simplest appliances practicable, and without a fire direction system of the least complexity, no more than with field guns. The truth seems to be that the manning detail for R.F. guns (p. 6) is too elaborate. This firing consists in watching shot-splashes and correcting by judgment for next shot. No elaborate fire direction scheme for this is necessary.

ELECTRICITY; COMMUNICATIONS:

The Typewriting Telegraph and Its Possibilities for Artillery Purposes.

Three years ago when considering the various means of making communications in fortresses, I examined the Telegraph Typewriting machine, Stelje's patent, but thought it rather too complicated to be used for chain of command purposes.

Several improvements have recently been made, and perhaps a short account of the instrument may be of interest.

The Russian government is adopting these instruments, and the German War Department is at the present time trying them, and experiments are being carried out with them by the German Field Telegraph Battalion.

I saw two instruments fitted up for the German army, which were evidently intended to be put into ammunition or general service wagons; as the weight of each instrument is only 18 lbs., including tools, and is contained in a strong box about the size of a Mountain Battery ammunition box, it would form an easy pack load. The inventor claims that there are no delicate parts which are likely to receive damage from jolting in transport, or from the weather, and there are no batteries to get out of order.

Without going into details, the instrument consists of:—

(*a.*) A transmitter which is fitted with a key-board of letters and numbers arranged around a dial, and with a magneto generator for sending the current. This generator is worked either by the operator turning a handle with one hand whilst he works the keys with the other, or by means of a treadle, or an electric motor similar to those used for electric fans.

(*b.*) A receiver fitted with a roll of tape paper, on which the message is typewritten both at the sending station, and at the receiving station or stations.

The letters and numbers are arranged round a circular key-board in alphabetical and numerical order. Any man who can spell, therefore, is able to send a message fairly quickly; and, with a little practice, a message can be sent quicker than by the ordinary Morse Code.

The tape winds off into a recess, and by locking the lid over it a message can be sent and received confidentially.

The instrument can, in a minute, be connected with any telegraph or telephone wire, and can be used on the same wire and at the same time as the telephone.

The advantages claimed for this instrument are:—

1. Messages can be sent simultaneously to any number of stations on the same line.

2. No expert operator is required at either end.

3. Absolute accuracy is ensured, and a check is obtained because the message is visibly printed at both ends, and responsibility for any mistake can at once be decided.

4. It can be used simultaneously with a telephone on the same line, so that a telephonist, in sending a message, may typewrite all proper names, numbers, &c., and speak the remainder of his message, or may typewrite his whole message.

5. The messages are received automatically, and, if desired, during the absence of the person for whom they are intended.

6. No batteries are required, so that no care is needed to make corrections or re-charge cells. Batteries would also be liable to damage in transport.

7. No one can read the message by sound.

8. Only a very light current is required.

Another great advantage which this instrument has over the telephone is that noise at either end of the wire makes no difference to its efficiency, and it has often seemed to one that even the most perfect telephone is liable to be rendered useless in a fortress in action for this reason.

By means of a special very light cable moored to a buoy at sea, a vessel is enabled to communicate with the shore, and on the East Coast of Africa a series of these cables have been contrived by one of the Liverpool lines at places where the surf prevents a vessel from going within two miles of the shore.

In coast defense the Typewriting Telegraph would appear to be of use either as a supplement to, or substitute for, chain of command telephones.

As every message is written down at the receiving end on receipt by telephone, time would not be lost by writing it from the transmitting end instead of sending it verbally. The contrary would be the case, as there would be no necessity for those asides, "Are you there?" and for the repetition of the message which are always considered essential in peace time, and which in all probability cannot be dispensed with in the din of a fight.

If time is saved in sending one message, much more would this be the case in sending several identical messages to different stations. By an ingenious switch arrangement communication can be made with one, two or fifty stations simultaneously.

This would enable an observing station to report at once to all batteries, &c., and would let the fire commander give orders without delay to all battery commanders in his command.

Unless wireless telegraphy is to be used between the examination vessel and the shore, a typewriting telegraph installation would enable the present difficulties of rapid communication with every battery to be in a manner overcome. Day or night would not make any difference in this method, and less attention would be drawn to the examining vessel than if visual signalling were used. This would, at any rate, give the poor examining vessel a chance; for, under existing arrangements, a disguised hostile ship would probably direct its first attention to her, as soon as the movement of her semaphore showed that she had penetrated the disguise.

The difficulty of a moving vessel being able to maintain communication with shore by means of a cable may be insuperable.

But as her area of action will be very restricted in any case, a way out of the difficulty might be found by using a drum similar to the high speed winding in gear, which would always keep sufficient tension on the wire to wind in any slack between the cable moorings and the vessel, and yet pay out when necessary.

The following is a suggested arrangement for the communications in a fire command:

From the examining vessel to every shore station collectively.

From the observing station to every shore station collectively.

From the fire commander to the examining vessel and every other shore station, and to each individually.

From each battery to the fire commander, and to each other battery commander individually—the latter chiefly for peace purposes.

From the electric light stations to the fire commander and examining vessel and observing post individually.

As to expenditure which would be incurred, the price of each instrument is between $100 and $150, which means a large initial cost. A saving would be made in the general up keep, for these instruments are not nearly so liable to get out of order as telephones. Existing wires could be utilized, and but few additions would be required.

For military purposes other than coast defense, many possible uses suggest themselves.

Most obviously as a cavalry adjunct to send back messages from advanced cavalry at any place with a wire to headquarters, and for general purposes.

Less obviously as a Field Artillery adjunct.

Now, wires are a common feature in every rural landscape, and the necessity of co-operation between artillery and the other arms which may be miles away, but in a better position to "observe," is being insisted upon. Possibly this instrument might be of use to communicate with, when signalling might be either too dangerous or too complicated.

Arrangements are made in the machine to prevent complications by the despatch of more than one message along the wire at the same time, and also temporarily to stop one message and to send another more important if desired.

The three magnets of the generator can "send" from Glasgow to London, which is probably sufficient for all military purposes.

After seeing the instrument working, one is not surprised to learn that it has been taken into general use by the Post Office, the Metropolitan Police Force, and by the Fire Brigade.

—Captain W. B. Spender, R.A.,
in *Proceedings Royal Artillery Institution*, October–December, 1902.

Description of the Typewriting Telegraph.

This is a new "tape machine" which has the advantage of using currents of only a few milliamperes in strength. The currents used are furnished by a magneto which is combined with the keyboard of the instrument. In the transmitter the keys are arranged round a dial, which is inscribed with the alphabet and the cardinal numbers, as well as a number of other signs in common use. There are 30 of these keys and two spacing keys, and by a shift

FIG. 1.—STELJE'S TYPEWRITING TELEGRAPH. Open, ready for sending.

key 58 characters can be sent by this keyboard. On turning the handle of the magneto, current impulses are sent through the line to the distant station, and simultaneously an index hand passes round the dial of the transmitter. On pressing down a key, this index hand is arrested as soon as it reaches the corresponding character, and the current is simultaneously interrupted in the line, the index remaining stationary and the circuit open until some other one of the remaining keys is depressed. When the circuit is closed for every half revolution of the magneto armature, the index passes over one character on the dial of the transmitter, and one impulse is sent to the receiver at the distant station.

In the recorder these impulses pass in the first place through an electromagnet, and secondly, through a polarized relay, which controls the escapement of the weight-driven clock, operating the printing mechanism. As the waves of current traverse the circuit, the armature A^1 of the polarized relay vibrates to and fro, and for every oscillation the escape-wheel E advances one tooth, carrying with it the type wheel. At the same time these currents passing through the electro-magnet aforesaid, attract an armature, A^2, and as the impulses follow each other very rapidly, this armature is unable to drop between successive oscillations; but once the circuit is broken, it falls,

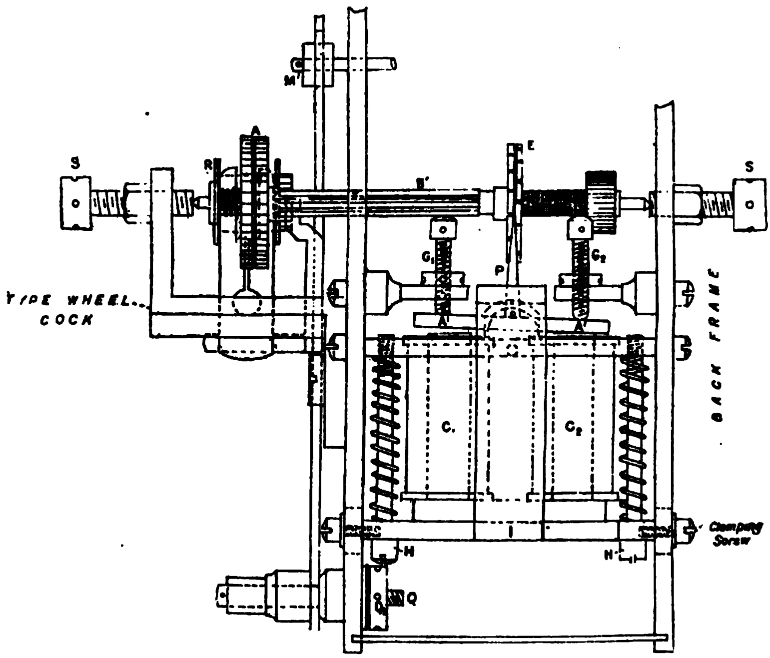


FIG. 2.—STELJE'S TYPEWRITING TELEGRAPH. Plan of Recorder.
A —Type wheel. G_1 G_2 —Adjusting screws for armature.
A^1 A^1 —Armature. H H—Adjusting screws for cores.
C_1 C_2 —Cores. E —Escapement wheel. S S—Adjusting screws for type wheel.

releasing the printing lever, P through arm L and cam M', and the proper character is impressed on the tape, the power necessary being provided by

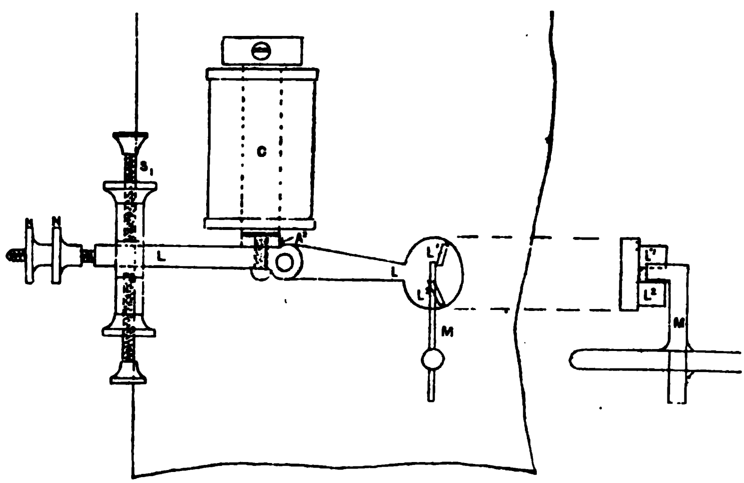


FIG. 3.—STELJE'S TYPEWRITIMG TELEGRAPH. Printing coils and escapement.
A_2 —Armature. C—Core.
L L —Lever arm. L^1 L^2 —Blades of escapement.

the weights driving the clock-work. The mechanism is provided with a simple synchronising device, Fig. 4. On the printing wheel shaft is a catch, which is engaged by a pawl, which rises to meet it step by step as the type wheel turns round. Should, however, a character be printed, this pawl is knocked out of the way, and cannot get into position again till the type has made a complete revolution.

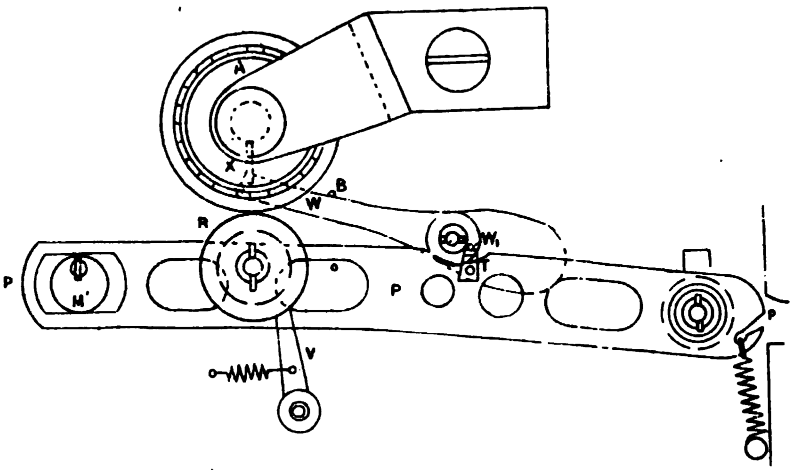


FIG. 4.—STELJE'S TYPEWRITING TELEGRAPH.

P—Printing lever.
M'—Cam.
R—Printing roller.
W_1—Pin on unison arm.
X—Pin on type wheel shaft.
W—Un son arm or pawl.
B—Banking pin.
A Type wheel.
T—Knock off piece on printing lever.

In one typewriting telegraph set the mechanism is actuated by weights, and the magneto sending the current is driven by an electric motor, thus setting the hands free for printing; in another the mechanism is actuated by springs, and the magneto sending the current is driven by hand. A new feature is a treadle which is worked by one foot on the basis of a free-wheel, combined with a fly-wheel. On the pedal being depressed, the mechanism is actuated, but as the foot is raised the free-wheel operates, as does a small free-wheel in the apparatus; pressure on the pedal again communicates power, and on the rising of the foot the free-wheels are again brought into action. The practical bearing of this is that friction is greatly reduced, and that the need for continuous working of the treadle is done away with, a single pressure causing fifteen or eighteen revolutions.

The average number of words which can be sent by the instrument by expert operators may be considerable. The speed with which a message, as read from the day's newspaper, could be sent from the works at Hackney to the London office, was tested and found it to be 22 words in one case, and 26 in another, per minute. It is said that 40 words per minute may be sent and recorded by any number of instruments by means of this apparatus.

The instrument has recently been tried for military purposes on the Continent. In Germany a message of 150 words was despatched simultaneously by a Morse set and by the typewriting telegraph; the time taken was in each case 6 minutes, but whilst the Morse message required transcription, that sent by the typewriting telegraph was already printed in plain Roman characters. In some of the trials the cable used was merely the Austrian Cavalry line. This consists of three wires, two of steel and one of copper, bound up together. Its weight is about 8 lbs. per mile. Hitherto this cable has been used only for telephonic communication, but it was found that the typewriting telegraph would work through it perfectly.

Further practical field tests have been made where double service was secured on one wire by the use of the telephone and the typewriting telegraph both at the same time. Communication was established with 4 or 5 stations, and talking and writing took place without one interfering with the other. One transmitter in a central station, in other tests, readily sent messages to eight outlying stations; by a switch, a message can be sent from one station to any other station singly, or it can be sent to any number at the same moment.

FIG. 5.—STELJE'S TYPEWRITING TELEGRAPH. Ready for transport.

The instruments packed in transportable boxes, as shown by the set illustrated, weigh complete about 18 lbs. per box. Altogether the instrument is the best designed of its kind yet brought out, and the success it has met with shows its value for all purposes where a simple but reliable means of communication is appreciated.

WARSHIPS.

H.M.S. Commonwealth.

Except the projected Russian ships, or the American Louisiana, there is nothing of the same displacement to compare with this ship. The Louisiana belongs to a later era, so we have selected the New Jersey as a fairer comparison. The Russian ships are not yet begun, or but barely so, and might therefore seem equally out of court. This, however, is hardly so; for though of later date, they were designed as soon as the particulars of the King Edward VII. class—to which the Commonwealth belongs—were known. It is the Russian policy to lay down something by way of a reply or copy, so soon as we get out a new design. Thus the Retvizan, though so lately completed, is Russia's equivalent to our Canopus, and the Birodinos, recently launched, are of the era of our Formidable and Londons. The French Republique is a smaller vessel by nearly 1400 tons, say nearly 10 per cent, but is is undoubtedly France's equivalent.

Now, looking at the four ships selected for comparison, we see at once that there are not four types, but only two. The King Edward and the New Jersey, despite differences that, on paper at any rate, favor the American vessel, are essentially of the same type. Both have armored walls amidships, extending up to form a main deck box battery, both have intermediate guns between the secondaries and primaries, which, though differently disposed, are carried in small turrets on the upper deck. That the New Jersey has superposed turrets is an incident, not an essential of the design. Finally, both rely for protection on a moderate belt reinforced by a sloping armor deck, and have huge barbettes inside which the main turrets work.

The Franco-Russian ships are totally different. The exact nature of the Russian design is not known, but it is generally understood that she will be an enlarged Tsarevitch. Essentially she embodies the integral features of the Republique—a ship we have fully described and illustrated in the past. The peculiar features are :—(1) Complete belts, with flat decks at top and bottom; (2) moderate sized bases to big guns; (3) secondary guns, all in pairs, in turrets, carried mostly a deck higher than in the Anglo-American type. Instead of walls, stout tubes protect the bases of these, and between exist vast unarmored spaces.

From this it follows that the sort of fire that will destroy one type will hurt tho other relatively little. For example, neither the Commonwealth nor the New Jersey has much need to dread big common shell. Their large armored areas, on the other hand, render them ideal targets for 12-inch armor piercing projectiles, which, hitting the relatively weak water-lines, might get through to the engine-rooms; and powerful 8-inch guns of high velocity might riddle the battery to a great extent.

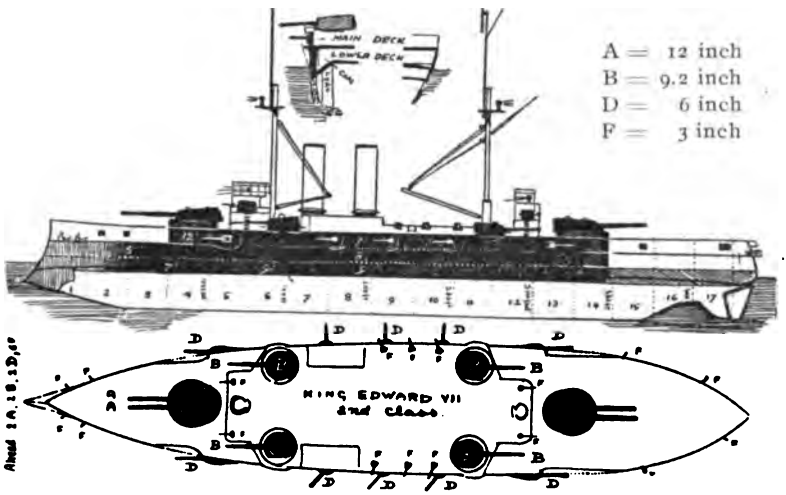
In the Franco-Russian designs there is none of this. The secondary guns offer a trifling target, they are impossible to aim at at modern ranges. The belts, indeed, are there to hit, but penetration only means that the projectile goes inside the armored box filled with coal; it is extremely unlikely to get through to the engines. These ships must be attacked by shell to do them any harm, and whatever is done they are very unlikely to sink. They will, if defeated, become floating rubbish heaps; the Anglo-American ships will, if defeated, go to the bottom in passable condition. He must be a rash or ultra-patriotic man who would assert that the King Edward class is better than the Republique, but whether she is worse is quite another matter.

No one can say. No one knows exactly what shell attack is going to do in battle. We think it will do a great deal; the French and Russians, apparently, are less believers in shell power. The real root of the matter, however, is quite unknown. No one can assess the chances of water-line hits or say how rare they will be. It is a sort of axiom that they will be rare; and there is logic in this view, because the water-line is a very small fraction of the total area presented by a ship.

Until she is so hit the Commonwealth will be pouring a tremendous fire, for all her guns are so far apart and isolated that it is not likely that anything

Name	Commonwealth.	New Jersey.	Republique.	New Russian.
Nation	British.	U.S.A.	French.	Russian.
Displacement, tons	16,350	15,000 nominal.	15,000 about.	16,000
Length, ft.	425	435	438¼	?
Beam, ft	78	76¼	79½	?
Draught (mean) ft.	26¼	26¼	27½	?
Guns A	Four 12-inch, IX., 40 cals.	Four 12-inch, 40 cals.	Four 12-inch, 45 cals.	Four 12-inch, 40 cals.
" B	Four 9.2-inch, X., 45 cals.	—	—	—
" C	—	Eight 8-inch, 45 cals.	—	Twelve 8-inch, 40 cals.
" D	Ten 6-inch, VII., 45 cals.	Twelve 6-inch, 50 cals.	Eighteen 6.4-inch, 45 cals.	—
" F	Fourteen 12-pdrs.	Twelve 14-pdrs.	—	Twenty 12-pdrs.
Tertiary	Fourteen 3-pdrs. Two Maxims.	Twelve 3-pdrs. Sixteen smaller.	Twenty-six 3-pdrs. Two 1-pdrs.	Twenty smaller.
Torpedo tubes, submerged	4	2	2	2
" above water	—	—	3	2
Armor belt	9-inch—2-inch.	11-inch—4-inch.	11-inch—6-inch.	11-inch—6-inch.
Deck	2-inch slope.	3-inch slope.	2¼-inch flat.	2¼-inch, flat.
Lower deck side	8-inch—3-inch.	6-inch.	10-inch—5-inch.	10-inch—3-inch.
Barbette bases, A guns	12-inch.	11-inch.	12-inch.	12-inch.
Turrets	8-inch.	10-inch.	12-inch.	12-inch.
On B or C guns	7-inch.	6-inch.	—	7-inch.
Protection to bases	7-inch.	6-inch.	—	6-inch.
On C or D guns (secondary)	7-inch.	6-inch.	6-inch and 5-inch.	—
Protection to bases	8-inch.	6-inch.	5-inch.	—
I.H.P.	18,000	19,000	18,000	?
Speed, knots	18.5	19	18	?
Normal coal	950	900	900	1,500 (reported).
Maximum coal	2,000	1900	1,825	3,000 (reported).
Oil	*none.*	?	Carried.	Much carried.

entering the battery will hurt more than one or, at the most, two guns. Inferior as she is to the Republique in secondary pieces, she has an enormous advantage in her 9.2's. These guns, in addition to excellent penetration power, fire lyddite shell, which are likely to wreck pretty effectually any spot they hit. The damage done by lyddite is probably not at all extensive, not so extensive as that done by a common shell, but it is singularly complete locally. This sort of thing cannot be stood long by any ship, and even if it could be, there would be a rapid end to all communications. From all this trouble the Commonwealth is free. High explosive shell may burst against her armor, and, bursting, destroy gun muzzles; but they are not going to inconvenience her to any serious extent. She will, in all probability, be able to go on fighting.



The design of the King Edward class has been adversely criticised on the grounds that on 16,350 tons displacement at least two more 9.2's could have been carried. Or, to put it another way, she is bigger than she need be for her guns and armor. There is possibly some truth in this; but, in view of the recent accident to the Maine, we do not think that the unfavorable comparisons drawn between the King Edward and the New Jersey hold water. Indeed, her most serious competitor is a ship only three-quarters her size—the Vittorio Emanuele. The principal guns are:—

King Edward.	Vittorio Emanuele.
Four 12-inch.	Two 12-inch.
Four 9.2-inch.	——
——	Twelve 8-inch.
Ten 6-inch.	——
——	Eight 4-inch.
Fourteen 3-inch.	——
18.5 kts.	22 kts.
9-inch belt.	10-inch belt.

In a battle, no doubt, the King Edward would have things her own way; but one is tempted to wonder what a 16,350-ton Vittorio Emanuele would be? The question has perhaps occurred before to a great many people in this country, and, indeed, is one of fascinating interest to us all. But only Colonel Cuniberti could answer it—speculations by anyone else would be vain.

In conclusion, we may mention a few details of the Commonwealth armor. The water-line belt is 9-inch K.C. amidships, tapering to 3-inch at the bow, and 2-inch at the stern. This last, of course, is nothing; the 3-inch bow, however, does not reach far—it soon becomes 4-inch, and then 6-inch. This water-line belt is reinforced by the usual inclined deck, 2-inch of steel—of course, not cemented, that process being impossible for thin plates. The total resisting value may be put at equivalent to a 12-inch Krupp, or a trifle more. A capped modern 10-inch, with direct impact, will get through this at 4000 yards by proving ground statistics. In battle, of course, there will not be direct impact, or anything like it. All 12-inch guns are supposed to be able to get through this uncapped at 3000—but, again, no one expects them to do so in battle.

Above the 9-inch belt is an 8-inch one; above again, a 7-inch protecting the battery. The best nominal capped penetration of the 6-inch gun is the American one, 7.2-inch, at 2000 yards. This battery, therefore, may be regarded as proof against any 6-inch gun in existence, or likely to be in existence yet awhile, for it is easier to talk of abnormal velocities than to secure them in practice.

The 9.2 guns rely rather on the inclined and bent surfaces of their turrets than on thickness. Probably in battle no capped 6-inch could get through them, but anything larger might. However, as anything big would probably be fully disastrous without getting through, these nickel 6-inch turrets are probably quite thick enough. The barbettes are of the usual form and thickness, made of K.N.C., 12-inch plates. There is a theory that these are either not thick enough, or else too thick. But this opens a very big question, better discussed at some other time. —*Engineer*, May 22, 1903.

BOOK REVIEWS.

L'Armée Allemande. Etude d'Organisation. Felix Martin, Chef de Bataillon, and F. Pont, Capitaine d'Artillerie, Breveté á l'Etat-Major de l'Armée. Paris: Libraire Militaire R. Chapelot et Cie. 1903. Pp. 869.

The work before us is a thorough study of the German army, in all its details of organization, by two able French officers, who would naturally attempt to learn all that could be of importance to their own army, and would therefore be desirous of making the work as complete as possible, and who have succeeded in producing perhaps the most satisfactory account of the present German army (as regards its organization) extant.

Looking upon the work as a whole, it is gratifying, in the first place, to note that the authors based their investigations invariably on the *laws* at the foundation of the army organization, in other words, on original sources; and, in the second place, the system of arrangement of the text, its subdivision into parts and chapters and sections, and a typography to emphasize this subdivision of the subject-matter, all combine to make the work a satisfactory text book to study and a convenient manual for reference.

Part I. traces the development of the German army from 1871 to 1902 by following the various laws that have been enacted on the military organization of the Empire during that interval of time, discussing the laws of recruitment, and describing the present condition of the men (their clothing, barracks, rations, etc.), their promotion, punishment for offences, etc., the recruitment and promotion of officers, the medical and administrative departments, and finally the centers of instruction (comprising the military schools of all kinds and the post schools, camps of instruction, maneuvers, etc).

Part II. contains the details of the present organization, beginning with the commander-in-chief (the Emperor) and his assistants (the military cabinet, the minister of war, the general staff, and the permanent inspectors), then down through the army corps to the different arms of the service (including the infantry, cavalry, field artillery, foot artillery, engineers, the troops of the lines of communication, and the train), and the various departments (such as pay, pensions, clothing, construction, medical, armament and material, remounts and military justice).

Thers is also an appendix on the German navy and the protectorate troops, and finally a good index.

This brief summary of the contents will give some idea of the scope of the work, but the real merits of this *study* (for such it is) can only be judged by a careful perusal of the book itself. It is not a mere collection of dry facts, but also contains pertinent remarks, expressed in clear and terse language, on what the authors consider good or bad points in the system, besides much information that must have been derived from real observation of the German army in the field or in garrison.

The general staff being a subject of much interest in our own country at the present time, we quote a few words on that subject from the work before us.

"The Grand General Staff, the center of the highest instruction in the army.—The Prussian Grand General Staff constitutes a kind of school of application for a large part of officers graduating from the war college, testing their capacity to enter on staff duty and determining their assignment. But, because of the great number of officers* thus detached from their respective arms, and attached to the Grand General Staff, the latter has become a true center of instruction, thus practically making its methods of work and its military ideas known to the entire army.

"How is the education of these officers effected in the General Staff?

"Even before 1870 Marshal von Moltke had recommended that the young officers be exercised in discussing, developing and solving tactical and strategical problems of all kinds, that they be required to submit criticisms of campaigns and other military events, and to study military history, under the direction of officers accustomed and able to draw deductions and lessons from the material available.

"Following the same order of ideas and to utilize the work of the various sections for the general good, he ordered the investigation of the condition of the principal foreign armies, and the publication of the results of such study, their war power, etc., and had these results communicated to all the officers of the Grand General Staff. In the German army, where tradition has the force of regulations, theses or similar methods are still in use at this very day, and in a recent (1901) work on *The Officer* by Major Fuller, the latter says: that 'the chief of the General Staff personally indicates the tactical questions to be studied, and himself criticises the work.' "

This work on the German army (published under the direction of the French General Staff) must be regarded as authoritative, and it is undoubtedly the most complete and thorough account of the organization of that great army now available. J.P.W.

The Commission of H.M.S. Terrible 1898-1902. By George Crowe, Master-at-Arms. London: George Newnes, Ltd. 1903. Pp. 370.

The splendid work of Captain Percy Scott and the gun crews of H.M.S Terrible in South Africa will long be remembered by military men as illustrating the spirit of *initiative* so desirable in all officers and men, and also the spirit of cordial *co-operation* between navy and army so necessary in time of war.

The present work is a complete account of the commission of the Terrible for some four years, part of which relates to the Boer war and part to the war in China. The part taken by the navy in both these wars will be a lasting monument to the energy and initiative of that branch of the British war forces.

The interesting and entertaining character of the account, as well as the literary qualities of the text, can best be illustrated by means of a few quotations:

"Reinforcements being urgently needed at every strategic point threatened by the Boers, a naval Brigade was despatched from the ships at Simonstown on October 20th, to co-operate with the troops holding Stormberg junction, whither they proceeded via De Aar. * * * The brigade consisted of 300 marines, 50 blue jackets, with 2 Q.F. field guns. The Terrible contributed 80 marines, under Lieutenant Lawrie, and one medical steward and eight stokers for ambulance parties. * * * Thus commenced the navy's active participation in the war. * * *

* There were 99 Lieutenants in 1901.

"The brief details of the Natal fighting received from the front had clearly demonstrated that the Boers were pre-eminently superior in artillery, both as regards power and range.

"They had in the field large mobile guns throwing a 94-lb. shell, with an effective range of 12000 yards. The British had only light field artillery, firing a 15-lb. shell, with a range of not more than 6000 yards. This disparity in artillery placed Sir George White in a very serious positition, and necessitated his appealing to the navy for assistance.

"The following extract from a paper read by Captain Scott, at Hong Kong, bearing on this subject may be found interesting:

"On Wednesday, October 25th, General White, in Ladysmith, finding that he had no artillery capable of keeping the Boer siege guns in check, wired to know if it were possible for the navy to send him some long range 4.7 guns.

"The Admiral asked me if I could design a mounting for a 4.7 and get two finished by the following afternoon. It was rather a rush, but they were ready by 5:00 p.m., put on board the Powerful, and she started with them and four 12-pounders for Durban.

"Immediately on arrival, Captain Lambton, with great promptitude, took the guns to Ladysmith. He arrived in the nick of time, and his brigade played a most important part in the defence of Ladysmith. Forty-eight hours after his arrival the door was closed, and the garrison remained beleaguered for 119 days."

Other conversions took place under the direction of the navy, and a number of 4.7 as well as 12-pounders, on good, serviceable field carriages were soon sent into the field.

"The next item deserving notice was the installation of a search light on a railway truck. The admiral's instructions required it to be ready by the evening of the 27th, the order being received late the previous night. * * Just as darkness set in, signals were being exchanged with the ship."

The work contains a very good account of the principal events in the Boer war, and then takes up the China war, which is described in quite as clear and graphic a way. It constitutes, as a whole, a valuable addition to the history of each of these wars, and its personal character gives it an added charm. J.P.W.

Handbook for Non-commissioned Officers of Infantry. By Captain M. B. Stewart, 8th U. S. Infantry. Kansas City, Mo.: Hudson-Kimberly Publishing Co. 1903. Pp. 102. T. Cloth. $0.50.

A most useful little volume of about one hundred pages, containing practically all that our non-commissioned officers of infantry should know for the performance of their ordinary duties. But it will also be of use in the cavalry and artillery, indeed, it should be in the hands of every non-commissioned officer in the army.

It contains chapters on the non-commissioned officer as instructor, as guide (in close order formations), and his duties in extended order, in advance and rear guards, in command of patrols, on escorts, on outpost duty, in charge of quarters and as sergeant or corporal of the guard, and has special chapters on the duties of the first sergeant and the company quartermaster sergeant. One of the most valuable features is the list of reports and returns to be rendered by commanding officers of companies, which is supplementary to the chapter on *The First Sergeant*.

The little volume must prove a valuable hand book for our non-commissioned officer and make their duties much easier and simpler.

Alloys of Iron and Tungsten. By R. A. Hadfield, Vice-President. London: Iron and Steel Institute. September, 1903. Pp. 66, with tables, diagrams and plates.

Mr. Hadfield's work in this field of investigation has been extended over a number of years (1888–1903), and he has considered the alloys of iron with various elements, namely, manganese, silicon, aluminum, chromium, nickel and tungsten, all of which original work he has generously given to the world in the interests of science.

All his previous papers have been regarded as classical, and as summing up the present knowledge of the world on the subject considered, but in every case his own investigations have greatly extended that knowledge, and have made the history of the alloys he studied *modern.*

This particular paper is a valuable addition to science, and will be of great value to chemists and metallurgists.

In concluding the essay the author remarks:

"Though tungsten-iron alloys will have an important future, there is no doubt that, so far as can be seen at the present time, their use is not likely to be on the same large scale as some of the other special steels now produced."

Cadet's Handbook. A Manual for Military Students at Colleges and Academies. By Captain John A. Lockwood, U. S. Army. Kansas City, Mo.: Hudson-Kimberly Publishing Co. 1903. 273 + 13 p. D.

This handy little volume should subserve a very good purpose, for it covers a field that has been but lightly touched by other works, and appeals to an audience that is constantly growing in importance.

"Military drill and instruction in the schools, academies, and colleges of the United States was never so general or so popular as it is today. Its great benefits, physical, moral, and mental, are becoming better appreciated as the subject is becoming better known."

The necessity for some book of reference on the various details of drill, field duty and customs of the service has long been felt, but the demand for such a work has not been great enough to warrant any one devoting time and labor on it, until quite recently. The present work covers the field very well, and the illustrations add materially to the usefulness as well as the beauty of the volume.

The handbook has chapters on Discipline, on the Composition and Organization of the United States Army, on the National Guard, on Orders, Correspondence and Rosters, on Military Engineering, First Aid, and Hygiene, and on a number of other subjects relating to garrison and field duty.

The illustrations are useful as well as ornamental, and include, besides such as would naturally go with the subjects enumerated above, the coats of arms of the Staff Departments, the chevrons to denote cadets' rank, and photographs of officers and men in the new uniforms, as well as at the various drills of the line. The articles on *Military Engineering* and *First Aid* are particularly well illustrated.

An Appendix contains the Articles of War and samples of the different blank forms used in company and post administration.

The volume also contains instructions as to entrance to the Military Acad- at West Point, and the methods of obtaining commissions in the army.

The handbook is timely, fills a serious want, is useful, neat and convenient for use, and will be effective in promoting much-needed general information at the various military schools throughout the country.

The International Encyolopaedia. Editors: D. C. Gilman, LL.D., President of Johns Hopkins University and of Carnegie Institution: H. T. Peck, Ph. D., Professor in Columbia University: F. M. Moore, M. A., Professor in New York University. Volumes IX. and X. New York: Dodd, Mead and Company. 1903.

The general scope and character of this work was discussed in our review of the first volumes, and it only remains to call attention to some of the special features of these later volumes.

Each succeeding volume as it appears increases our admiration for the entire work, and gives greater satisfaction in the library and office.

Volume IX. carries the work well through the latter I, and preserves the character promised by the initial volume in all respects.

The artistic element is upheld by the usual number of colored plates, maps and engravings, the most striking of which are reproductions from the works of Frans Hals, Hobbema, Hogarth and Holbein, plates illustrating the National Coat of Arms, Heraldry, Humming Birds and American Indians, and a number of portraits, landcapes, etc.

Some of the more important articles of general interest are: one on the *House of Hapsburg*, giving a complete genealogy of the Hapsburg Family, an interesting one on *Harbors*, an excellent one on *Harvard University* and another on the *Hawaiian Islands*, a charming one on *Heine*, a very entertaining one on *Heraldy*, beautifully illustrated, a most useful one on the *Horse* and on *Horseshoeing* and a very complete one on *India*, containing much new matter.

The purely military articles are comparatively few and unimportant. They include articles on the *Howitzer*, the *Hotchkiss Gun*, *Homing Pigeon*, *Helmet*, *Hand Grenade*, *Hang Fire*, *Honors of War*, *Military Honors*, *Hospital Corps*, and *Hospital Ship*. There are however more than the usual number of military historical, biographical and geographical articles, many in this volume of exceptional importance.

This encyclopaedia, as a simple work of reference, aside from its many excellencies, continues to be the most satisfactory in the market at present.

The work is about half completed with volume X. which carries it to include the word *Larramendi*. This volume appeared early in June, 1903, and is a very interesting one, although the artistic feature is not so predominant as in previous volumes: it is devoted more to the *Useful* than to the *Beautiful*.

Some of the most interesting of the larger articles are: Kindergarten, Iron and Steel, Knotting and Splicing, Lace, Jupiter, International Date-Line, Insect, and Laboratory, (all adorned with full-page illustration). The usual number of biographical, historical and geographical articles are found. The military articles include: Infantry, Inspector-General, International Law (an excellent article with a good bibliography), Intrenchment, Island Number Ten (Civil War), Stonewall Jackson, General Philip Kearney, Kellermann, Kit (carried by soldiers), Knotting and Splicing (an excellent article, fully illustrated, by Lieutenant Winchell, U. S. Navy), Lance and Lancer, besides many articles of military, but also of more general interest.

Of colored illustrations there are but three in this volume, (two of flowers and one of insects), but of engravings there thirty, besides ten maps. Among the engravings is a good reproduction of the Laocoon from the statue in the Vatican Museum, Rome, and one of Jupiter from the Zeus of Otricoli in the same museum, as well as of the Jupiter from Pompeii, now in Naples; Japanese Art is represented by a terra cotta statue of the VIII. Century, a wooden statue of the XII. Century, and the chief Temple of Horluji of the VII. Century; in ancient architecture we have the Kaaba and the Haram of Mecca, the enterance to the Temple of Chons built by Ramesses III., the entrance to the Temple of Chi-on-in in Kioto, Japan, and the Kremlin of Moscow.

In bibliographies the articles of this volume are as satisfactory as in the earlier volumes: the comprehensive article on *Italian Litrature*, for example, has a bibliography appended comprising the titles of thirty different works on the subject, all of comparatively recent date, and several as late as 1901: again, the article on *Irrigation* has a bibliography of forty-five different works, all very recent: and finally, the bibliography of the word *Japan* contains ninty-four titles of books, many of which have more complete bibliographies themselves. Other important words have full bibliographies, the number of authorities referred to varying with the importance of the subject.

In every respect, then, the character of the original volumes is maintained.

J. P. W.

The Cavalry Horse and his Pack. Embracing the Practical Details of Cavalry Service. For the use of Officers and Non-Commissioned Officers of Cavalry. By 1st Lieutenant Jno. J. Boniface, 4th Cavalry. Kansas City, Mo.: Hudson Kimberly Publishing Company. 1903. 22 + 538 p. D.

In the preparation of this excellent work Lieutenant Boniface has rendered valuable service to his arm, and presented a valuable companion volume to Carters' *Horse*, *Saddles and Bridles*, with which it is uniform in binding and general appearance.

As the author himself tells us:

"Its object is to place in the hands of the young cavalry officer one volume embracing the duties and responsibilities which confront him from the moment he joins his troop, and to make clear to him how things are done in the cavalry service, The author has consulted all the professional works pertaining to the cavalry horse and his pack that were within reach, and to this has added the results of his own observations during ten years of cavalry service. To this he has added a vast amount of information obtained from those older cavalry officers who have made our cavalry service all what it is."

The work opens with a brief history of the horse and pack, then describes the various classes of cavalry and of horses, as well as the world's horse supply. In these opening chapters particular attention is given to the *American* horse and *American* cavalry.

The succeeding chapters are devoted to the practical duties of cavalry, including shoeing, bitting, saddling, riding, training, grooming, watering, and feeding, as well as the field work of cavalry, such as marches, the passage of rivers, tranporting cavalry horses, the pack and the pack train, and finally there is an excellent chapter on diseases and medicines.

The work is fully and beautifully illustrated, —an important factor in the practical utility of such a hand book of the cavalryman.

We know of no better work on the subject, nor have we ever seen a libary of a mounted command that was as generally useful as this simple volume. It is not only essential to the cavalryman, however, but will be of use to all mounted officers and men, and all others interested in horses and horsemanship.

J. P. W.

Die Bein und Hufleiden der Pferde. By Spohr, Oberst a. D. 7th Edition, enlarged. Leipzig: Arwed Strauch. 1903. xviii+198 p. O. Paper, Mk. 2.

The success of the preceding editions of this work and the favor that this method of treatment of diseases of the horse has met with, has demanded a new edition of this excellent pamphlet. In its present form it embraces the results of more than 50 years' experience and observation on the part of the author, confirmed by satisfactory and successful results obtained by a large number of veterinarians, who have carefully and intellegently followed the author's rules and principles, not only in the German army but in Austro-Hungary, Russia, and also in this country.

The book prescribes methods of treatment for all external troubles of the horse by the so-called *natural* method, without the use of drugs, by baths, douches, compresses, massage, etc., with some considerations on proper feeding, drink, sunlight and air, and a chapter on the treatment of injuries and wounds.

The author's style is clear and his work is based on facts. In many cases he illustrates his methods by practical examples, so that his book is truly a practical handbook containing much useful information and simple and effective remedies for the use of those interested in the care and management of horses, who desire to keep their horses in good condition or when sick, to restore them to good health.

Termes Militaires Français-Anglais (French and English Military Terms.) By Albert Septans, Brevet Colonel, Colonial Infantry, and Victor Schmid, Professor of English at the Brest Lycée. Paris: Henri Charles-Lavauzelle. 10, Rue Danton. 1903. 25+246 p. O. Paper, 4 francs.

This will be found a very useful work and one of much practical value to officers desirous of becoming familiar with French terms and phrases more commonly met with in French military literature. It is not only a dictionary but also a military manual, as most of the definitions are accompanied by extracts from some competent writer or quotations from official manuals, explaining or illustrating the term considered.

The work is divided into several parts thus facilitating ready reference. The first part is devoted first to everything concerning infantry, tactics, strategy and the different services of the French and English armies. Then follows similar chapters on cavalry, its use in battle, etc., on artillery, engineering and fortification. The second part treats of general tactics, reconnaissance and field operations containing numerous explanatory remarks and extracts from the works of prominent military writers. The authors give specimen orders and field service instructions in both languages, and conclude this part with a chapter comprising geographical terms most generally used, and details and nomenclature of all kinds of transport used in campaigns. The book concludes with a series of "military dialogues" on pertinent subjects, reconnoitring, questioning a native, a trooper, etc., and some between English and French officers, associated in operations or opposed to one another under various conditions.

The idea of the work is admirably carried out. As a *dictionary*, we regret that its scope is not more extended. Under *artillery*, for example, we looked for several terms pertaining to the new field artillery, but they are not given. The book possesses the advantage of giving one the English equivalent of many technical French terms by one who, perfectly familiar with French, is also a competent professor of *English*. Hence a fuller vocabulary as well rendered as this is, would increase the value of the work.

INDEX TO CURRENT MILITARY LITERATURE.

[For Abbreviations used in Index see first number of each *volume*.]

[Periodicals of June, July, August, 1903.]

ARTILLERY MATERIAL.

AUTOMOBILES, BICYCLES, AEROSTATION.

Results of the international kite-flying contest.—**Scien. Amer.**, July 25.
New Santos-Dumont airships.—**Scien. Amer.**, July 11.
Aerial flight experiments of Captain Ferber.—**A. Marine**, August 2.
The Zeppelin balloon.—**Genie C.**, August 8.
Development of the electric vehicle.—**West. Elec.**, July 18.
Steam autocar notes.—**Eng.**, July 17; August 21.
Steam motor wagons.—**Eng'ing.**, August 7.
The automobile congress.—**Genie C.**, August 1.
Serpollet steam automobile. **Scien Amer.** Supplement, August 1.
The use of automobiles in the maneuvers of the year 1902. **Mitth. Art. u. G.**, 5 and 6 1903.
Mililary automobiles for the transport of material.—**R. Artig.**, May.

BALLISTICS.

Influence of atmospheric conditions on shooting.—**Organ**, lxvi, 4, 1903.
Graphic solution of some ballistic problems.—**R. Artig.**, June.
Extracts from exterior ballistics.—**R. Mil. Brazil**, June.
New ballistic tables.—**Mitth. Art. u. G.**, 8, 1903.
Ballistic apparatus: determination of wind velocity and wind direction.—**Mitth. Art. u. G.**, 8, 1903.
Recent trials of cemented armor plates, 1902-1903.—**Genie C.**, August 15.
Theory and practice of armor attack.—**Eng.**, July 17.
Note on a particular case of indirect fire for field artillery.—**Exercito**, June.
Estimation of distances.—**Organ**, lvvi, 4, 1903.
Note on the measurement of parallaxes with sights graduated in *decigrades*, (indirect laying new French field artillery).—**R. Artillerie**, June.
Minimum distance between a battery and its cover.—**R. Artillerie**, June.
Brief comparative study on the firing regulations for field, siege and position and coast artillery.—**M. de Art.**, June.

CHEMISTRY AND PHOTOGRAPHY.

The specific heat of solutions.—**Phys. Rev.**, August.
The permanent protection of iron and steel.—**Jour. Chem. Soc.**, July.
The new chemistry.—**Iron Age**, July 9.
Practical aspects of radio-activity.—**Iron Age**, August 6.
Schroeder contact process of sulphuric acid manufacture.—**Scien. Amer.** Supplement, August 8, 15, 22.
Radium and its recent development.—**Scien. Amer.** Supplement, July 25.
Atomic theory and the development of modern chemistry.—**Scien. Amer.** Supplement, July 25.
New stability test for nitro-cellulose powders.—**Jour. Chem. Soc.**, June; **Arms and Expl.**, August.
Notes on some processes of development.—**Genie C.**, July 11.
Beginnings of photography; history of the development of photography with the salts of silver.—**Photo. Jour.**, June.
A rapid blue-print frame.—**Amer. Mach.**, August 13.
Automatic focussing enlarging apparatus.—**Scien. Amer.** Supplement, July 11.
Electric blue-print making.—**Scien. Amer.**, July 18.

DRILL REGULATIONS, MANEUVERS AND PRACTICE.

New infantry drill regulations.—**Cercle**, July 11, 18.
Musketry training.—**Wochenblatt**, June 18.

Considerations on some branches of field artillery training.—**Wochenblatt**, June 20.

Military instruction of the recruit.—**R. Artig.**, May.

Individual training of the marksman.—**Cercle**, July 25.

Notes on field service in the French army.—**R. M. Suisse**, July.

Training the army.—**A. and N. Gaz.**, July 11.

Training and educational duties of officers.—**Wochenblatt**, July 4, 7.

Instruction and training in battle firing.—**Wochenblatt**, July 7, 9, 11.

Draft of regulations for drill and maneuvers of infantry.—**R. Inf.**, July.

French field service regulations for infantry.—**S. M. Blaetter**, June, July.

Garrison artillery training.—**U. Serv. Mag.**, August.

Use of the saber on horseback.—**R.Cav.**, July.

Some more results showing hits made by infantry section-firing under battle conditions.—**Jahrbuecher**, August.

Infantry musketry training and instruction; instruction firing—school firing.—**Jahrbuecher**, August.

New firing regulations for batteries of field artillery.—**M. de Art.**, July.

Noteworthy items from the new firing regulations for the Austro-Hungarian infantry.—**Wochenblatt**, July 30, August 1.

Draft of regulations on field service and battle instruction of the three arms.—**Sbornik**, June.

Gun and battery drill according to the French field artillery regulations.—**Sbornik**, June.

English infantry drill regulations.—**Sbornik**, July.

Battle training of the sotnia.—**Sbornik**, June July.

Notes on the German maneuvers.—**Jour. U. S. Cav.**, July.

Combined maneuvers of 1903, U. S.—**A. and N. Jour.**, August 3.

Rules for the joint maneuvers, U. S.—**A. and N. Jour.**, July 11.

Garrison maneuvers.—**Belgique M.**, July 12.

The point of direction in marching.—**Wochenblatt**, June 18, 27.

The planning of small infantry maneuvers —**Wochenblatt**, June 20.

The Delhi maneuvers, December 1902.—**Jour. R. U. S. I.**, June.

Report on exercises with troops, bivouacs etc., made on snow.—**R. Inf.**, July.

Information on the transport of two infantry brigades with artillery from European Russia to the Transbaikal.—**Wochenblatt**, August 6.

Retrospect on the German maneuvers, 1902.—**A. S. M. Zeit.**, August 1.

Grand maneuvers; Belgian grand maneuvers; grand maneuvers abroad.—**Belgique M.**, August 9, 16.

The May cruise of the First Squadron, 1903.—**Rundschau**, July.

The grand naval maneuvers (Austria, Germany.)—**Boletin**, May.

Naval maneuvers, England.—**U. S. Gaz.**, July 18, August 15, 22; **A. and N. Gaz.**, August 22.

Fleet and torpedo craft maneuvers, 1903.—**U. S. Gaz.**, August 8.

Admiralty report on the English fleet maneuvers in the Mediterranean, 1902.—**Seewesens**, 8, 1903.

English fleet maneuvers.—**R. G. de Marina**, August.

Firing tests of rapid-fire field artillery.—**R. M. Suisse**, July.

Shooting in the navy, England.—**U. S. Gaz.**, August 1.

Some notes on practice with the 15-cm. Bc. mortar.—**M. de Art.**, July.

Ship prizes and prizes for gun crews.—**A. and N. Jour.**, August 3.

ELECTRICITY.

Wireless telegraphy as a means of signalling for scouting service.—**Rundschau**, August–September.
Hertzian wave wireless telegraphy.—**Pop. Sc. Mo.**, August; **Scien. Amer.** Supplement, July 18, 25.
The Musso duplex typewriting wireless telegraph.—**Elec. World**, July 4.
Telephone engineering.—**Amer. Elec.**, July.
Intercommunicating telephone systems.—**Amer. Elec.**, July.
Common battery systems.—**Tel. Mag.**, July.
Recent improvements in the Pollak-Virag rapid telegraph system.—**West. Elec.**, August 1; **Elec. World**, July 18.
Lodge-Muirhead system of wireless telegraphy.—**Elec. World**, August 1.
Gruhn telechirograph.—**Elec. Rev.**, July 4.
Stringing outdoor wires.—**Amer. Elec.**, August 1.
Description of the Siemens-Halske artillery telegraph.—**R. G. de Marina**, July.
Westinghouse electro-magnetic brake.—**Memoires I. C.**, May.
Electrical measurements and measuring instruments.—**Zeitschr. I. A. V.**, August 7, 14.
Electrical installations in armored forts.—**A. Belge**, May–June.
Defective machine insulation.—**Frank. Inst.**, August.
Electricity in the shop—the switchboard.—**Amer. Manfr.**, July 16, 23; August 6.
Automatic means for disconnecting disabled apparatus.—**West. Elec.**, July 11.
Methods of combining resistances.—**Elec. Rev.**, July 4, 18.
Power measurement on alternating current circuits.—**Elec. Rev.**, August 15, 22.
The ondograph (instrument that indicates on paper alternate current waves).—**West. Elec.**, August 22.
Electric light plant for Dutch torpedo boats.—**Eng'ing**, July 31.
Storage batteries in electric railway operation.—**Eng'ing Mag.**, August.
Alternating current motors for variable speed.—**Elec. World**, July 4.
Edison's storage battery.—**Amer. Mach.**, August 6.
More news about the Edison storage battery.—**Scien. Amer.**, August 8.
The tracing and remedy of motor troubles.—**Eng. Cleve.**, August 1; July 15.
Thompson's electrostatic motor.—**West. Elec.**, August 15.
Electric auto-transformers.—**R. Artig.**, June.

ENGINEERING AND FORTIFICATIONS.

Foundations.—**Jour. Eng. Soc.**, June.
Failure of a seawall and its reconstructiou.—**Jour. Eng. Soc.**, June.
Military engineering and civil opportunities in the Philippines.—**Eng'ing Mag.**, August.
Instrument for interpolating contours.—**Eng'ing News**, July 16.
Tests of Portland cement mortar exposed to cold.—**Eng'ing News**, July 30.
Hammer-Fennel instrument for stadia work.—**Eng'ing News**, August 13.
Development of the field railway system.—**Ueberall**, 41, 1903.
Use of armored cement for military purposes.—**R. Artig.**, May.
Preservation and care of wood; more especially the handles of tools.—**Genie M.**, July.
Construction of works of concrete along the coasts of the United States

ENGINES, BOILERS AND MECHANISM.

METALLURGY.

MILITARY GEOGRAPHY.

The Corinthian canal.—**Scien. Amer.** Supplement, July 25.
Belfast harbor and its development.—**Eng'ing.**, July 17.
An Indian ship canal.—**Eng'ing.**, August 14.
Russia.—**U. Serv. Mag.**, July, August.
Canal connecting the Atlantic and Mediterranean.—**Cercle**, July 11, 18.
Chinese eastern (Manchurian) railway.—**Page's Mag.**, July.
A German Gibraltar on the Gulf of Persia.—**Marine F.**, July 15.
A Russian creation in the Far East: Dalny.—**Marine F.**, July 15.
British interests in Persia.—**Marine F.**, July 15.
The new port of Saigon, Indo-China.—**R. Maritime**, June.
The great Siberian and Manchurian railroad in regard to its general and military importance.—**Jahrbuecher**, July.
Senegal and the port of Dakar.—**Genie C.**, August 15.
Bizerta as a fortress and as a naval base.—**Wochenblatt**, August 18, 20.
The North-Atlantic Powers, a politico-geographical study.—**Rundschau**, August–September.
Military and statistical description of Macedonia, Old Servia and Albania.—**Sbornik**, June.

MILITARY HISTORY.

Studies of military history: The Franco-Spanish invasion of Portugal in 1807.—**Exercito**, June.
A battle in a forest on a winter's night, (battle of Morschheim, 1794).—**Wochenblatt**, June 13.
Former commanders of the Royal Hanoverian army and their troops.—**Wochenblatt**, June 18.
A new contribution to the history of the campaign of 1815.—**Wochenblatt**, June 25.
A Hessian regimental history.—**Wochenblatt**, June 27.
Characteristics of the European armies.—**Int. Rev. Beiheft**, 41, June.
The maps to be consulted for the study of military history.—**Int Rev.** Supplement, 52, July.
Railway warfare in South Africa.—**Int. Rev.** Supplement, 52, July.
Battle of Ball's Bluff.—**U. Serv.**, July.
The cavalry arm of the service.—**U. Serv.**, July.
The Spanish-American war, 1898.—**Ueberall**, 42, 45, 1903.
Campaigns against India from the west and through Afghanistan.—**Jour. R. U. S. I.**, June, July.
The military revolution in Servia.—**A. S. M. Zeit.**, July 4.
Recollections: Strasbourg, 1870.—**Cercle**, July 25, August 1.
History of the artillery.—**R. Univ.**, July, August.
Campaign in China, May to September, 1900.—**R. Univ.**, July, August.
American cavalry.—**U. S. Gaz.**, July 4.
An episode of the campaign of 1801.—**R. Mil. Portugal**, July 15.
How Prussia prepared her revenge, 1806-1813.—**R. Inf.**, July.
Studies of the South African war.—**R. M. Etrang.**, July, August.
Service of the military engineers in France during the reign of Louis XIV.—**Genie M.**, July.
A French view of the Boer war.—**U. Serv. Mag.**, August.
Conquest of Java.—**U. Serv. Mag.**, August.
A chief of cossacks in the campaign of 1813.—**R. Cav.**, July.
German mountain artillery in China.—**Int. Rev.** Supplement, 53.
Battle of Albuera.—**R. Mil. Portugal**, June 30.

Individual initiative of commanders in wars; as illustrated by the III. and V. French army corps, August 6, 1870. -**Jahrbuecher**, July.

The Royal Hanoverian army and its end.—**Jahrbuecher**, July, August.

Report of the commission on the selection and transport of war material from the Philippines.—**M. de Art.**, July.

William III. of England and Maximilian-Emmanuel of Bavaria in the war in the Low Countries, 1692-97.—**A. Belge.**, May-June.

American cavalry in China.—**Jour. U. S. Cav.**, July.

Battle of El Caney.—**Jour. U. S. Cav.**, July.

France and the American revolution.—**A. and N. Jour.**, July 25.

The battle of Bacolod.—**A. and N. Jour.**, July 25.

Orders on the cessation of the battle of Worth.—**Wochenblatt**, July 21, 23, 25.

Events in North Africa.—**Wochenblatt**, July 23, 30; August 4.

Artillery side-lights on the South African war.—**Wochenblatt**, August 6.

The Venetian Republic; a concise sketch of its rise and its prosperous days.—**Rundschau**, August-September.

Prince Eugene Napoleon in the campaign of 1809.—**Sbornik**, June, July.

Behind the army of the Danube 25 years ago.—**Sbornik**, June.

Events at Vilna in 1812.—**Sbornik**, June.

The war of 1877-1878.—**Sbornik**, June.

Use of block houses during the civil war.—**A. and N. Jour.**, July 11.

In the times of Admiral Von Stosch.—**Rundschau**, July.

The Wasp and the Frolic and other incidents of the war of 1812.—**U. Serv.**, August.

The English navy in the second half of the 19th century.—**Rundschau**, August-September.

The role of the navy during the war of 1877-1878.—**Sbornik**, July.

MILITARY SCHOOLS.

A public service medical school.—**Jour. Mil. Surg.**, July.

Reorganization of the artillery and engineer school of application, France. —**Cercle**, August 8.

The New Royal Naval College.—**U. S. Gaz.**, August 22.

Establishment of a cadet school for the nobility in Russia.—**Wochenblatt**, July 16.

Greater frequency and new terms for admission to the Russian Junker Schools.—**Wochenblatt**, August 8.

ORGANIZATION AND ADMINISTRATION.

A Russian opinion on the formation of batteries.—**R. Artig.**, May.

What are the requirements of our position artillery to repulse successfully an enemy entering our land in case of war; does its present organization and armament suffice, or what changes are necessary?—**S. M. Blaetter**, June, July.

Machine guns in the Swiss army.—**R. Mil. Portugal**, June 30.

System of local guides for home defense.—**Jour. R. U. S. I.**, July.

The army of a manufacturing people.—**U. Serv. Mag.**, July.

Mounted orderlies with the Russian infantry.—**Wochenblatt**, June 6; **Armee**, June 5.

Administrative work of Russian troops.—**Wochenblatt**, June 30.

Impressions of a cavalry officer travelling in England, France, Italy, Austria, and Germany.—**Organ**, lxvi, 4, 1903.

SMALL-ARMS AND EQUIPMENTS.

STRATEGY AND TACTICS.

Service of security and information for infantry.—**Armee, June** 5.
Crossing of rivers in the presence of the enemy.—**Armee, June** 26.
Study of a tactical question.—**R. Univ.**, July, August.
Tactical problems.—**Belgique M**, July 19.
Military reconnaissances.—**R. Mil. Portugal**, July 15.
Problems of applied tactics.—**R. Inf.**, July.
Machine guns on the field of battle.—**M. de Art.**, June.
The offensive and the defensive, or the concentration and division of effort. —**Int. Rev.** Supplement, 53.
Infantry fire instruction.—**R. Mil. Portugal**, July 21.
Tactical considerations on the attack of fortified field positions.—**Beiheft zum M. W.**, 8, 1903.
Initiative and responsibility.—**Cercle**, August 15.
German ideas on tactics: influence of the South African war.—**R. M. Etrang.**, August.
The services of observation and security.—**A. and N. Gaz.**, July 4.
A military problem and solution for it. (Supply of ammunition in battle). **Jour. U. S. Cav.**, July.
Fleet tactics based upon the gun.—**Rundschau**, July.

SUBMARINES, TORPEDO BOATS AND WARSHIPS.

Submarine boats Pike and Grampus.—**Scien. Amer.** Supplement, July 18.
Submarine operations.—**R. Marit. Brazil**, June.
On the use of submarines.—**R. Maritt.**, June.
The German navy and the submarine.—**Marine F.**, July 15.
Submersible and submarine torpedo boats.—**R. G. de Marina**, August.
Our torpedo boat destroyers.—**A. Marine**, July 12.
French torpedo boat Audacieux.—**Yacht**, July 11.
New torpedo boats for the navy, England.—**U. S. Gaz.**, August 22.
American 1st class destroyer Nicholson.—**Yacht**, July 25.
Dutch sea-going torpedo boat Ophir.—**Yacht**, August 8.
Japan's naval review at Kobe (description of ships).—**Ueberall**, 41, 1903.
French naval forces in 1904.—**Yacht**, July 11.
School and transport ship Ocean.—**Schiffbau**, July 8, 23.
Naval notes.—**Page's Mag.**, July.
The Imperial German gunboat Eber.—**Rundschau**, July.
Scouting ships.—**Rundschau**, July.
English battleship Commonwealth.—**R. G. de Marina**, July.
Description of the turrets of the Princess de Asturias type of cruisers.—**R. G. de Marina**, July.
The vicissitudes of the Italian navy.—**Yacht**, July 18.
Transformation of the Furieux.—**Yacht**, July 18.
Guns and armor.—**A. and N. Gaz.**, July 25.
Modern battleships.—**Armee**, June 5.
The Japanese naval review and the Imperial navy.—**Club Mil. Nav.**, June.
Portuguese battleship Vasco da Gama.—**Club Mil. Nav.**, June.
German gunboat Tfingtau.—**Yacht**, August 1.
British warships and those of other nations.—**Seewesens**, 9, 1903.
Battleship or cruiser?—**Int. Rev.** Supplement, 53.
Armored or unarmored warships?—**Marine F.**, June 15.
French battleship St. Louis.—**R. G. de Marina**, August.
English first-class cruiser Donegal.—**Yacht**, August 15; **Eng.**, July 24.
Development of the floating dry dock.—**Eng'ing. Mag.**, August.

Great run of the Kearsarge —**A. and N. Jour** , August 3.
Ammunition supply (naval guns).—**A. and N. Gaz.**, July 4.
The 13,000-ton battleship problem.—**Iron Age**, July 30; **A. and N. Reg.**, August 8; **Mar. Rev.**, July 30.
Design for the new battleships, U. S.—**A. and N. Jour.**, July 18.
The torpedo tube and our new battleships.—**Scien. Amer.**, August 1.
Progress of warships and machinery building in England.—**Eng.**, July 3.
Again the Hyacinth and Minerva.—**Eng.**, July 3.
War conditions trial of the Europa and Spartiate.—**Eng.**, July 10.
French commerce destroyer, Guichen.—**Scien. Amer.**, July 25.
H.M.S. King Edward VII.—**Eng.**, July 31.
Turkish cruiser Medjidie.—July 23, 30.
Our latest design of battleships.—**A. and N. Jour.**, August 22.
On the speed of battleships.—**R. Maritt.**, July.

Sit Right Down and write for a Sample of

WHEATLET

It will cost you but three two cent stamps and your grocer's name to receive full half pound sample of

WHEATLET

and know why it is the very best cereal food you can possibly eat.

ELBERT HUBBARD, Editor of *The Philistine*, says :—

"You will see this issue is a 'hot' number, all being written on a Wheatlet diet. In fact, I have never been so doosed clever in my literary work as since I tackled Wheatlet."

(Tell us the mispelled word in January Ad. Early Breakfast Picture in 14 colors, 17x22 to first fifty corrections.)

Before you forget it, write for sample to

The Franklin Mills Co.,

"All the Wheat that's Fit to Eat."

729 Springarden St., LOCKPORT, N. Y.

OCEAN VIEW

THE ATLANTIC CITY OF THE SOUTH

Nine Miles from the City of Norfolk, 30 minutes from Old Point.
Boat leaves Old Point 20 minutes after the hour.

BOATING! BATHING!! FISHING!!!

Varied Amusements.

HIGH CLASS ATTRACTIONS IN CASINO.

BAND CONCERTS. DANCING.

OCEAN VIEW HOTEL,

EXCELLENT CUISINE.

NORFOLK'S STORES CATER TO ARMY OFFICERS.

CHINA, GLASSWARE,
LAMPS, CUT GLASS,
BRIC A BRAC,
LATEST DESIGNS
AND
DECORATIONS.

DINNER AND TOILET SETS.

BELOW COST

NEW STOCK.

JOHNSTON'S,

Take a Sea Trip

FOR

COMFORT, PLEASURE and RECREATION

Merchants and Miners Trans. Co.

"QUEEN OF SEA ROUTES"

NOVEMBER–DECEMBER.

Vol. XX. No. 3. Whole No. 64.

1903.

JOURNAL

OF THE

UNITED STATES ARTILLERY

DEC 18

PUBLISHED UNDER DIRECTION OF THE

ARTILLERY BOARD.

FORT MONROE, VA.

ARTILLERY SCHOOL PRESS.

1903.

The **JOURNAL OF THE UNITED STATES ARTILLERY** is published, as a bi-monthly, at Fort Monroe, Virginia, under the direction of the Artillery Board.

MANAGER AND EDITOR.

Captain Andrew Hero, Jr., Artillery Corps.

Subscription	$2.50
For countries in the postal union	$3.00
Single numbers	$0.50

All remittances should be made payable to **Journal of the U. S. Artillery.** These and communications relating to the editorial management should be addressed **Editor Journal U. S. Artillery, Fort Monroe, Virginia.**

AGENTS.

New York — *Dyrsen & Pfeiffer,* successors to *F. W. Christern,* 254, 5th Avenue.

London — *B. F. Stevens & Brown,* 4 Trafalgar Square.

ADVERTISING DEPARTMENT.

All communications in regard to advertising should be addressed to **Mr. Frank St. Clair, Box 799, Norfolk, Va.,** who has complete charge of this department.

THE FRENCH FIRST-CLASS BATTLESHIP "ST. LOUIS" 11,275 TONS; 14,500-I.H.P.; Speed 18 Knots.

ARMOR PROTECTION: Water-line belt, 15.7 in.; tapering to 10 in.; upper belt, 3 in.; turret, 15.7 in.; armored deck, 3.5 in.
ARMAMENT: Four 12-in. guns in turret, one forward and one aft; ten 5.5-in. quick-firing guns; twenty 3-pounder quick-firing guns; four 1-pounder quick-firing guns; and thirteen machine guns; with four torpedo tubes (two submerged).

By courtesy of the Royal United Service Institution.

HARVARD COLLEGE LIBRARY
DEC 18 1903
CAMBRIDGE, MASS.

JOURNAL

OF THE

UNITED STATES ARTILLERY.

VOL. XX. NO. 3. NOVEMBER—DECEMBER 1903. WHOLE NO. 64.

TEST OF EXPERIMENTAL FIRE-CONTROL INSTALLATION AT PENSACOLA, FLA.*

The Board of Engineers,
Army Building, New York City,
July 31, 1903.

Brig. Gen. G. L. Gillespie,
Corps of Engineers,
Washington, D. C.

General:

1. The Board of Engineers has the honor to submit the following report on the test of the fire control system at Pensacola Harbor April 20 to 23, 1903:

2. The Board, consisting of Colonels Suter and Stickney, Lieutenant-Colonel Livermore and Majors Birnie and Pratt, with Lieutenant Schultz, Recorder, arrived at Pensacola on April 18, inspected the defenses of Pensacola on April 19 and the proposed system of fire control on April 20.

3. A description of the fire control system and the methods of operation, as well as the results observed by Captain R. R. Raymond, Corps of Engineers, are given in his report which is published herewith as an appendix.

4. The batteries under test were Battery A, B.L.R., at Fort Pickens, Battery B, B.L.R., at Fort Pickens, Battery C, B.L.R., at Fort McRee and Battery D, B.L.M., at Fort Pickens. The actual test began April 23.

*Extracts from Engineer Mimeograph No. 68. Publication authorized by the Chief of Engineers, U. S. A.

5. For purposes of observation, during the morning of April 21 the Board was stationed in the fort commander's station at Fort Barrancas, where also were the district commander and Major G. N. Whistler, Artillery Corps, the latter being in immediate charge of the test.

6. The tests as witnessed April 21, were as follows:

INDICATION TEST.

Major Whistler was at the telephone in fort commander's station, Fort Barrancas, and indicated to the fire commanders at Forts Pickens and McRee by means of numbered squares, e. g., 917 N.W. on the harbor chart, meaning the N.W. section of square No. 917. Each square was 500 yards on a side.

All communication between fort commander and fire commanders was by telephone; there was no telautograph or means of visual signaling by the fort commander. The times given are not official but are those observed by the Board as nearly correct as possible. Three indications are given, the replies being received as follows:

1st Indication:—Reply by Pickens 1 min.

2nd Indication:—Reply by Pickens 1 min., McRee 40 sec.

3rd Indication:—Reply by Pickens 20 sec., McRee 45 sec., wrong, 1 min. 55 sec. correct,

giving an average of 59 seconds between indication and the reply.

7. Orders for trial shots were then given. The telephone worked badly and it was some time before the targets were identified. Regular fire was then begun as follows:

From the command commence firing,

Battery A fired shot in 3 m. 8 sec.

Battery B fired shot in 4 m. 15 sec.

Battery C fired shot in 3 m. 0 sec.,

giving an average of 3 m. 27 sec. To this interval must be added the time between indication and reply, of about 59 seconds, making a total average lapse of time between indication and fire of 4 m. 26 sec.

8. A second series was then begun.

Battery A fired in 4 m. 15 sec. (wrong target reported.)

" B " " 6 m. " " "

" C " " 2 m. 36 sec.

The grass in front of battery A took fire after first shot, and required 2 minutes to be extinguished.

DISPERSION AND CONCENTRATION TEST.

9. Orders were given assigning Battery A on easterly squadron and Battery B on westerly squadron,

Battery A fired 1st shot 4 m. 43 sec. after orders,
2nd " 2 m. 22 sec. interval,
3rd " 1 m. 28 sec. interval.
Battery B fired 1st shot 4 m. 48 sec. after orders,
2nd " 3 m. 35 sec. interval,
3rd " 2 m. 11 sec. interval.
Battery C fired 1st shot 3 m. 03 sec. after orders,
2nd " 2 m. 47 sec. interval.

10. Order to concentrate on 1514 S.W. (square).
Battery A fired 1st shot 5 m. 16 sec. after orders,
2nd " 1 m. 18 sec. interval,
3rd " 1 m. 18 sec. interval.
Battery B fired 1st shot 4 m. 58 sec. after orders,
2nd " 2 m. 54 sec. interval.
Battery C fired 1st shot 3 m. 45 sec. after orders,
2nd " 1 m. 44 sec. interval,
3rd " 1 m. interval.

DISPERSION TEST.

11. Battery A fired 1st shot 3 m. 44 sec. after orders,
2nd " 1 m. 16 sec. interval,
3rd " 1 m. 27 sec. interval.
Battery B fired 1st shot 2 m. 50 sec. after orders.
2nd " 1 m. 32. sec. interval.

12. Orders to change target.
Battery B fired 3rd shot 1 m. 25 sec. interval.
Battery A fired 1st shot 2 m. 55 sec. after orders.

The grass in front of Battery B took fire and required to be extinguished. The telephone could not be used for several minutes between the concentration and dispersion tests. The trouble was said to be due to a loose binding screw.

CHANGE OF BASE FOR BATTERY C.

13. This was accomplished by changing to another base line.

1st	shot	fired	4 m.	8 sec.	after orders,
2nd	"	"	1 m.	7 sec.	interval,
3rd	"	"	1 m.	10 sec.	interval,
4th	"	"	5 m.	26 sec.	interval,
5th	"	"	1 m.	52 sec.	interval.

The delay between shots 3 and 4 was caused by smoke; also reported that shot truck fell down shaft.

SALVO TEST.

14. It required some time to properly describe and identify the target among the several officers in the fort commanders' stations.

Battery C ready 1 m. 15 sec. after orders given,
Battery A fired 2 guns 2 m. 10 sec. after orders.
Battery B fired 4 guns 2 m. 10 sec. after orders.

Battery C missed fire three times and finally fired by lanyard 13 m. 53 sec. after first order.

This closed the tests for the morning.

15. During the afternoon the Board was stationed in the fire commander's and battery commander's stations at Fort Pickens to witness the test of mortar fire with a constant angle of elevation of 45° at moving targets. The mortar fire was computed by certain zones, and charges giving the required velocities were prepared accordingly.

1st shot, 3rd zone, 8100 yds. range,
2nd shot, 4th zone, 7200 yds. range, interval 4 m. 55 sec.
3rd shot, 5th zone, 6300 yds. range, interval 8 m. 45 sec.
4th shot, 6th zone, 5400 yds. range, interval 7 m. 35 sec.
7th zone, 4500 yds. range, lost on account of passing vessel.
5th shot, 8th zone, 3700 yds. range, interval 13 m. 39 sec.

16. In all of the above shots the mortar was ready in about 4 to 5 minutes, the remaining time of the interval being lost in order to await the arrival of the target in the zone. The weather was to some extent hazy and the target could not be seen with type B instrument in the secondary stations beyond the 3rd zone or about 8100 yards. This closed the test for the day.

17. On April 22 the Board proceeded to Fort Barrancas and Fort Pickens to witness further test of guns at moving targets and test of mortars at 52° elevation. Owing to the haze in the atmosphere no tests took place on this date.

The Board, except Lieut. Colonel Livermore and Major Pratt, left Pensacola on the evening of April 22 and returned to their stations.

18. The object of the tests as given by General Orders No. 4, Artillery District of Pensacola, March 28, 1903, was to determine the following points, viz: (1) rapidity and accuracy of indication, (2) rapidity and accuracy of identification, (3) rapidity and accuracy of location, (4) concentration and dispersion of fire, (5) rapidity and accuracy in firing at moving targets, (6) efficiency of methods of communication, (7) value of mechanical devices used in fire control and direction.

19. The Board found that the average time of indication and identification was about 1 minute. This time should be made shorter by having other means of communication besides the

telephone and telautograph; especially should visual signals be employed.

20. In the matter of location, great difficulty was experienced with the type B instrument. In slightly hazy weather it was impossible to see the target with this instrument, when it was easily distinguished by the type A instrument. This rendered the system, as far as the horizontal base method was concerned, worthless until the atmosphere became clearer. The instrument for the secondary station should have a telescope of equal power and range as the type A.

21. The concentration and dispersion tests were dependent entirely on the methods of communication, which, as already stated, was the telephone only, between the fort commander at Fort Barrancas and the fire commanders at Fort Pickens and Fort McRee. It seemed that the effort to concentrate the whole command under the fort commander at Fort Barrancas was not entirely satisfactory for the reason that the whole system depended on a single means of communication, which at best is easily rendered useless. It seemed advisable that the fort commander, who was some distance from the fire commanders, should not burden himself with petty details nor attempt to transmit nor receive information concerning them. The general features only should be under his direction.

22. The firing at moving targets with mortar at fixed angles of elevation while satisfactory as to the plotting and locating the targets and course, appeared to the Board to present serious objections. The freedom of fire is greatly restricted if the fixed angle method is used. In the test as witnessed on April 21 a delay of 4 minutes was often necessary to await the target's position on the zone. By modifying the course of the vessel the delay might be made interminable. It seems that by altering the elevation and weight of charge, no delay will be occasioned and the target may be fired at as rapidly as plotting and loading conditions will permit.

23. Regarding the engineering features, the Board found the temporary structures for primary and secondary stations as constructed by Captain Raymond very satisfactory. Where the conditions of site allow, the several primary and secondary stations should be brought nearer together. These stations being primarily for horizontal base methods, it is not desirable to give the instrument greater height than about 32 feet unless the natural elevation of the site renders it practicable. In all cases they should have natural or artificial cover when possible. The secondary stations, it is believed, should be larger.

24. The instrument and plotting rooms of the primary station were ample in size, and afforded comfortable means of performing all the work of locating and plotting. The type B pedestal should be entirely separate from the concrete pillar for the type A instrument. In general it will be sufficient to reinforce the floor and attach the pedestal directly to the floor.

25. The features of having all base lines on the same line where possible and having the fire and battery commander's stations near one another has many advantages. The great disadvantage is that it takes the battery commanders some distance from their batteries. If the communications can be made reliable, this defect is not so grave.

26. On two occasions during the morning of April 21 the parapet grass took fire. Notwithstanding this occurrence, the Board believes that a good sod is the best covering for the superior slopes. The sod and ground should be kept thoroughly wet while the batteries are in action, in which case there will be neither fire, smoke nor dust. All slopes should be provided with the necessary means for accomplishing this purpose.

27. The proper system of cables for power, electric light and communications is a matter which will require careful study. The Board believes that all cable should be buried, and that their number should be reduced to a minimum consistent with efficient control. A multiplicity of cables and complication of instruments and appurtenances may cause greater injury than benefit.

28. The telautograph booths as constructed on the platforms of the batteries were very satisfactory.

29. The damage to emplacements by the firing was very slight. During the firing at Battery C the telautograph was thrown from the wall of the battery commander's station. It would seem that this station was too near the battery.

In the battery commander's station at Fort Pickens the master clock was stopped by the discharge of one gun at Battery A. These clocks should be spring movement instead of pendulum.

30. The failure of the electric firing circuit and delay by lanyard firing, while having no bearing on the test, should not be lost sight of, as in actual operations such a defect might have serious consequences.

31. The Board is unable to arrive at a definite conclusion as regards the comparative value of the system of fire control as tested at Pensacola. It seemed, however, the general conclusion,

that the fort commander's duties were too comprehensive and extended, and that there was unnecessary complication of instruments and methods. The chief merit claimed for the system is the ability to identify targets by a subsidiary use of the vertical range finder instruments at an axis elevation of about 32 feet and thereupon passing to the horizontal method for accurate purposes. If further experience shows this system to be satisfactory, the range finding towers now conspicuous by their height above the natural site, may be dispensed with. It is understood that other systems have been proposed, and if so, comparative tests should be made as far as practicable.

For the Board:

Very respectfully,
Your obedient servant,
CHAS. R. SUTER,
Colonel, Corps of Engineers,
President of the Board.

United States Engineer Office,
Montgomery, Ala.,
May 9, 1903.

Colonel Charles R. Suter,
Corps of Engineers, U. S. A.,
President, Board of Engineers,
Army Building,
New York City.

Colonel:

1. In compliance with indorsement from the Office of the Chief of Engineers, dated March 31, 1903, I have the honor to submit the following report upon the installation and test of the experimental fire control system at the fortifications of Pensacola Harbor, Fla.

2. This system does not embody new principles, but is rather a new combination of well known methods of position finding and communication. It secures the accuracy of the horizontal base for the actual location of the target, and, at the same time, the convenience and rapidity of the depression system for the indication and identification of the target.

3. The object of the system is to improve the control by one commander of all the batteries combined; and for this purpose, the battery commanders are placed, not in their several batteries, but in battery commander's stations grouped in the immediate vicinity of the fire commander's stations. Each group of bat-

teries is therefore under the immediate personal supervision of a fire commander.

4. Two such groups exist at the present installation; one at Fort Pickens, consisting of Battery *B*, Battery *A*, and Battery *D*, and the other at Fort McRee, consisting of Battery *C*.

These two fire commands are under the control of a fort commander stationed at Fort Barrancas. Thus each battery, each fire command and the whole fighting force are under the supervision and control of the fort commander.

CONTROL OF ONE EMPLACEMENT.

5. To obtain a clear understanding of the method of control, it will be best to begin with a single gun.

Each gun (or mortar pit) is under the direction of a lieutenant, and may be operated under any one of three cases.

In Case I., direct aiming is used. This case is to be used only at the shortest ranges, or during the complete disablement of the position finders.

In Case II., the piece is laid in azimuth by direct sighting, the range being given from the battery commander's station. The time of firing and corrections of the azimuth due to all causes, are estimated at the gun. This case applies at moderate ranges, or during partial disablement of the position finding system, which does not prevent the use of the depression instrument.

In Case III., which is used at long range, the piece is laid entirely by direction of the battery commander and is fired by him at his station.

6. Each emplacement is provided with a telautograph receiver; and the directing gun is provided with a telephone, these instruments connecting only to the battery commander's station.

CONTROL OF ONE BATTERY.

7. The battery commander's station is placed in the vicinity of the fire commander's station and contains a type *A* position finder and also a type *B* finder. The larger instrument is centered upon one end of the horizontal base, which, in this installation, is approximately 2,000 yards long. At the other end of the base is mounted a type *B* instrument alone. This station is called the secondary station, usually abbreviated to *S. S.* The battery commander's station is called the primary station, or *P. S.*

The *P. S.* contains a telautograph, complete with transmitter and receiver, and also a telephone, connected with *S. S.*; a complete telautograph and telephone to the directing gun; and a relocating board. The gun telautograph of this station is used for sending messages only, as there is no transmitter at the gun for reply, the extra receiver at the station affording simply a check on the operation of the instrument at the gun.

S. S. contains a complete telautograph and telephone connected to *P. S.*

The telephones are intended to supplement the telautographs, and being operated over the telautograph wires cannot be used while the latter instruments are in operation.

When firing under Case I., the battery commander simply observes the fire.

Under Case II., the battery commander observes the range only and transmits it at short intervals to the gun.

Under Case III., relocation must be provided for. To obtain simultaneous readings at both observing stations, electric bells controlled by one master clock for the whole installation, are struck every 20 seconds in all the stations.

The reading at *P. S.* is called by word of mouth to the plotters, and that from *S. S.* is obtained from the telautograph, whose reading may be seen by the plotters, or called off to them.

A location of a fixed target is thus plotted, the corrections for atmospheric conditions and drift are determined by the ballistic board, the range and azimuth for the gun are determined by relocation on the plotting board, and transmitted to the gun by the gun telautograph. When the gun is reported ready, it is fired by the battery commander, whose firing switch is placed near the type *B* instrument at *P. S.*

In firing at a moving target, readings are taken at each stroke of the bell until four positions of the target have been plotted. This requires one minute. The course is thus indicated, and the probable position of the target at the end of any short interval desired is determined by means of a proportional scale or dividers. Corrections are made as before, and the corrected range and azimuth for the gun are transmitted to the gun by telautograph. The proper set-back is then determined and the two type *B* instruments are set for this point. The set-back point is the point where the target should be at the instant of firing, in order that during the flight of the projectile the target may move to the predicted point and arrive there simultaneously with the shot.

Each instrument is provided with three vertical wires. When the target crosses the first wire at *S. S.*, a vibratory bell at *P. S.* is rung by the operator at *S. S.*, and changed to a single stroke bell when the middle wire is reached. Thus the battery commander at *P. S.* knows when the target is crossing the field of the *S. S.* instrument, and if it crosses his own middle wire at the proper time, he fires the gun by means of his firing switch.

CONTROL OF ONE FIRE COMMAND.

8. The grouping of the battery commander's stations in the immediate vicinity of the fire commander's station, enables the fire commander to personally direct the battery commanders. No system of communication has yet been devised by which the fire commander can indicate a target to his battery commander as quickly as by going personally into their stations and setting their type *A* telescopes upon the desired target.

Thus the grouping of the stations is of great importance.

It has been stated that four batteries are about as many as one fire commander can properly handle. This estimate was based upon the time required for him to move between extreme stations. It has since appeared that the intervals between stations can be greatly reduced, thus increasing the number of stations within the working radius of the fire commander.

The fire commander's station is equipped as a battery commander's station, and is located as nearly as possible at the center of the group, to minimize the distance to be travelled.

CONTROL OF ENTIRE SYSTEM.

9. The fort commander's station was at Fort Barrancas. The telescope of the type *A* position finder has a reference of 100 feet. There is no secondary station, as only the vertical base is used. This station has telephonic communication with all fire commander's stations.

The fort commander controls the action only in its general features ; yet the system enables him to issue detailed orders, if desired.

The operation of firing from any desired gun at any target is as follows :

The fort commander determines the azimuth and distance from his station to the target by means of his depression instrument. The position is then located upon the chart by means of a permanent azimuth circle drawn upon the chart and a scale whose zero is pivoted upon the chart at the location of the fort commander's station. The chart is divided into squares numbered and lettered. The proper square is then telephoned to the fire commander, together with instructions for the firing. At the fire commander's station is a similar chart provided with a range scale and azimuth circle centered upon his own station. By simply turning the scale upon the proper square, the azimuth and range from the fire commander's station may be instantly read. The type *A* finder, set in accordance with this data, should find the desired target in its field of view.

The fire commander now proceeds to the proper battery commander's station and sets the telescope upon the target, thus completing the *indication* of the target. He also issues proper orders for the firing.

The battery commander reads the range and azimuth to the target from his own station by means of his depression instrument, plots the same on his plotting board, measures directly the range and azimuth from his secondary station, and sends the data by telautograph to that station, where the secondary instrument, properly set, should pick up the proper target. Thus the target is completely *identified*. It is now *located* by the horizontal base system as already described.

During these operations the gun may be made ready for firing, and may be fired as soon as properly set in accordance with the data resulting from the *location* of the target.

ENGINEERING FEATURES OF INSTALLATION.

10. The system was installed in accordance with the general plan devised by Major G. N. Whistler, Artillery Corps, by the Engineer and Ordnance Departments and the Signal Corps.

The Ordnance Department furnished the range finding instruments, plotting and ballistic equipment, and installed the firing wires and devices for the guns. It is thought that a detailed account of this work is not desired in this report.

The Signal Corps furnished and installed all telautographs, telephones, clocks, bells, æroscopes and other similar instruments, as well as the wiring and some of the cables. It is thought port, this installation is not desired to be made a part of this re- that further than already described in the general explanation of the system.

The Engineer Department constructed all stations, telautograph booths, storage battery houses, datum points, etc., laid cables and refilled the trenches ; consolidated the power plants, and supplied many fittings and accessories throughout the installation.

TEST OF THE SYSTEM.

11. G. O. No. 4, Headquarters Artillery District of Pensacola, March 28, 1903, prescribes the several tests and the program.

The tests were carried out substantially as ordered, beginning April 20, 1903, the only changes in the program being variations in the order of the tests.

The detailed report of the firing can be obtained only from the reports of the battery commanders, which will probably be available to the Board of Engineers as early as to me. These details will therefore be omitted from this report.

The order mentioned states the conditions and methods of working the tests. It therefore remains only to report the results.

12. FIRST TEST. GROUP INDICATION.

"The fort commander will direct the fire commander to open fire upon a certain group of targets, using the system of Indication. The fire commander will determine the group indicated, and assign targets to the several batteries all in the same group.

The battery commanders will *identify* the target to the secondary station, *locate* the same and fire one shot thereat. This test to be repeated, using a different range. The time from the sending of the order from the fort commander's station, to the firing of the gun, taken in connection with the accuracy of fire, will determine the value of this test." (G. O. No. 4).

Battery *A* fired a shot at the proper target in 3 minutes from the receipt by the fire commander of the fort commander's instructions.

Battery *B* fired in 4 minutes and 10 seconds.

Battery *C* fired in 2 minutes and 58 seconds.

As these intervals were observed by me personally as far as possible, other reports from other observers at different parts of the system may not agree exactly, because of the impossibility of timing from the same instant under the circumstances. It should be noted that the battery commander at Battery *C* is his own fire commander, and is thus enabled to save the time consumed by the fire commander at Fort Pickens in passing between stations.

This test was repeated, using a different range, and indicating by squares only.

Battery *A* fired in 4 minutes 15 seconds.

Battery *B* fired in 6 minutes 45 seconds.

Battery *C* fired in 2 minutes 37 reconds.

The delay at Battery *B* was the result of a mistake, which necessitated a change from a wrong to a correct target.

13. SECOND TEST. CONCENTRATION AND DISPERSION.

"The fort commander will direct the fire commanders to assign the several batteries to targets in different groups, and to open fire at their respective targets. Each battery will fire 10 rounds, except Battery *C*, which will fire 5 rounds. While firing the fort commander will direct the fire to be concentrated on a single target. And after such concentration, at a signal from the fort commander, the fire to be again dispersed at targets in different groups.

The time required to make these changes, together with the accuracy of the work done, will determine the value of this test". (G. O. No. 4).

In this test the indication was by squares. Battery *C* took no part in the dispersion test.

Battery *A* opened fire in 4 minutes 15 seconds from the receipt of the order at the fire commander's station; Battery *B*, in 4 minutes 23 seconds; and Battery *C* in 3 minutes. Each battery fired 3 shots.

After the order to concentrate was issued by the fort commander, Battery *A* reopened fire in 5 minutes 25 seconds; Battery *B* in 5 minutes 10 seconds; and Battery *C* in 3 minutes 57 seconds. Battery *A* fired three shots, each other battery fired two.

Cease firing was then ordered, and the fire was dispersed to scattered targets. Battery *A* reopened fire in 3 minutes 45 seconds and fired three shots; Battery *B* opened fire in 3 minutes and fired three shots.

Battery *A* was then ordered to change to another target, and fired in 3 minutes 15 seconds.

Battery *B* was ordered to change to a new target, and fired in 3 minutes 25 seconds and fired a second shot 2 minutes 18 seconds later.

Although forming no part of this test, it is interesting to note that so far as the work at the guns is concerned, the guns of Battery *A* could have been fired at 50-second intervals, an interval actually measured from one discharge until the gun was again in battery being 45 seconds.

14. THIRD TEST. CHANGE OF BASE LINE.

"One of the special features of the Wadsworth Board System is the change of base line for all around fire. Fort McRee alone has the double base line installed.

The fort commander will direct the fire commander at Fort McRee to open fire on a target at sea, or in the inner bay. The battery will fire five rounds. While firing, at a signal from the fort commander, the target will be changed from the outer target to the inner target or vice versa. Time and accuracy will determine the value of this test." (G. O. No. 4).

Owing to an accident at the gun platform the change of base was so delayed as to require 5 minutes 13 seconds. The results previously obtained at drill indicated that the change could have been made as rapidly as a change from one target to another without a change of base.

15. FOURTH TEST. SALVO TEST.

"Three salvo points lettered *A*, *B* and *C* will be established along the channel. They will be carefully located and the data placed in each emplacement. One of these points will be designated to be fired at. The order to fire at salvo point *A*, *B* and *C* according to designation will be given by the fort commander, and a salvo will be fired thereat from all of the guns. Accuracy of grouping of the shots about the indicated target will determine the value of this test. (G. O. No. 4.)

The time consumed from the order to fire at salvo point *B* until the salvo was fired was 2 minutes 20 seconds.

This completed the test of the system of control; the remainder of the test was devoted to target practice to test the accuracy and convenience of the system of laying, which is an artillery problem not within the scope of this report. It may be mentioned that the practice was excellent, the target being repeatedly struck when moving at a good speed and at a long range.

THE MORTAR TEST.

16. This test forms no part of the test of the fire control system. It is interesting, however, to note that the errors in range varied from 45 yards short to 80 yards over. Out of seven shots, two would have fairly struck a battleship moving across the field of fire. The mean variation in range was only 31 yards.

Very respectfully,
Your obedient servant,
R. R. RAYMOND,
Captain, Corps of Engineers.

FORMULAS FOR VELOCITY AND PRESSURE IN THE BORE OF A GUN, AND THEIR VERIFICATION BY RECENT EXPERIMENTS.

By Lieutenant-Colonel JAMES M. INGALLS, U. S. A., Retired.

The formulas for computing the velocity of a projectile in the bore of a gun and the corresponding pressure upon its base, which are the subjects of this article, were first published in 1893 in the author's work on interior ballistics, prepared as a text book for the Artillery School at Fort Monroe. Their deduction in Chapter IV. of that work is followed by an example showing the remarkable agreement between the velocities of a projectile at several positions in the bore of a 10-inch gun, computed by these formulas, and those deduced by Noble from the direct measurements of velocities by means of his chronograph. In this example the projectile was propelled by a charge of black powder. But other examples of agreement, quite as remarkable, where smokeless powders were employed, were subsequently given, or referred to, in the JOURNAL OF THE UNITED STATES ARTILLERY, volume 2, pages 85-94, and volume 6, pages 148-149. Recently the author has come across three other independent sets of experiments where nitro-cellulose powders were employed, in which velocities or pressures have been determined at various positions in the bore by measurements more or less indirect, and has made use of the data thus afforded for a fresh comparison with his formulas. The results are quite as satisfactory as those previously obtained and prove that these formulas actually give the velocity of a projectile in the bore of a gun in terms of the path described, and also the corresponding pressure on its base, for all kinds of powders with great accuracy, —greater, it is confidently believed, than by any other formulas yet published.

These formulas have, as yet, received but scant attention outside the Artillery School, and as, moreover, the work in which they are deduced is out of print and difficult to procure, it has been thought advisable to give them here without proof, for ready reference, and adapted to both the foot-pound (F.P.) and metre-kilogram (M.K.) units. They are partly theoretical and partly empirical, and like all physical formulas must stand or fall according as they tally with experiment and observation.

Let u be any distance travelled by the projectile in the bore, measured from its initial or firing position.

z_0 the reduced length of the initial air space in the chamber.

Put

$$\varepsilon = \frac{u}{z_0}. \tag{1}$$

With black powder the solid residuum left on burning occupies very nearly the same volume as the original powder grains, and therefore for this kind of powder ε expresses the number of volumes of expansion of the powder gases corresponding to the distance the projectile has travelled. This, as has been shown by Sarrau, is also approximately true for all varieties of smokeless and nitro-celloluse powders, and therefore the work done by the charge for a travel u is a function (or a combination of functions) of ε.

Since ε is the ratio of two linear values it is immaterial what units are employed in its determination provided, of course, the same units are employed throughout. Now determine an auxiliary angle θ by the equation

$$\sec\theta = (1+\varepsilon)^{\frac{1}{6}}$$

and take the following functions of θ, namely,

$$X_0 = 6\int_0^\theta \sec^3\theta\, d\theta = 3\tan\theta\sec\theta + 3\log_e(\tan\theta + \sec\theta)$$

$$X_1 = X_0 \sin^2\theta$$

$$X_2 = \sin\theta\cos^4\theta \left\{ 1 + \tfrac{1}{3}X_0\cos^4\theta\,\mathrm{cosec}\,\theta \right\}$$

$$X_3 = X_0 \left\{ 1 + \frac{1}{\tfrac{1}{3}X_0\cos^4\theta\,\mathrm{cosec}\,\theta} \right\}$$

Then, if v is the velocity of the projectile after a travel u, and p the corresponding pressure on its base, we shall have the very simple expressions

$$v^2 = M X_1 \left\{ 1 - N X_0 \right\} \tag{2}$$

and

$$p = M_1 X_2 \left\{ 1 - N X_3 \right\} \tag{3}$$

In these equations M, M_1 and N are functions of the density of the powder grains, the density of loading, the weight of charge, weight of projectile and diameter of bore. They are of course constant for a single shot, and in this case the values of v and p determined by equations (2) and (3) will vary only with X_0, X_1,

X_1 and X_2. That is, these are the equations of the velocity and pressure curves for a given gun and conditions of loading.

There is a fixed relation existing between M and M_1 so that there are really but two constants to be determined by experiment, namely, M and N. Before giving this relation it will be necessary to know the expression for z_0 which enters into it. Let

Δ be the density of loading.

δ the density (specific gravity) of the powder grains,

C the capacity of the powder chamber in cubic inches or cubic decimetres, according to the units employed.

w the weight of the projectile in pounds or kilograms.

$\tilde{\omega}$ the weight of charge in pounds or kilograms.

c the calibre of the bore in feet or metres. Then

$$\Delta = [1.442218] \frac{\tilde{\omega}}{C} \qquad \text{(F.P. units)},$$

$$\Delta = \frac{\tilde{\omega}}{C} \qquad \text{(M.K. units)}.$$

Let

$$a^2 = \frac{1}{\Delta} - \frac{1}{\delta} = \frac{\delta - \Delta}{\delta\Delta}.$$

Then

$$z_0 = [8.30955 - 10] \frac{a^2\tilde{\omega}}{c^2} \qquad \text{(F.P. units)}$$

or

$$z_0 = [7.10491 - 10] \frac{a^2\tilde{\omega}}{c^2} \qquad \text{(M.K. units)} \qquad (4)$$

We may now give the relation between M and M_1 which is as follows:

$$M_1 = M \frac{2w}{\pi g c^2 z_0}.$$

This value of M_1 substituted in the pressure formula would give the pressure either in pounds per square foot or in kilograms per square metre according to the units employed. In practice the pressure is generally required in pounds per square inch or in kilograms per square centimetre. Employing the proper reduction factors, giving to g and π their values, and substituting for $c^2 z_0$ its values from equations (4), we have the working expressions

$$M_1 = [7.82866 - 10]\, M \frac{w}{a^2\tilde{\omega}}, \qquad \text{(F.P. units)},$$

or

$$M_1 = [7.70764 - 10]\, M \frac{w}{a^2\tilde{\omega}}, \qquad \text{(M.K. units)}. \qquad (5)$$

The functions M_1, X_2 and X_3 in equation (3) are derived from M, X_0 and X_1 by differentiation of equation (2) in accordance with the principles of mechanics, so that the velocity and pressure curves correspond at every point. That is, they satisfy the equation of work

$$\int_0^u p\,S\,du = \frac{w\,v^2}{2\,g}$$

from which we get since $S = \frac{\pi\,c^2}{4}$,

$$p = \frac{2w}{\pi\,gc^2} \cdot \frac{d\,(v^2)}{du} = \frac{2w}{\pi\,gc^2 z_0} \cdot \frac{d\,(v^2)}{d\,\varepsilon}$$

It follows, therefore, that if the velocity curve agrees with experiment in any case the derived pressure curve must be correct, and *vice versa*.

The constants M and N can be determined when our data are such that we can form two independent equations involving those quantities. In the applications of these formulas to be given further on there will be two cases: 1. Two measured velocities of the same shot at different positions in the bore will be given. 2. The muzzle velocity and maximum pressure on the base of the projectile will be given. Of course all the elements of loading and the powder and gun constants are also supposed to be known.

FIRST CASE.

Let v_1 and v_2 be two measured velocities of the projectile in the bore at the distances u_1 and u_2 from the origin, or base of shot when in the firing position. From the gun and powder constants compute z_0 by equation (4), and then ε_1 and ε_2 corresponding to u_1 and u_2, by equation (1). With these values of ε_1 and ε_2 as arguments interpolate, from the table appended to this article, the corresponding values of log X_0 and log X_1 distinguishing them by accents. We thus form the two independent equations

$$v_1^2 = MX_1' \left\{ 1 - NX_0' \right\}$$

$$v_2^2 = MX_1'' \left\{ 1 - NX_0'' \right\}$$

From these we readily find in a form adapted for computation,

$$M = \frac{v_1^2 \left\{ \frac{X_0''}{X_1'} - \frac{X_0'}{X_1''} \left(\frac{v_2}{v_1} \right)^2 \right\}}{X_0'' - X_0'} \qquad (6)$$

and

$$N = \frac{1 - \frac{v_1^2}{MX_1'}}{X_0'} = \frac{1 - \frac{v_2^2}{MX_1''}}{X_0''} \qquad (7)$$

APPLICATION TO SIR ANDREW NOBLE'S EXPERIMENTS.

Sir Andrew Noble caused some experiments to be made at the Elswick works with an experimental 6-inch gun, which could be lengthened from 40 calibres (its original length) to 50, 75 and 100 calibres. The velocity of the projectile (weight 100 pounds) was measured for each length of bore in the usual manner of measuring muzzle velocities, from which the velocity and pressure curves were deduced presumably by a graphic method, though the method of deduction is not given in Sir Andrew Noble's paper published in the Philosophical Transactions for 1894.*

The following table gives the weights of charge and measured velocities for the various kinds of powder experimented with.

KIND OF POWDER.	Weight of Charge.	Measured vel. when projectile had travelled—			
		16.6 ft.	21.6 ft.	34.1 ft.	46.6 ft.
Cordite, (0''.4)	27.5 lbs.	2794 f.s.	2940 f.s.	3166 f.s.	3284 f.s.
Cordite, (0''.35)	22.0 "	2444	2583	2798	2915
Cordite, (0''.3)	20.0 "	2495	2632	2821	2914
Ballistite, (0''.3 cubes)	20.0 "	2416	2537	2713	2806
French B. N.	25.0 "	2422	2530	2700	2786
Amide prismatic	32.0 "	2225	2331	2486	2566
Brown "	50.0 "	2145	2257	2435	2529
Pebble	36.0 "	1885	1980	2110	2190
R. L. G_2.	23.0 "	1533	1592	1668	1705

For the purpose of testing the functions X_0, X_1, X_2 and X_3 by means of these measured velocities, which are assumed to be correct, we proceed as follows: The constants M and N are determined for each kind of powder by employing the velocities at 16.6 feet and 46.6 feet travel. The equations thus established are then applied to computing the velocities at 21.6 feet and 34.1 feet travel. It will be seen that these velocities never differ from the measured velocities by as much as one per cent, and generally considerably less. A much more crucial test of the correctness of these functions is found by computing by their aid the magnitude and position of the maximum pressure on the base of the projectile and the position of the point of inflection of the pressure curve. It will be seen by examining the table of these functions in connection with the pressure-curve equations given further on, that, on account of the subtractive term, the pressure curves have a maximum ordinate when ε is less than that for which the tabular log X_2 is a maximum. From numerous trials we have assumed that the pressure curve has a maximum ordinate when

* An abstract of this paper is given in the English "Text Book of Gunnery," 1902. Also, in "Nature" for May 24, 1900.

$$\varepsilon = 0.4524$$

and therefore

$$\log X_2 = 9.85663 - 10$$
$$\log X_3 = 0.48555$$

Upon this supposition the maximum pressure upon the base of the projectile occurs when it has travelled a distance determined by the equation

$$u = 0.4524\, z_0. \qquad (8)$$

As an illustration of our method we will give the computations for cordite of 0.4 inch diameter, in full. The data are

$\Delta = 0.55$	$u_1 = 16.6$ feet.
$\delta = 1.56$	$v_1 = 2794$ f.s.
$c = 0.5$ feet	$u_2 = 46.6$ feet.
$\tilde{\omega} = 27.5$ lbs.	$v_2 = 3284$ f.s.
$w = 100$ lbs.	

In these calculations we have taken for w the actual weight of the projectile instead of the weight increased by one-half the weight of the charge.

The cordite used in these experiments contained 37 per cent of gun cotton, 58 per cent of nitroglycerine and 5 per cent of vaseline. The ballistite was composed of 50 per cent of dinitrocellulose and the same of nitroglycerine. The French B.N. powder consisted of nitro cellulose partially gelatinized and mixed with tannin, and with barium and potassium nitrates.

It has been urged in certain quarters against the applicability of the formulas here given to powders now in use, that they were originally intended for gunpowder only. But an examination of the following tables will show that they apply as well to cordite and ballistite, which are nitro cellulose powders, as they do to amide and brown prismatic and to pebble powders. With regard to the differences between the computed maximum pressures and those given by the crusher-gauge the following remarks of Sir Andrew Noble are apropos: "As a general rule it may be said that, where the powders are slow in lighting and no wave action exists, the chronoscope pressures are generally somewhat higher than those of the crusher-gauge; but the case is very different where the powder is of a highly explosive or quick-burning description. With such powders the crusher-gauge pressures are greatly above those of the chronoscope. The chronograph takes little or no note of the violent oscillations of pressure acting during exceedingly minute intervals of time."

NOTE: In the computations which follow we have generally omitted the "— 10" at the right of a logarithm of a fraction as being unnecessary. It can easily be replaced when its omission is likely to cause confusion. We have also indicated the arithmetical complement of a logarithm by the abbreviation "*c* log."

$$\delta = 1.56$$
$$\Delta = 0.55$$

$$\log\ 1.01 = 0.00432$$
$$c \log \delta = 9.80688$$
$$c \log \Delta = 0.25964$$

$$\log a^2 = 0.07084$$
$$\log \tilde{\omega} = 1.43933$$
$$c \log c^2 = 0.60206$$
$$\text{const} \log = 8.30955$$

$$\log z_0 = 0.42178 \quad \therefore\ z_0 = 2.641 \text{ ft.}$$
$$\log u_1 = 1.22011$$

$$\log \varepsilon_1 = 0.79833 \quad \therefore\ \varepsilon_1 = 6.285$$

$$\therefore\ \log X_0' = 0.81942 + \frac{67}{123} \times .00309 = 0.82110$$

$$\log X_1' = 0.50296 + \frac{67}{123} \times .00569 = 0.50606$$

$$\log u_2 = 1.66839$$
$$\log z_0 = 0.42178$$

$$\log \varepsilon_2 = 1.24661 \quad \therefore\ \varepsilon_2 = 17.645$$

$$\therefore\ \log X_0'' = 0.97476 + \frac{282}{416} \times .00345 = 0.97710$$

$$\log X_1'' = 0.76783 + \frac{282}{416} \times .00541 = 0.77150$$

Also

$$X_0'' = 9.4864$$
$$X_0' = 6.6237$$

$$X_0'' - X_0' = 2.8627$$

We are now prepared to compute *M* and *N* by means of equations (6) and (7).

$$\log X_0'' = 0.97710$$
$$\log X_1' = 0.50606$$

$$\log 2.9583 = 0.47104$$

$$\begin{aligned}
\log 2.9583 &= 0.47104 \\
\log v_2 &= 3.51640 \\
\log v_1 &= 3.44623 \\
\hline
& 0.07017 \\
& 2 \\
\hline
& 0.14034 \\
\log X_0' &= 0.82110 \\
c \log X_1'' &= 9.22850 \\
\hline
\log 1.5486 &= 0.18994 \\
\hline
\log 1.4097 &= 0.14913 \\
\log v_1^2 &= 6.89246 \\
c \log (X_0''-X_0') &= 9.54322 \\
\hline
\log M &= 6.58481
\end{aligned}$$

$\log v_1^2 = 6.89246$	$\log v_2^2 = 7.03280$
$c \log M = 3.41519$	$c \log M = 3.41519$
$c \log X_1' = 9.49394$	$c \log X_1'' = 9.22850$
$\log 0.63327 = 9.80159$	$\log 0.47478 = 9.67649$
$\log 0.36673 = 9.56435$	$\log 0.52522 = 9.72034$
$\log X_0' = 0.82110$	$\log X_0'' = 0.97710$
$\log N = 8.743325-10$	$\log N = 8.74324-10$

$$\begin{aligned}
\text{const} \log &= 7.82866 \\
\log M &= 6.58481 \\
\log w &= 2.00000 \\
c \log a^2 &= 9.92916 \\
c \log \tilde{\omega} &= 8.56067 \\
\hline
\log M_1 &= 4.90330
\end{aligned}$$

The equations of the velocity and pressure curves for this shot are therefore

$$v^2 = [6.58481]X_1 \left\{ 1-[8.74325-10]X_0 \right\}$$

$$p = [4.90330]X_2 \left\{ 1-[8.74325-10]X_3 \right\}$$

Since the functions X_0, X_1, X_2 and X_3 are all zero when ϵ is zero, that is, at the origin of motion, the velocity and pressure given by the above equations are also zero at this point. The computed velocities should also exactly agree with the observed velocities when the projectile has travelled 16.6 feet and also 46.6

feet. This follows of course from the method of computing the constants M and N. We will however calculate the velocities for these two values of u for the purpose of verifying the previous calculations, using numbers already obtained.

$u = 16.6$ *feet.*	$u = 46.6$ *feet.*
$\log N = 8.74325$	$\log N = 8.74325$
$\log X_0 = 0.82110$	$\log X_0 = 0.97710$
$\log 0.36673 = 9.56435$	$\log 0.52523 = 9.72035$
$\log 0.63327 = 9.80159$	$\log 0.47477 = 9.67648$
$\log X_1 = 0.50606$	$\log X_1 = 0.77150$
$\log M = 6.58481$	$\log M = 6.58481$
2)6.89246	2)7.03279
$\log v = 3.44623$	$\log v = 3.51639$
$\therefore\ v = 2794$ f.s.	$\therefore\ v = 3284$ f.s.

Calculations entirely similar to those given above have been made for all the different kinds of powder experimented with by Sir Andrew Noble and the results are embodied in the following tables which need no more particular explanation than that given in the tables themselves.

Cordite, 0.4-inch Diameter.

Charge 27.5 pounds. Density of loading 0.55.

$$v^2 = [6.58481]X_1 \left\{ 1 - [8.74325 - 10]X_0 \right\}$$

$$p = [4.90330]X_2 \left\{ 1 - [8.74325 - 10]X_3 \right\}$$

Max. pressure at 14.3 inches from seat.		Velocity when projectile had travelled—					
		21.6 feet.			34.1 feet.		
Measured by crusher gauge	Computed:	Meas.	Comp.	D.	Meas.	Comp.	D.
44800 lbs. to 49280 lbs.	47792 lbs.	2940 f.s.	2954 f.s.	+14 f.s.	3166 f.s.	3180 f.s.	+14 f.s.

CORDITE, 0.35-INCH DIAMETER.

Charge 22 pounds. Density of loading 0.44.

$$v^2 = [6.49064]X_1 \left\{ 1 - [8.74476 - 10]X_0 \right\}$$

$$p = [4.76423]X_2 \left\{ 1 - [8.74476 - 10]X_3 \right\}$$

Max. pressure at 15.9 inches from seat.		Velocity when projectile had travelled—					
		21.6 feet.			34.1 feet.		
Measured by crusher gauge	Computed.	Meas.	Comp.	D.	Meas.	Comp.	D.
28896 to 31808	34671	2583	2593	+10	2798	2809	+11

CORDITE, 0.3-INCH DIAMETER.

Charge 20 pounds. Density of loading 0.4.

$$v^2 = [6.54060]X_1 \left\{ 1 - [8.78696 - 10]X_0 \right\}$$

$$p = [4.79895]X_2 \left\{ 1 - [8.78696 - 10]X_3 \right\}$$

Max. pressure at 16.5 inches from seat.		Velocity when projectile had travelled—					
		21.6 feet.			34.1 feet.		
Measured by crusher gauge	Computed.	Meas.	Comp.	D.	Meas.	Comp.	D.
34496 to 38080	36772 lbs.	2632	2638	+6	2821	2833	+12

BALLISTITE, 0.3-INCH CUBES.

Charge 20 pounds. Density of loading 0.4.

$$v^2 = [6.51754]X_1 \left\{ 1 - [8.79463 - 10]X_0 \right\}$$

$$p = [4.77589]X_2 \left\{ 1 - [8.79463 - 10)X_3 \right\}$$

Max. pressure at 16.5 inches from seat.		Velocity when projectile had travelled—					
		21.6 feet.			34.1 feet.		
Measured by crusher gauge	Computed.	Meas.	Comp.	D.	Meas.	Comp.	D.
33600 to 34272	35156 lbs.	2537	2552	+15	2713	2734	+21

FRENCH, B. N.

Charge 25 pounds. Density of loading 0.5.

$$v^2 = [6.49705]X_1 \left\{ 1-[8.78677-10]X_0 \right\}$$

$$p = [4.79455]X_2 \left\{ 1-[8.78677-10]X_3 \right\}$$

Max. pressure at 15.0 inches from seat.		Velocity when projectile had travelled—					
		21.6 feet.			34.1 feet.		
By crusher gauge	Computed.	Meas.	Comp.	D.	Meas.	Comp.	D.
44800 to 45024	36405 lbs.	2530 f.s.	2555	+25	2700	2723	+23

AMIDE, PRISMATIC.

Charge 32 pounds. Density of loading 0.64.

$$v^2 = [6.37352]X_1 \left\{ 1-[8.75073-10]X_0 \right\}$$

$$p = [4.73254]X_2 \left\{ 1-[8.75073-10]X_3 \right\}$$

Max. pressure at 13.1 inches from seat.		Velocity when projectile had travelled—					
		21.6 feet.			34.1 feet.		
By crusher gauge	Computed.	Meas.	Comp.	D.	Meas.	Comp.	D.
34048 to 36288	32140 lbs.	2331 f.s.	2345	+14	2486	2501	+15

BROWN, PRISMATIC.

Charge 50 pounds. Density of loading 1.00.

$$v^2 = [6.16129]X_1 \left\{ 1-[8.58618-10]X_0 \right\}$$

$$p = [4.63641]X_2 \left\{ 1-[8.58618-10]X_3 \right\}$$

Max. pressure at 7.9 inches from seat.		Velocity when projectile had travelled—					
		21.6 feet.			34.1 feet.		
By crusher gauge	Computed.	Meas.	Comp.	D.	Meas.	Comp.	D.
Not given	27499 lbs.	2257 f.s.	2262	+5	2435	2433	−2

PEBBLE.

Charge 36 pounds. Density of loading 0.72.

$$v^2 = [6.19221]X_1 \left\{ 1-[8.71717-10]X_0 \right\}$$

$$p = [4.59074]X_2 \left\{ 1-[8.71717-10]X_3 \right\}$$

Max. pressure at 11.9 inches from seat.		Velocity when projectile had travelled—					
		21.6 feet.			34.1 feet.		
By crusher guage	Computed	Meas.	Comp.	D.	Meas.	Comp.	D.
Not given	23546 lbs.	1980 f.s.	1986	+6	2110	2126	+16

As a second test of our formulas we will make use of some very elaborate experiments made in France with a 16-centimetre gun specially prepared for the purpose.* The chase of this gun could be increased in length by the addition of either one or two tubes at pleasure, so as to give three measured muzzle velocities corresponding to three different travels of the projectile. So far the arrangements are similar to those employed, about the same time, by Sir Andrew Noble, already given. Three different weights of projectiles were employed, namely, 45, 67.5 and 90 kilograms. The charges varied from 9.135 kg. to 38.45 kg., but by means of adjustable powder chambers the density of loading varied only from 0.4 to 0.571. Three kinds of nitro-cellulose powders were experimented with, designated, respectively, as B_{19}, B_{24} and B_{34}.

The data we have used for comparison are given in the following tables taken from the volume of the Mémorial referred to in the foot note:

POWDER, B_{19}.

Volume of powder chamber. Cubic Dec.	Weight of charge. kgs.	Density of loading.	weight of projectile. kgs.	Chamber pressure. kgs. per cm^2	Measured velocity when projectile had travelled—(metres)		
					7.5616	10.6416	13.7216
44.846	17.94	0.40	45.117	1538	824.3	890.0	931.1
"	17.94	0.40	67.567	1982	728.3	785.4	807.3
"	20.18	0.45	45.375	2045	894.8	968.7	1001.5
"	20.18	0.45	67.600	2498	797.1	848.2	873.2
"	22.00	0.49	45.250	2463	956.5	1029.2	1059.3
67.186	26.875	0.40	45.033	2239	950.0	1025.1	1074.1

* An account of these experiments may be found in "Memorial de l'Artillerie de la Marine", vol. 21, pages 509-546 and vol. 22, pages 539-681.

POWDER, B_{24}.

Volume of powder chamber. Cubic Dec.	Weight of charge. kgs.	Density of loading.	Weight of projectile kgs.	Chamber pressure. kgs per cm²	Measured velocity when projectile had travelled—(metres)		
					7.5616	10.6416	13.7216
44.846	17.94	0.40	45.058	1151	753.8	811.7	852.7
"	17.94	0.40	67.567	1427	685.0	736.6	773.2
"	20.18	0.45	45.042	1474	815.0	893.7	936.2
"	20.18	0.45	67.550	1862	750.6	802.8	832.1
"	22.42	0.50	45.008	1896	897.6	945.5	979.2
"	22.42	0.50	67.558	2395	810.0	869.9	903.6
67.186	26.875	0.40	90.133	2456	717.2	781.3	818.8

POWDER, B_{34}.

Volume of powder chamber. Cubic Dec.	Weight of charge. kgs.	Density of loading.	Weight of projectile. kgs.	Chamber pressure. kgs. per cm²	Measured velocity when projectile had travelled—(metres)		
					7.5616	10.6416	13.7216
44.846	17.94	0.40	44.95	798	666.9	729.8	769.1
"	22.42	0.50	45.20	1427	799.3	874.1	923.7
"	22.42	0.50	67.51	1846	738.3	796.5	837.1
67.186	33.595	0.50	45.10	2119	922.1	1041.1	1099.5
"	33.595	0.50	67.55	2512	856.8	950.7	983.3

NOTES: For the powder chamber of 67.186 cubic decimetres the travels of projectile for which velocities were measured are 7.2911, 10.3711, and 13.4511 metres, respectively.

The density of the powder grains is not given in the article from which these data are taken. It has been assumed to be 1.56, which is about the mean density of nitro-cellulose and kindred powders.

The weights of projectile given in these tables are each a mean of the three employed in getting the three velocities.

As in the case of the cordite charge already illustrated, we will give the calculations in full for the charge of 17.94 kgs. of powder B_{19}. The data are

$$\Delta = 0.4$$
$$\delta = 1.56$$
$$c = 0.1662 \text{ m.}$$
$$\tilde{\omega} = 17.94 \text{ kg.}$$
$$w = 45.117 \text{ kg.}$$
$$u_1 = 7.5616 \text{ m.}$$
$$u_2 = 13.7216 \text{ m.}$$
$$v_1 = 824.3 \text{ m.s.}$$
$$v_2 = 931.1 \text{ m.s}$$

PRELIMINARY COMPUTATIONS.

$$\delta = 1.56$$
$$\Delta = 0.40$$

$$\log 1.16 = 0.06446$$
$$c \log \delta = 9.80688$$
$$c \log \Delta = 0.39794$$

$$\log a^2 = 0.26928$$
$$\log \tilde{\omega} = 1.25382$$
$$c \log c^2 = 1.55874$$
$$\text{const} \log = 7.10491$$

$$\log z_0 = 0.18675 \quad \therefore z_0 = 1.5373 \text{ m}$$
$$\log u_1 = 0.87862$$

$$\log \varepsilon_1 = 0.69187 \quad \therefore \varepsilon_1 = 4.919$$

$$\therefore \log X_0' = 0.77655 + \frac{165}{183} \times .00609 = 0.78204$$

$$\log X_1' = 0.42193 + \frac{165}{183} \times .01173 = 0.43251$$

$$\log u_2 = 1.13740$$
$$\log z_0 = 0.18675$$

$$\log \varepsilon_2 = 0.94065 \quad \therefore \varepsilon_2 = 8.926$$

$$\therefore \log X_0'' = 0.87258 + \frac{172}{184} \times .00318 = 0.87555$$

$$\log X_1'' = 0.59847 + \frac{172}{184} \times .00554 = 0.60365$$

$$X_0'' = 7.5085$$
$$X_0' = 6.0540$$

$$X_0'' - X_0' = 1.4545$$

COMPUTATIONS OF M AND N.

$$\log X_0'' = 0.87555$$
$$\log X_1' = 0.43251$$

$$\log 2.7736 = 0.44304$$
$$\log v_2 = 2.96900$$
$$\log v_1 = 2.91609$$

$$0.05291$$
$$2$$

$$0.10582$$

$$
\begin{aligned}
& \quad 0.10582 \\
\log X_0' &= 0.78204 \\
c \log X_1'' &= 9.39635 \\
\log 1.9240 & \quad 0.28421 \\
\log 0.8496 &= 9.92921 \\
2\log v_1 &= 5.83218 \\
c \log (X_0''-X_0') &= 9.83729 \\
\log M &= 5.59868
\end{aligned}
$$

$$
\begin{aligned}
2 \log v_1 &= 5.83218 \\
c \log M &= 4.40132 \\
c \log X_1' &= 9.56749 \\
\log 0.63240 &= 9.80099 \\
0.36760 &= 9.56538 \\
\log X_0' &= 0.78204 \\
\log N &= 8.78334-10
\end{aligned}
\qquad
\begin{aligned}
2 \log v_2 &= 5.93800 \\
c \log M &= 4.40132 \\
c \log X_1'' &= 9.39635 \\
\log 0.54409 &= 9.73567 \\
\log 0.45591 &= 9.65888 \\
\log X_0'' &= 0.87555 \\
\log N &= 8.78333-10
\end{aligned}
$$

$$
\begin{aligned}
\text{const} \log &= 7.70764 \\
\log M &= 5.59868 \\
\log w &= 1.65434 \\
c \log a^2 &= 9.73072 \\
c \log \tilde{\omega} &= 8.74618 \\
\log M_1 &= 3.43756
\end{aligned}
$$

The equations of the velocity and pressure curves for this shot are therefore,

$$v^2 = [5.59868]X_1 \left\{ 1-[8.78334-10]X_0 \right\}$$

$$p = [3.43756]X_2 \left\{ 1-[8.78334-10]X_3 \right\}$$

We will now compute the velocity of this projectile when it had travelled 10.6416 m. and compare the result with observation:

$$
\begin{aligned}
u &= 10.6416 \\
\log u &= 1.02701 \\
\log z_0 &= 0.18675 \\
\log \varepsilon &= 0.84026 \quad \therefore \ \varepsilon = 6.923
\end{aligned}
$$

$$\therefore \ \log X_0 = 0.83628 \text{ and } \log X_1 = 0.53384$$

$$
\begin{aligned}
\log N &= 8.78334 \\
\log X_0 &= 0.83628 \\
\hline
\log 0.41650 &= 9.61962 \\
\hline
\log 0.58350 &= 9.76604 \\
\log X_1 &= 0.53384 \\
\log M &= 5.59868 \\
\hline
& 2)5.89856 \\
\hline
\log v &= 2.94928 \\
v &= 889.8 \text{ m.s.} \\
\text{Measured velocity} &= 890.0 \\
\hline
\text{Difference} &= 0.2
\end{aligned}
$$

Computation of maximum pressure on projectile.

$$
\begin{aligned}
\log N &= 8.78334 \\
\log X_3 &= 0.48555 \\
\hline
\log 0.18573 &= 9.26889 \\
\hline
\log 0.81427 &= 9.91076 \\
\log X_2 &= 9.85663 \\
\log M_1 &= 3.43756 \\
\hline
\log P &= 3.20495 \\
P &= 1603 \\
\text{Chamber pressure} &= 1538 \\
\hline
\text{Difference} &= +65
\end{aligned}
$$

The maximum pressure on this projectile occurred when it had travelled a distance

$$0.4524 \times 1.5373 = 0.6955 \text{ m}.$$

Similar computations for the other two kinds of powder experimented with, employing the same weight of charge and projectile, give the following values of M, M_1 and N:

POWDER B_{24}.

$\log M = 5.51815$. $\log M_1 = 3.35646$. $\log N = 8.77835-10$.

These give for a travel of 10.6416 m,

$$v = 814.3 \text{ m.s.},$$

differing from the measured velocity by +2.6 m.s.; and a maximum pressure on the projectile of 1333 kgs. per cm^2.

POWDER B_{34}.

log $M = 5.37083$. log $M_1 = 3.20810$. log $N = 8.69583 - 10$

The computed middle velocity is 727.7 m.s., differing from the measured velocity by -2.1 m.s.; and the computed maximum presssure on the projectile is 984 kgs. per cm².

As previously stated, M and N are functions of the density of the powder, density of loading, weight of charge, weight of projectile and diameter of the bore. By theory they are expressed by the following relations:

$$M = M_0 \frac{a\,\bar{\omega}^{\frac{3}{4}}}{c^2 w^{\frac{1}{2}}} \tag{9}$$

$$N = N_0 \frac{a\,\bar{\omega}^{\frac{1}{2}} w^{\frac{1}{2}}}{c^2}$$

where M_0 and N_0 are constant for the same powder. But, as everybody knows, theoretical expressions have always to be altered more or less to make them conform to experiment; and this is particularly true of the formulas of interior ballistics, as those who have studied Sarrau's works well know. As the result of a study of the measured velocities and other data given in the table for powder B_{19} and also in guns of different calibres, we will adopt for this powder the following expression for N leaving M its theoretical value as given in equation (9):

$$N = N_0 \frac{a\,\bar{\omega}^{\frac{1}{2}} w^{\frac{1}{2}}}{c^{\frac{7}{4}}} \tag{10}$$

We will now take the values of M and N as determined on page 273 from what may be considered a *single shot* with two measured velocities, and by equations (9) and (10) compute M_0 and N_0 which we will consider constant for powder B_{19}. We will then compute velocities corresponding to those given in the table for B_{19}, for different charges and weights of projectile, for comparison.

The data for computing M_0 and N_0 are given on pages 271 and 273.

$$\begin{aligned} \log M &= 5.59868 \\ \log c^2 &= 8.44126 - 10 \\ \tfrac{1}{2} \log w &= 0.82717 \\ \tfrac{8}{2}\, c \log \bar{\omega} &= 8.11927 - 10 \\ c \log a &= 9.86536 - 10 \\ \hline \log M_0 &= 2.85174 \end{aligned}$$

$$\begin{aligned}
\log N &= 8.78334-10 \\
\tfrac{7}{6}\log c &= 9.09073-10 \\
\tfrac{1}{6}c\log w &= 9.66913-10 \\
\tfrac{1}{3}c\log \tilde{\omega} &= 9.58206-10 \\
c\log a &= 9.86536-10 \\
\hline
\log N_0 &= 6.99062-10
\end{aligned}$$

Now take the following data from the fourth line of the table for powder B_{19}, where both the weight of charge and weight of projectile are increased:

$$\begin{aligned}
\tilde{\omega} &= 20.18 \text{ kgs.} \\
w &= 67.6 \text{ kgs.} \\
\Delta &= 0.45, \text{ and therefore,} \\
\log a &= 0.09950. \\
c &= 0.1662 \text{ m.}
\end{aligned}$$

We must first compute M and N for this particular charge and weight of projectile by equations (9) and (10), as follows:

$$\begin{aligned}
\log M_0 &= 2.85174 \\
\log a &= 0.09950 \\
\log \tilde{\omega} &= 1.30492 \\
\tfrac{1}{2}\log \tilde{\omega} &= 0.65246 \\
c\log c^2 &= 1.55874 \\
\tfrac{1}{2}c\log w &= 9.08502 \\
\hline
\log M &= 5.55238
\end{aligned}$$

$$\begin{aligned}
\log N_0 &= 6.99062 \\
\log a &= 0.09950 \\
\tfrac{1}{3}\log \tilde{\omega} &= 0.43497 \\
\tfrac{1}{6}\log w &= 0.36599 \\
\tfrac{7}{6}c\log c &= 0.90927 \\
\hline
\log N &= 8.80035-10
\end{aligned}$$

To determine the maximum pressure on the base of the projectile (designated by P) we have by equation (5)

$$\begin{aligned}
\log M &= 5.55238 \\
\text{const} \log &= 7.70764-10 \\
\log w &= 1.82995 \\
c\log a^2 &= 9.80101-10 \\
c\log \tilde{\omega} &= 8.69508-10 \\
\hline
\log M_1 &= 3.58606
\end{aligned}$$

Now compute the velocity when the projectile has travelled 13.7216 m. For this travel we have

$$\varepsilon = 9.329 \text{ and } \log X_0 = 0.88230, \ \log X_1 = 0.61536$$

$\log N = 8.80035$	$\log N = 8.80035$
$\log X_0 = 0.88230$	$\log X_2 = 0.48555$
$\log 0.48156 = 9.68265$	$\log 0.19315 = 9.28590$
$0.51844 = 9.71470$	$\log 0.80685 = 9.90679$
$\log X_1 = 0.61536$	$\log X_2 = 9.85663$
$\log M = 5.55238$	$\log M_1 = 3.58606$
$2)5.88244$	$\log P = 3.34948$
$\log v = 2.94122$	$P = 2236$ kg. per cm²
$v = 873.4$ m.s.	Chamber pres. 2498 " " "
measured 873.2 m.s.	Difference −262 " " "
difference 0.2 m.s.	

Similar computations for all the measured velocities found in the preceding table for B_{19}, have been made and are given in the following table :

Table of measured and computed velocities and maximum pressures on projectile, for powder B_{19}.

Volume of chamber. Cubic Dec.	Distance travelled. Metres.	Weight of projectile. Kilos.	Weight of charge. Kilos.	Chamber pressure. kg. per cm²	Max. pressure on projectile. kg. per cm²	Measured velocity. Metres per sec.	Computed velocity. Metres per sec.	Differences.	Diff. by Sarrau's formula.
41.846	7.5616	45.117	17.940	1538	1603	824.3	824.3	0.0	−23
"	10.6416	"	"			890.0	889.8	−0.2	−15
"	13.7216	"	"			931.1	931.1	0.0	− 1
"	7.5616	67.567	"	1982	1924	728.3	726.7	−1.6	−30
"	10.6416	"	"			785.4	779.8	−5.6	−29
"	13.7216	"	"			807.3	811.5	+4.2	− 6
"	7.5616	45.375	20.180	2045	1866	894.8	883.1	−11.7	−19
"	10.6416	"	"			968.7	953.6	−15.1	−14
"	13.7216	"	"			1001.5	998.7	−2.8	+12
"	7.5616	67.600	"	2498	2236	797.1	780.5	−16.6	−36
"	10.6416	"	"			848.2	838.3	−9.9	−25
"	13.7216	"	"			873.2	873.4	+0.2	0
"	7.5616	45.250	22.000	2463	2082	956.5	931.1	−25.4	−22
"	10.6416	"	"			1029.2	1005.7	−23.5	−11
"	13.7216	"	"			1059.3	1053.8	−5.5	+22
67.186	7.2911	45.033	26.875	2239	1896	950.0	953.9	+3.9	− 8
"	10.3711	"	"			1025.1	1047.5	+22.4	− 1
"	13.4511	"	"			1074.1	1107.8	+33.7	+17

The last column of this table gives the differences between the measured velocities and those computed by Sarrau's formulas, and are taken from vol. 22 of the "Mémorial". With regard to the pressures it must be remembered that those in the fifth column are chamber pressures determined by a crusher gauge, while the computed pressures in the sixth column are the maximum pressures on the base of the projectile. It is difficult to make a just comparison between them; but it is believed that the latter should not exceed the former, and with a single exception they do not.

We will now apply the constants determined from a *single shot* on page 273, to computing the muzzle velocity and maximum pressure on the base of the projectile for two guns differing greatly from the 16 cm. gun on which the constants are based. The data are taken from the volume of the Mémorial already referred to. First take the following data:

$$c = 0.422 \text{ m.}$$
$$C = 326.3 \text{ cubic dec.}$$
$$\tilde{\omega} = 72 \text{ kgs.}$$
$$\Delta = 0.29503$$
$$w = 650 \text{ kgs.}$$
$$u = 7.035 \text{ m.}$$

From these data are deduced

$$\log a^2 = 0.59006$$
$$\log z_0 = 0.30168$$
$$\varepsilon = 3.5122$$
$$\log X_0 = 0.72682$$
$$\log X_1 = 0.32322$$

First compute M and N for this gun and charge.

$$\begin{aligned}
\log N_0 &= 2.85174\\
\log a &= 0.29503\\
\log \tilde{\omega} &= 1.85733\\
\tfrac{1}{2}\log \tilde{\omega} &= 0.92866\\
2\,c\log c &= 0.74938\\
\tfrac{1}{2}\,c\log w &= 8.59355\\
\hline
\log M &= 5.27569
\end{aligned}$$

$$\begin{aligned}
\log N_0 &= 6.99062\\
\log a &= 0.29503\\
\tfrac{1}{3}\log \tilde{\omega} &= 0.61911\\
\tfrac{1}{5}\log w &= 0.56258\\
\tfrac{7}{6}\,c\log c &= 0.43714\\
\hline
\log N &= 8.90448
\end{aligned}$$

$$\log N = 8.90448$$
$$\log X_0 = 0.72682$$
$$\log 0.42786 = 9.63130$$
$$\log 0.57214 = 9.75750$$
$$\log X_1 = 0.32322$$
$$\log M = 5.27569$$
$$2)5.35641$$
$$\log V = 2.67820$$
$$V = 476.6$$
Measured 495.4

Difference —18.8

$$\log M = 5.27569$$
$$\text{const log} = 7.70764$$
$$\log w = 2.81294$$
$$c \log a^2 = 9.40994$$
$$c \log \tilde{\omega} = 8.14267$$
$$\log M_1 = 3.34888$$

$$\log N = 8.90448$$
$$\log X_2 = 0.48555$$
$$\log 0.24549 = 9.39003$$
$$\log 0.75451 = 9.87761$$
$$\log X_2 = 9.85663$$
$$\log M_1 = 3.34888$$
$$\log P = 2.08312$$
$$P = 1211 \text{ kgs. per cm}^2$$

Next, take the following data:

$$c = 0.342 \text{ m.}$$
$$C = 187.86 \text{ dec.}^3$$
$$\tilde{\omega} = 70 \text{ kgs.}$$
$$\Delta = 0.3726$$
$$w = 420 \text{ kgs.}$$
$$u = 8.304 \text{ m.}$$

From these we obtain

$$\log a^2 = 0.31021$$
$$\log z_0 = 0.19217$$
$$\varepsilon = 5.3348$$

$$\log X_0 = 0.79502$$
$$\log X_1 = 0.45739$$
$$\log M = 5.39482$$
$$\log N = 8.82905 - 10$$
$$\log M_1 = 3.57040$$

The muzzle velocity and maximum pressure on the base of projectile given by these numbers are, respectively, 642.0 m.s. and 2122 kgs. per cm². The measured muzzle velocity was 613.6 m.s., giving a difference of +28.4. The chamber pressures in the two preceding examples are not known to the writer.

SECOND CASE.

The data obtained from firing guns not specially prepared for experiment are generally a measured muzzle velocity and a chamber pressure determined by crusher gauge. Admitting that there is a simple, or at least, ascertainable relation between the chamber pressure so determined and the maximum pressure upon the base of the projectile we may obtain the values of M and N by means of the equations

$$V^2 = MX_1 \left\{ 1 - NX_0 \right\}$$

and

$$P = [9.85663 - 10] M_1 \left\{ 1 - [0.48555] N \right\}$$

Substituting for M_1 its values from equations (5), and making

$$[2.31471] \frac{a^2 \bar{\omega} P X_0}{w V^2} = A \ (F.P. \text{ units})$$

or

$$[2.43573] \frac{a^2 \bar{\omega} P X_0}{w V^2} = A \ (M.K. \text{ units})$$

and

$$\frac{[0.48555]}{X_1} = B$$

we shall have

$$M = \frac{V^2 (A - B)}{X_0 - 3.0588}$$

and

$$N = \frac{1 - \dfrac{V^2}{MX_1}}{X_0} = \frac{1 - \dfrac{AV^2}{MX_0}}{[0.48555]}$$

In these equations V is the muzzle velocity and X_0 and X_1 refer to the muzzle travel of the projectile. Also P is the maximum pressure on the base of the projectile.

As an example of the application of these formulas we will make use of some very interesting and valuable data obtained at the proving ground of Sevran-Livry, in March, 1895, with a 10-centimetre gun mounted upon an experimental carriage and recoiling freely. In these experiments the pressure upon the breech (P_1) and the corresponding path of the gun (u_1) were registered directly by the apparatus employed; and the corresponding pressure upon the base of the projectile (p) and its path (u) were computed by the equations

$$p = \frac{P_1 w'}{w + \frac{\tilde{\omega}}{2}}$$

$$u = \frac{w'_1 u_1}{w + \frac{\tilde{\omega}}{2}}.$$

in which w_1 is the weight of the gun and the accessory parts recoiling with it (1303 kilograms).* As a first example from these experiments we will take the fourth shot, fired March 16, 1895, which yields the following data:

POWDER BM_8.

$$\tilde{\omega} = 2 \text{ kgs.}$$

$$w = 14.1 + \frac{\tilde{\omega}}{2} = 15.1 \text{ kgs.}$$

$$c = 0.1 \text{ m.}$$
$$\Delta = 0.423$$
$$\delta = 1.588$$
$$V = 578.7 \text{ m.s.}$$
$$P = 2607 \text{ kgs. per cm}^2.$$
$$u = 2.097 \text{ m. (muzzle travel).}$$

The value of z_0 computed by equation (4) is

$$\log z_0 = 9.64508 - 10.$$

$$z_0 = 0.44165 \text{ m.}$$

At the muzzle we have

$$\varepsilon = 4.7481$$
$$\log X_0 = 0.77634$$
$$\log X_1 = 0.42153$$

From which we find, by the formulas on page 280.

$$\log M = 5.30442$$
$$\log M_1 = 3.65087$$
$$\log N = 8.79253 - 10$$

* For a translation of this most interesting paper see Notes on the Construction of Ordnance, No. 84, June 27, 1902.

The equations for the velocity and pressure curves for this shot are therefore

$$v^2 = [5.30442]X_1 \left\{ 1-[8.79253-10]X_0 \right\}$$

$$p = [3.65087]X_3 \left\{ 1-[8.79253-10]X_2 \right\}$$

In the following table velocities and pressures computed by these formulas are given in the third and fourth columns, corresponding to the volumes of expansion and paths of projectile contained in the first and second columns. These latter were computed from the former by the relation

$$u = \varepsilon z_0 = 441.65\ \varepsilon.$$

The fifth column contains the paths of the projectile determined

Volume of expansion. (ε)	Computed paths of projectile. (u)	Computed pressures on base of projectile. (p)	Computed velocities of projectile. (v)	Paths of projectile.	Correspond'g experimental pressures.	Interpolated pressures from column 3.	Differences.
	mm.	kg. per cm²	m. s.	mm.	kg. per cm²	kg. per cm²	
0.0000	0.000	0	0.000	0	0	0	0
0.0037	1.634	459	7.126	9	639	1011	−372
0.0147	6.492	891	20.03	17	896	1354	−458
0.0335	14.80	1289	36.56	26	1017	1622	−605
0.0640	26.68	1642	55.94	35	1154	1802	−648
0.0962	42.49	1946	77.70	43	1243	1952	−709
0.1418	62.63	2195	101.5	52	1402	2063	−661
0.1983	87.58	2385	127.1	60	1697	2161	−464
0.2675	118.1	2517	154.3	69	1821	2249	−428
0.3513	155.0	2590	183.0	78	1901	2312	−411
0.4524	199.8	2607	212.9	86	1931	2373	−442
0.5104	225.4	2595	229.0	129	2217	2539	−322
0.5740	253.5	2572	244.0	173	2417	2600	−183
0.6438	284.3	2536	259.9	216	2465	2600	−135
0.7203	318.1	2489	276.1	259	2528	2566	−38
0.8044	355.3	2431	292.5	302	2607	2511	+96
0.8969	396.1	2365	309.1	345	2560	2447	+113
0.9986	441.0	2289	325.8	388	2528	2378	+150
1.1105	490.5	2207	342.8	431	2417	2306	+111
1.2340	545.0	2117	359.9	475	2417	2232	+185
1.3704	605.2	2022	377.1	518	2369	2161	+208
1.5212	671.7	1922	394.5	690	1892	1896	−4
1.6883	745.5	1818	411.9	863	1715	1669	+46
1.8738	827.7	1711	429.4	1036	1370	1476	−106
2.0800	918.6	1602	447.0	1208	1323	1316	+7
2.3099	1020	1492	464.5	1381	1109	1179	−70
2.5666	1134	1381	482.1	1553	1053	1062	−9
2.8540	1260	1271	499.5	1726	868	961	−93
3.176	1402	1162	516.9	1899	767	875	−108
3.539	1563	1055	534.1	2071	752	798	−46
3.949	1744	951	551.1	2097	737	787	−50
4.412	1949	850	567.9	2244	723	729	−6
4.937	2180	752	584.3	2416	653	669	−16
5.535	2445	658	600.3	2589	667	615	+52
6.218	2746	568	615.7				

by the experimental shot from which all these data are taken, and the sixth column gives the corresponding pressures on the base of the projectile. The pressures in the seventh column are interpolated from the computed pressures in the third column, for the paths in the fifth column. The differences between the experimental and computed pressures for the same travel of projectile are given in the last column. With regard to these differences it will be seen that for three-fourths of the entire travel of the projectile they are practically nil. While for the remaining fourth we have the same pressures in both columns, but those resulting from theory occur sooner than the experimental ones. May not this be accounted for by the inability of the apparatus to register quickly enough during the one two-hundred-and-fiftieth part of a second required for the projectile to describe this part of its path?

The numbers in the second and fourth columns of the table enable us to compute the time of describing any portion of the projectile's path with great precision.

Let v_0, v_1, v_2, etc., be the successive velocities in the fourth column and u_1, u_2, u_3, etc., the paths corresponding to the mean velocities $\frac{1}{2}(v_0 + v_1)$, $\frac{1}{2}(v_1 + v_2)$, etc. Then we shall have approximately,

$$t = \frac{1}{500}\left(\frac{u_1}{v_0 + v_1} + \frac{u_2}{v_1 + v_2} + \text{etc.}\right)$$

By this method we find that the time from the beginning of motion to the point of maximum pressure is 0.0027 second; and from the origin to the muzzle 0.0072 second. If we divide the distance from the origin to the muzzle (2.097 m.) by the time of describing it we shall have for the mean velocity, 291.3 m.s., which is but a trifle greater than one-half the muzzle velocity.

In the preceding example we have taken for w the weight of shot increased by one-half the weight of charge to conform to the data on which the example is based.

Table of the functions X_0, X_1, X_2 and X_3.

ε	D.	log X_0.	D.	log X_1.	D.	log X_2.	log X_3
0.0037		9.32135		6.40696		9.01845	9.44640
0.0147		9.62313		7.31029		9.31457	9.74854
0.0335		9.80058		7.83905		9.48259	9.92658
0.0604		9.92737		8.21448		9.59617	0.05420
0.0962		0.02671		8.50605		9.67848	0.15461
0.1418		0.10887		8.74463		9.73976	0.23809
0.1983		0.17936		8.94671		9.78549	0.31015
0.2675		0.24149		9.12217		9.81894	0.37410
0.3513		0.29739		9.27735		9.84221	0.43207
0.4524		0.37264		9.41662		9.85663	0.48555
0.5104		0.39595		9.48130		9.86087	0.51096
0.5740		0.34582		9.54310		9.86327	0.53560
0.6438		0.41853		9.60229		9.86389	0.55960
0.7203		0.44047		9.65909		9.86281	0.58302
0.8044		0.46182		9.71372		9.86009	0.60593
0.8969		0.48267		9.76635		9.85578	0.62841
0.9986		0.50307		9.81716		9 84992	0.65051
1.1105		0.52307		9.86629		9.84257	0.67229
1.2340		0.54271		9.91385		9.83374	0.69377
1.3704		0.56205		9.95999		9.82347	0.71504
1.5212		0.58111		0.00479		9.81178	0.73610
1.6883		0.59995		0.04837		9.79869	0.75701
1.8738		0.61859		0.09081		9.78422	0.77780
2.0800		0.63707		0.13219		9.76839	0.79852
2.3099		0.65542		0.17260		9.75120	0.81917
2.5666		0.67367		0.21211		9.73266	0.83980
2.8540	103	0.69184	605	0.25077	1271	9.71279	0.86043
2.957	108	0.69789	605	0.26348	1263		
3.065	111	0.70394	604	0.27611	1255		
3.176	117	0.70998	604	0.28866	1247	9.69157	0.88110
3.293	120	0.71602	604	0.30113	1240		
3.413	126	0.72206	604	0.31353	1231		
3.539	131	0.72810	604	0.32584	1225	9.66903	0.90183
3.670	137	0.73414	604	0.33809	1217		
3.807	142	0.74018	605	0.35026	1211		
3.949	148	0.74623	606	0.36237	1204	9.64514	0.92265
4.097	154	0.75229	605	0.37441	1197		
4.251	161	0.75834	606	0.38638	1191		
4.412	167	0.76440	607	0.39829	1185	9.61992	0.94357
4.579	175	0.77047	608	0.41014	1179		
4.754	183	0.77655	609	0.42193	1173		
4 937	191	0.78264	610	0.43366	1168	9.59335	0.96464
5.128	199	0.78874	611	0.44534	1162		
5.327	208	0.79485	612	0.45696	1158		
5.535	217	0.80097	613	0.46854	1152	9.56543	0.98587

ε	D.	log X_0	D.	log X_1	D.	log X_2	log X_3
5.752	228	0.80710	615	0.48006	1147		
5.980	238	0.81325	617	0.49153	1143		
6.218	123	0.81942	309	0.50296	569	9.53614	1.00728
6.341	126	0.82251	309	0.50865	570		
6.467	128	0.82560	310	0.51435	568		
6.595	132	0.82870	310	0.52003	567		
6.727	135	0.83180	310	0.52570	565		
6.862	138	0.83490	311	0.53135	563		
7.000	141	0.83801	312	0.53698	563	9.50549	1.02890
7.141	145	0.84113	312	0.54261	563		
7.286	148	0.84425	313	0.54824	562		
7.434	151	0.84738	313	0.55386	561		
7.585	156	0.85051	313	0.55947	559		
7.741	159	0.85364	315	0.56506	559		
7.900	162	0.85679	314	0.57065	558	9.47344	1.05077
8.062	167	0.85993	315	0.57623	557		
8.229	171	0.86308	316	0.58180	557		
8.400	175	0.86624	317	0.58737	556		
8.575	179	0.86941	317	0.59293	554		
8.754	184	0.87258	318	0.59847	554		
8.938	188	0.87576	319	0.60401	554	9.43998	1.07290
9.126	193	0.87895	319	0.60955	553		
9.319	198	0.88214	319	0.61508	551		
9.517	203	0.88533	320	0.62059	551		
9.720	208	0.88853	322	0.62610	551		
9.928	213	0.89175	322	0.63161	551		
10.141	219	0.89497	322	0.63712	549	9.40510	1.09532
10.360	224	0.89819	323	0.64261	549		
10.584	230	0.90142	325	0.64810	548		
10.814	236	0.90467	325	0.65358	548		
11.050	242	0.90792	326	0.65906	547		
11.292	249	0.91118	326	0.66453	547		
11.541	255	0.91444	327	0.67000	546	9.36876	1.11805
11.796	262	0.91771	328	0.67546	546		
12.058	269	0.92099	329	0.68092	545		
12.327	276	0.92428	330	0.68637	545		
12.603	283	0.92758	331	0.69182	545		
12.886	291	0.93089	331	0.69727	544		
13.177	299	0.93420	332	0.70271	544	9.33095	1.14112
13.476	307	0.93752	334	0.70815	544		
13.783	316	0.94086	334	0.71359	543		
14.099	324	0.94420	336	0.71902	543		
14.423	333	0.94756	336	0.72445	543		
14.756	342	0.95092	338	0.72988	543		
15.098	351	0.95430	338	0.73531	542	9.29162	1.16457

ε	D.	log X_0	D.	log X_1	D.	log X_2	log X_3
15.449	362	0.95768	340	0.74073	542		
15.811	371	0.96108	340	0.74615	542		
16.182	383	0.96448	342	0.75157	542		
16.565	393	0.96790	342	0.75699	542		
16.958	405	0.97132	344	0.76241	542		
17.363	416	0.97476	345	0.76783	541	9.25074	1.18843
17.779	428	0.97821	346	0.77324	542		
18.207	441	0.98167	346	0.77866	541		

THE NEW FIELD ARTILLERY.

By Captain GEORGE W. BURR,* Ordnance Department, U. S. A.

PART I. A REVIEW OF THE TESTS LEADING TO ITS ADOPTION.

The marked advance in Ordnance material in the past twenty years is at last fully reflected in the new models of mobile artillery. The advantage to be derived from the greatest rapidity of fire in field artillery has long been recognized by military men, but the methods by which it has been proposed to secure this end have, until the past three or four years, been so unsatisfactory as to fail of general approval.

Our present 3.2-inch field gun and carriage was adopted in the middle '80's and until quite recently represented the usual type of material in use in all foreign services; in fact, as recently as the campaign of the allies in China, a distinguished officer in our service officially reported that the artillery material of our troops was equal to the best, and superior to most, of the field artillery material accompanying that expedition.

The efforts of designers to secure increased rapidity of fire for field artillery can best be explained by accepting this 3.2-inch material as the leading type in existence fifteen years ago and considering the steps necessary to increase its rapidity of fire. In successive firing of this piece the following operations are required for each round:

Running the piece by hand to the front to its firing position;

Pointing the piece in direction by shifting the trail, in elevation by manipulating the elevating mechanism;

Cannoneers jumping clear of the carriage.

All of these are time-consuming operations and must be performed consecutively. There is usually more or less interference between the loading and aiming numbers in serving the piece, and strictly considered, the interval between rounds is prolonged by the loading operation. No mention is, however, made of this delay because improvements in ammunition and breech mechanisms of small calibre guns for fortification and naval use several years ago indicated the method by which the time of

* Captain Burr conducted the preliminary tests of the field artillery material at the Sandy Hook Proving Ground under the supervision of the Ordnance Board, and was also present throughout the field tests at Fort Riley, Kansas. Since the adoption of material for service, based upon the results of these tests, he has, under the direction of the Commanding Officer of Rock Island Arsenal, had charge of the manufacture of the carriages and of the remaining material excepting the guns. His duties have also included the designing of a new caisson, battery wagon and forge, and store wagon.—Ed.

loading field guns could be reduced to a minimum. The failure to adopt these methods clearly indicated the belief that the advantage to be gained from their adoption would be of little appreciable benefit as long as the time required for the other operations, mentioned above, was not greatly reduced.

These latter requirements can now be fulfilled and the new guns will appear with fixed ammunition and the single motion, quick action, breech mechanism.

Returning to the three time-consuming operations mentioned above, namely: running the carriage by hand to the front, pointing the piece and jumping clear of the carriage before firing, it will be noted that they all pertain to the carriage and are necessitated by the fact that the carriage moves from its firing position at each round. Anything which will reduce this movement, or prevent it altogether, will increase the rapidity of fire of the piece and the ease of its service. Artillerists early devoted their efforts to this end and many devices were suggested.

Among the first of these very naturally were different kinds of wheel brakes, with the idea of reducing the rearward movement of the carriage on the ground by skidding the wheels; some were rigidly and some were elastically connected to the carriage, the elastic connection tending to move the carriage forward again at the end of its recoil. A type of such a brake is the well known bow spring brake of the 3.2-inch carriage.

Working along similar lines other designers suggested the use of wedge shaped shoes placed under and in rear of the wheels. These shoes were fastened by spring connections to some part of the carriage; upon recoil the wheels ran up and back upon the shoes and were skidded by them; at the end of the recoil the carriage ran down and forward off the shoes to its firing position. Many of these designs of wheel brake and wheel shoes accomplished, in a measure, the purpose for which intended—the reduction of the recoil of the carriage on the ground. They, however, required time for adjustment before firing and were something of a hindrance to shifting the trail in pointing the piece for direction. On many firing grounds, one wheel would be more easily skidded than the other, or one wheel shoe would take better in the ground than the other, so that on recoil the gun would be thrown to one side off the target, and the time saved in running up would be lost in pointing for direction.

Another method of controlling the recoil of the carriage on the ground much favored by designers was that of the trail spade, a fin-like metal piece projecting downward into the ground.

When used alone, that is to say, without an elastic medium between the gun and carriage or the spade and carriage and rigidly attached to the end of the trail, this device throws an unnecessary strain upon the carriage and causes an excessive jump of the wheels. Upon rough ground and in cases where the spade encounters more resistance on one side than the other, the carriage is usually thrown out of the line of fire, and as the spade is embedded in the ground the trail can be shifted for the next round only at the expense of considerable labor.

This fact has prevented its use alone, but as will appear hereafter it is a valuable auxiliary to the means of controlling the recoil. To reduce the great strain brought upon the carriage and the excessive jump of the wheels due to the use of the rigid spade, resort has been had to an elastic attachment of the spade to the trail. The elastic medium has varied in different designs; but has usually been some kind of a spring interposed between the spade and its point of support on the trail. The carriage is thus permitted a short ground recoil against the force of the spring which returns it to its firing position. The elastic trail spade equally with the rigid one causes considerable departure from the line of fire and entails undue labor in shifting the trail. To remove the latter objection some constructors changed the location of the elastic spade from the end of the trail to the center of the axle. With such a construction the wheels usually leave the ground so that the carriage is momentarily supported by the spade and the end of the trail, and upon rough ground is apt to be returned to the firing position with piece pointing far off the target.

The means for reducing the ground recoil of the carriage outlined above, viz: elastically connected wheel shoes and trail and axle spades, were for the reasons stated not entirely satisfactory. However, upon favorable ground they returned the carriage approximately to its firing position and with the addition to the carriage of some arrangement for giving the piece a small azimuth movement, enabled several rounds to be fired quite rapidly and in that respect were an improvement upon the previously existing types.

They were, moreover, simple appliances and their attachment to the old type of field carriages afforded an economical method of securing an accelerated rate of fire. These facts recommended them to minds which were not yet ready to believe in the practicability for field service of the hydraulic or pneumatic type of recoil buffers.

The result was that they were regarded with considerable favor abroad, and the closing years of the last century witnessed the partial conversion to this type of the field armament of several continental powers. In the United States these expedients never met with much favor.

All of the devices described above for increasing the rapidity of fire of field artillery attempted to accomplish that end by controlling the movement of the carriage upon the ground. They failed to give a complete solution of the problem, due to the diversity of the firing grounds, which makes impossible that uni formity of action of the recoil checks which is essential if the carriage is to be returned to the firing position with the aim of the piece unchanged or but slightly altered.

Realizing the incomplete success of all the appliances so far suggested for the control of the ground recoil of the carriage, constructors approached the problem from another direction and attempted to control and reduce the force directly producing this ground recoil. Existing naval and fortification gun mounts suggested a movement of the gun upon the carriage as the means of attaining the desired result, but the exacting conditions to be fulfilled, and the weight limitations imposed by a sufficiently mobile field gun carriage, made the difficulties of the application of a gun recoil check to such a carriage seem insuperable. This was due to the fact that the previous experiments indicated the necessity of having no recoil of the carriage on the ground and no jump of the wheels if the maximum rapidity of fire were to be obtained. This could only be accomplished by giving the gun such a length of recoil on the carriage as to make the moment of the piston rod pull around the end of the trail less than the moment of the weight around the same point. This necessitated an increase in the length of recoil from 4 calibers, that usually given naval and fortress guns, to sixteen calibers. The difficulty of obtaining this length of recoil within the prescribed limit of weight was increased by that of providing means for returning the gun to the firing position after recoil. The problem was, however, attacked with energy at home as well as abroad and after much effort was finally satisfactorily solved. The French are entitled to, and have received, credit for the production of the first rapid-fire field gun carriage, but independent of their success and following close upon it our home talent, after prolonged study and experiment, accomplished a like result.

As the new field carriage is the result of these experiments, a brief review of their progress is of interest.

The Ordnance Departments of our Army and Navy for many years prior to 1898 had achieved unqualified success in the application of hydraulic buffers to the control of guns recoiling on fixed carriages. Their application as recoil checks for mobile artillery was, however, restricted and their use for that purpose was generally regarded with disfavor and distrust by military men. The reasons urged (which for a long time were potent enough to lead designers to avoid their use) were the additional weight, complication of parts, and their supposed liability to derangement. Experience in their construction and operation now shows these arguments to be unfounded.

It is a noteworthy fact that the Ordnance Department of the Army was the pioneer in the application of such cylinders to mobile artillery. As early as 1890, the present Chief of Ordnance, General (then Captain) William Crozier, designed a 7-inch howitzer carriage in which three such cylinders were used; one for the control of the recoil of the carriage upon the platform, and the other two for the control of the recoil of the gun upon the carriage. Many such carriages were put in the service in the ensuing few years. In Notes on Construction of Ordnance No. 57, published Jan. 12, 1891, the designer states that "the main feature of the carriage is the recoil which is permitted to the piece upon it," and that "the main advantage claimed for the construction is that the recoil of the piece on the carriage so diminishes the strain upon the flasks and trail that they can be made very light." The designer, at that time, probably did not seriously consider the application of the principles thus stated to the smaller field carriage, his object being to provide for the 7-inch howitzer a practicable road and firing carriage within permissible weight limits.

The principle thus stated is nevertheless the underlying one of the modern field carriage; i. e., that the recoil of the piece upon the carriage can be so regulated as to reduce the firing strains transmitted to the carriage to such limits that it can be made quite light, and its movement in recoil on the ground entirely prevented by simple appliances. The experience of the Ordnance Department with the howitzer carriages indicated that the hydraulic cylinders were entirely practicable for field purposes. Experience abroad with mountain gun carriages confirmed this view.

The first attempt of the Ordnance Department to apply such cylinders to a field gun carriage was made in 1898. The carriage then made had hydraulic cylinders for the control of the recoil with springs to return the piece to battery. It is, however, noticeable principally for the manner in which motion in azimuth was given the piece by the so-called axle traverse. The piece and entire carriage were moved along the axle about a center of motion at the end of the trail. The mass to be moved and the amount of motion necessary to secure comparatively small changes in azimuth condemned this method. In all future constructions a pivotal or turn-table system of traverse has been used. The piece and parts that traverse with it, constituting the cradle or upper carriage, are mounted upon a turn-table upon the lower carriage. The center of mass of the moving parts is placed directly over the center of motion so that a minimum of effort is required to produce a given amount of movement of the piece.

The second carriage built by the Ordnance Department in the attempt to secure a rapid-fire field carriage was designed in 1900, It is known as the Ordnance Department short recoil carriage, and is fully described in appendix 4 of the Report of Chief of Ordnance for 1902.

Its distinguishing features are hydraulic cylinders containing counter-recoil springs, a turn-table traversing arrangement, and a folding trail spade. Before this second carriage was manufactured another design known as the Ordnance Department long recoil carriage, fully described in the above mentioned report, was brought out. This carriage was distinguished from its predecessors by the length of recoil of the gun upon the carriage—44 inches. The recoil was controlled by two hydraulic cylinders, one upon either side of the piece. The return to battery was accomplished by counter-recoil springs enclosed in the cylinders. The trail was fitted with a fixed spade. This carriage was designed in 1900 and was completed ready for test early in 1901. In 1901 and 1902 an exhaustive competitive test of field artillery material was held under direction of the Ordnance Board. Detailed report of this test is given in the Report of the Chief of Ordnance above referred to. The Ordnance Department long recoil carriage was entered in these trials and demonstrated its superiority to any other carriage tested. Among those entered were two creditable carriages of domestic manufacture and four from abroad, embodying the latest and best efforts of foreign makers, The record of the long recoil carriage in this test—of a year's duration at the Proving Ground and in the field, and embracing hundreds of rounds fired under all extremes of condition without once being put out of action from accident or breakdown, is a remarkable achievement. This carriage, as well as its predecessors, was designed by Captain Charles B. Wheeler, Ordnance Department, for whom its performance was a notable professional triumph.

As a result of this competition the War Department adopted this type with such modifications as the experience of the trials indicated as desirable. This modified carriage is known as the 3-inch field carriage, model of 1902, and is now being manufactured for issue to the service.

The change from the service to this new model carriage carries with it the change from separate to fixed ammunition, and the consequent change in the ammunition vehicles of the field batteries. Advantage has been taken of the re-armament of the field artillery to design improved material throughout. The new types of gun, carriage, limber, caisson, and battery repair wagons, are described in the following pages.

PART II. A DESCRIPTION OF THE NEW MATERIAL.

THE GUN.

The gun is a built-up nickel steel rifle consisting of a tube, jacket, locking hoop and clip. The jacket envelops the rear portion of the tube and projects beyond it to form a seat for the breech mechanism. A lug depends from the extreme rear end of the jacket for the attachment of the recoil cylinder of the carriage.

On the underside of the piece extending the entire length of the jacket, locking hoop and clip, are formed two recoil clips which fit over and secure the piece to the guide rails of the cradle. When the piece is assembled on the carriage the portion of the cradle rails between the locking hoop and clip is covered by a dust guard so that the bearing surfaces of the recoil clips and guide rails are thoroughly protected from dust and dirt.

The breech mechanism is of the interrupted-screw type. The block has two threaded and two flatted sectors. When the breech is open the block is supported by the usual form of block carrier hinged to the right side of the jacket. The breech is opened or closed by a single horizontal motion of the operating lever which is pivoted on the carrier immediately under the block. This operating lever has bevel gear teeth which mesh with corresponding ones formed on the rear face of the block.

The latter is bored out to receive the firing mechanism and its rear end is closed by a steel cover which excludes dust and dirt.

The firing pin is eccentrically located in the block. In firing position it lies in the axis of the piece opposite to the percussion primer of the cartridge. As the block is rotated to open the breech the pin is moved to one side clear of the primer and remains in that relative position until the block is again rotated in closing the breech.

The device insures safety from a premature discharge due to the protuding point of a broken firing pin striking the cap as the block is swung to its seat in closing. In rotating the block to open the breech a cocking lever working on a cam draws the point of the firing pin below the face of the block, where it is caught by the sear. The mainspring remains free until the block is rotated in closing, when it is compressed by the same lever. The mechanism is provided with a positive safety device which makes it impossible to release the sear and thus fire the piece before the block is fully closed.

The extractor is a ring which passes entirely around the cartridge. The ring has two lips which take under the rim on opposite sides of the cartridge and two guides which slide in grooves in the right side of the breech recess. The extractor lever is proportioned so as to act first as a wedge to start the empty case and then as a lever to throw it clear of the breech.

The gun may be fired by a lanyard attached to the sear catch on the breech of the gun, but habitually it is fired by the firing handle at the right side of the cradle. A firing shaft mounted in a bearing on the cradle has a squared end projecting to the rear through a squared hole in a sleeve resting in a bearing in the recoil lug of the gun. Pulling the firing handle turns the squared shaft and sleeve, and an arm on the latter releases the sear and thus fires the piece. In case of misfire the firing pin can be re-cocked without opening the breech. The firing shaft on the cradle is limited in length so that the piece cannot be fired until it has returned to a safe position in battery.

The breech mechanism has been exhaustively tested and has been found decidedly superior to other systems of breech closure. Among its advantages may be enumerated: rapidity of fire; great power of extraction and ejection and also of rotation; ring form of extractor; ease of loading in that the cartridge does not have to be pushed home by hand; protection of parts from dust or injury; simplicity of parts, few in number, and easily assembled or dismounted without tools; safety insured by eccentric location of firing pin, as well as by provision making impossible the release of the sear before the gun is fully closed.

The weight of the piece with breech mechanism complete is 832 pounds. The diameter of the bore is three inches; total length of bore, twenty-eight calibres; total length of piece, 87.8 inches; capacity of powder chamber, 65 cubic inches. The weight of the projectile is fifteen pounds and the muzzle velocity is 1700 f. s. with a pressure per square inch not exceeding 33,000 pounds. The range of the piece at 15° elevation is 6250 yards. By sinking the trail of the carriage in the ground a greater elevation can be obtained with correspondingly greater range. The maximum range of the piece is probably correctly stated as 7500 yards. The accuracy of the piece at ranges of 6000 yards is quite remarkable and is comparable to that of the 3.2-inch gun at about 4000 yards.

THE CARRIAGE.

The carriage consists of the following principal parts: the wheels, axle, trail and elevating mechanism forming the lower carriage, the cradle with recoil-controlling parts constituting the upper carriage and the rocker and traversing mechanism intermediate between the two.

The wheels are a modified form of the 3.2-inch service wheel, 56 inches in diameter with 3-inch tires and dust-proof nave boxes; the axle is hollow and is made of forged steel in one piece. For fastening the wheel on the axle a collar with an interrupted lug is fitted to a groove in the axle; corresponding interrupted lugs are cut in the inner end of the nave boxes. The wheel is placed on the axle and turned so that these lugs interlock; the axle collar is then locked to the wheel by a hasp, and turns with it. The arrangement permits the wheel to be quickly removed if desired; removal, however, is only necessary for cleaning. Oiling is accomplished through automatic closing oil holes without removing the wheels. A quantity of oil slushing around in the hollow axle will keep the wheels lubricated for a long time.

The trail is of the usual construction of two pressed steel flasks of channel section tied together by transoms and plates. The front end of the trail is clamped by bolts and nuts to the axle. The rear end terminates in a fixed spade, the noticeable feature of which consists of the "float" or wings which spread out for five inches on either side of the blade and prevent excessive burying in the ground. The lunette ring is held in its seat by a nut so as to be readily replaced when much worn. The trail is fitted with a folding handspike, and is provided with a roomy tool box.

The elevating mechanism is of the double-screw type and provides for a range of movement from minus five to plus fifteen degrees elevation. The outer screw works in a threaded bracket resting in transom bearings between the flasks; the head of the inner screw is attached to the rear end of the rocker. The mechanism is actuated by crank shafts located one on either side of the trail, working through bevel gears. The mechanism does not project below the flasks. It is so enclosed by transoms between the flasks and so housed in traveling that it is securely protected from dust or injury. This complete protection and the arrangement for giving elevation from either side of the trail are the distinguishing features of the design.

The rocker is the intermediate connection between the upper carriage, or cradle, and the lower carriage, or trail. It forms a platform upon which the cradle is moved in azimuth and moves with the cradle, relatively to other parts of the carriage, in elevation. The rear end of the rocker is supported by the elevating screw; its forward end is journaled upon the axle between the flasks so that when the gun is moved in elevation the rocker rotates about the axle. The front end of the rocker is also fashioned into a socket to take the cradle pintle piece, to which it is secured by clips.

The cradle receives the gun, guides it in recoil and forms a housing for the recoil-checking parts; it consists of a sheet steel body formed to a horseshoe shape with the upper edges flanged outward, and connected by a cover plate riveted on. The flanges are bronze lined and form guides for the gun in recoil. The cradle is traversed upon a pintle which is riveted to its bottom side and fits the pintle socket in the rocker. In normal position clips on either side of the rocker socket engage projections on the cradle pintle locking the two parts together. The cradle is disengaged for dismounting by turning it through an angle of 38°. It is also clipped to, and has a broad bearing upon, the rocker at the rear end of the latter, the bearing being directly over the point of attachment of the elevating screw.

The rear end of the cradle has an opening through which the cylinder projects for attachment to the recoil lug on the gun and through which it moves in recoil. The clearances of this opening around the cylinder are closed by a felt washer to keep out dust. The front end of the cradle is closed by a retaining ring and cradle head; the former is held in place by swing bolts; the latter has an interrupted collar by which it is fastened to the retaining ring; both are arranged as described so as to be quickly dismounted to permit access to the recoil controlling parts inside the cradle.

The *traversing mechanism* consists of a worm shaft with bearings in a steel housing on the rocker, and a nut moving longitudinally on the shaft, but restrained from turning with it. The nut is connected by a link to a lug on the under side of the cradle. As the shaft is held in its rocker bearings, its rotation moves the nut relatively to the rocker. The link connection imparts a corresponding motion to the cradle which turns on the pintle as a center. The amount of motion thus provided for is eight degrees, four on each side of the carriage. The moving parts of of this mechanism are enclosed so as to be dust-proof and thoroughly protected. The hand-wheel for turning the worm shaft is at the left of the cradle conveniently placed for use by the number who lays for direction.

The recoil-controlling parts of the carriage include the cylinder, piston rod, counter-recoil buffer and counter-recoil springs.

The cylinder lies inside of the cradle and is surrounded by the counter-recoil springs; its rear end projects through the rear end of the cradle and is attached to the recoil lug on the gun; its front end is closed by a stuffing box through which the piston rod works. The front end of the piston rod is attached to the cradle head. In recoil the cylinder moves to the rear with the gun while the piston rod is fixed in position. The piston rod is bored out to take the counter-recoil buffer, which is a bronze rod screwed into the front end of the cylinder, and fitting with small clearance into the piston rod bore.

Each counter-recoil spring is made of a thin rectangular steel ribbon coiled on edge. The spring column of each carriage consists of three of these coils placed end to end around the cylinder inside the cradle. The spring column presses in the rear against the end of the cradle, in front against a bronze spring support, which in turn bears against a shoulder at the front end of the cylinder. This spring support rests on guides in the cradle and affords a centering bearing and support for the front end of the cylinder so as to preserve the alignment of the piston rod and cylinder as the latter recoils with the piece. The spring column is assembled under an initial tension sufficient to return the piece to battery at 15° elevation.

On the interior of the cylinder are three longitudinal ribs or throttling bars of uniform width but of varying height. Corresponding notches are cut in the piston head forming ports for the passage of the liquid from one side of the piston to the other. The height of the throttling bars along the cylinder regulates the area of these ports, and is calculated so as to make the resistance which the liquid offers, plus the resistance of the springs, such that the wheels will not jump from the ground when the piece is fired at 0° elevation. This object is accomplished by making at each instant the gravity moment of the system about an axis through the point of support of the trail greater than the sum of the moments of the piston rod pull and the spring resistance about the same axis.

The action of these recoil-controlling parts when the piece is fired is as follows: The gun travels to the rear 48 inches on the cradle, carrying with it the cylinder and compressing the counter-recoil springs. The energy of recoil of the gun is absorbed by the resistance which the liquid in the cylinder offers to being forced through small openings past the piston head. A portion of the energy of recoil sufficient to return the gun to its firing position is absorbed by the counter-recoil springs. The return movement is regulated by the counter-recoil buffer. The piston rod pull and spring resistance is transmited to the carriage but, owing to its weight and the resistance opposed to the trail spade by the earth, the carriage remains stationary.

The recoil-checking arrangement is simple and compact; all the parts are enclosed in the cradle and are thoroughly protected from dust and dirt. The walls of the cradle are of sufficient thickness to protect them from small-arm and shrapnel bullets. The gun above and the springs surrounding the cylinder afford it additional protection. The cylinder is small and the amount of liquid (8 pounds) it contains is limited so that the usual objection to the weight of liquid carried fails. The cylinder and contents recoiling with the piece increase the recoiling mass and reduce the velocity of recoil so that the limited additional weight of the cylinder is utilized to the best advantage.

As there is but one stuffing box which is deep and well packed, leakage is not anticipated; in fact judging from experience with such cylinders at the proving ground and in the field, the cylinder once filled will not again require attention for months.

The counter-recoil springs, three in number, are assembled without separators, end to end on the cylinder. They cannot be assembled improperly, and in that respect, as well as in simplicity, are in striking contrast to the nest of coils and separators used by some foreign makers. The throttling bars forming ribs in the interior of the cylinder give it longitudinal stiffness, much needed but generally lacking in other designs. The counter-recoil rod, with one end secured to the cylinder, has its free end centered and supported at all times in the bore of the piston rod; it regulates the velocity of return of the piece throughout the length of the counter recoil, obviating the sudden strain and shock inseparable from designs where the counter recoil is unrestrained until the piece is nearly in battery.

The arrangements for the care and assemblage of these important parts are quite complete. The cylinder may be filled or emptied without being removed from the carriage; the gun, cylinder and counter recoil springs may be dismounted in less than a minute, a single wrench being the only tool required.

The parts described above are the essential parts of the carriage. In addition there are many appliances and conveniences provided which conduce to the comfort or protection of the crew and ease and rapidity of the service of the piece. Some of these arrangements will be briefly mentioned.

Two *axle seats* are provided, one on either side of the piece. They are raised above and supported from the axle and have wheel guards while the main shield, referred to hereafter, serves as a back. Underneath each seat and supported and braced by the brackets which support the seats, are two steel tubes ingeniously fashioned at their front ends into foot-rests for the cannoneers and supports for the road brake beams. The tubes are fitted to take each one round of ammunition; their rear ends are closed by hinged covers and project over the axle through the main shield so as to be conveniently reached by a cannoneer from in rear of the shield. Provision is thus made for having at hand for emergency use four rounds of ammunition per gun.

The *shield* for the protection of the gun crew is a flat plate of hardened steel .2-inch thick made in three parts, the apron, the main and the top shield. The apron is hinged under the axle, and for traveling is fastened up under the cannoneer's foot-rest; the main shield is rigidly attached by bolts to axle brackets and reaches to within a few inches of the tops of the wheels; the top shield is hinged to the main shield and projects up far enough to afford protection from long range small-arm and shrapnel fire; for traveling it is folded down on the main shield. Since no part of the shield projects above the wheels when on the road, it is less liable to injury should the carriage be overturned.

Prior to acceptance by the Ordnance Department, each one of these plates is actually tested by firing at it at a range of 100 yards with the new magazine rifle, model 1903, and steel jacketed bullet with muzzle velocity of 2300 feet per second. The plate must not be penetrated, cracked, broken or materially deformed. Against plates that have withstood this test, small-arm and shrapnel fire at battle ranges will be ineffective. Gun crews thus sheltered cannot be reached and driven from their guns by any frontal attack.

The *road brakes* are of the lever type, the shoes being placed in front (rear, carriage limbered) of the wheels. Thus placed they do not gather as much mud on the road as if placed on the opposite side of the wheels and in action they are entirely out of the way of the cannoneers. The brake beams are pivoted on supports at the front ends of the ammunition tubes and are connected by rods and cranks to a shaft mounted in bearings just in front of the axle. The lever which works the shaft is double, with one arm in front and one in rear of the main shield; the former for use from the ground or from the left axle seat in traveling; the latter for use in action. The brakes can be set or released with either lever. They are intended for use as firing as well as road brakes and will be of considerable assistance on firing grounds sloping to the front.

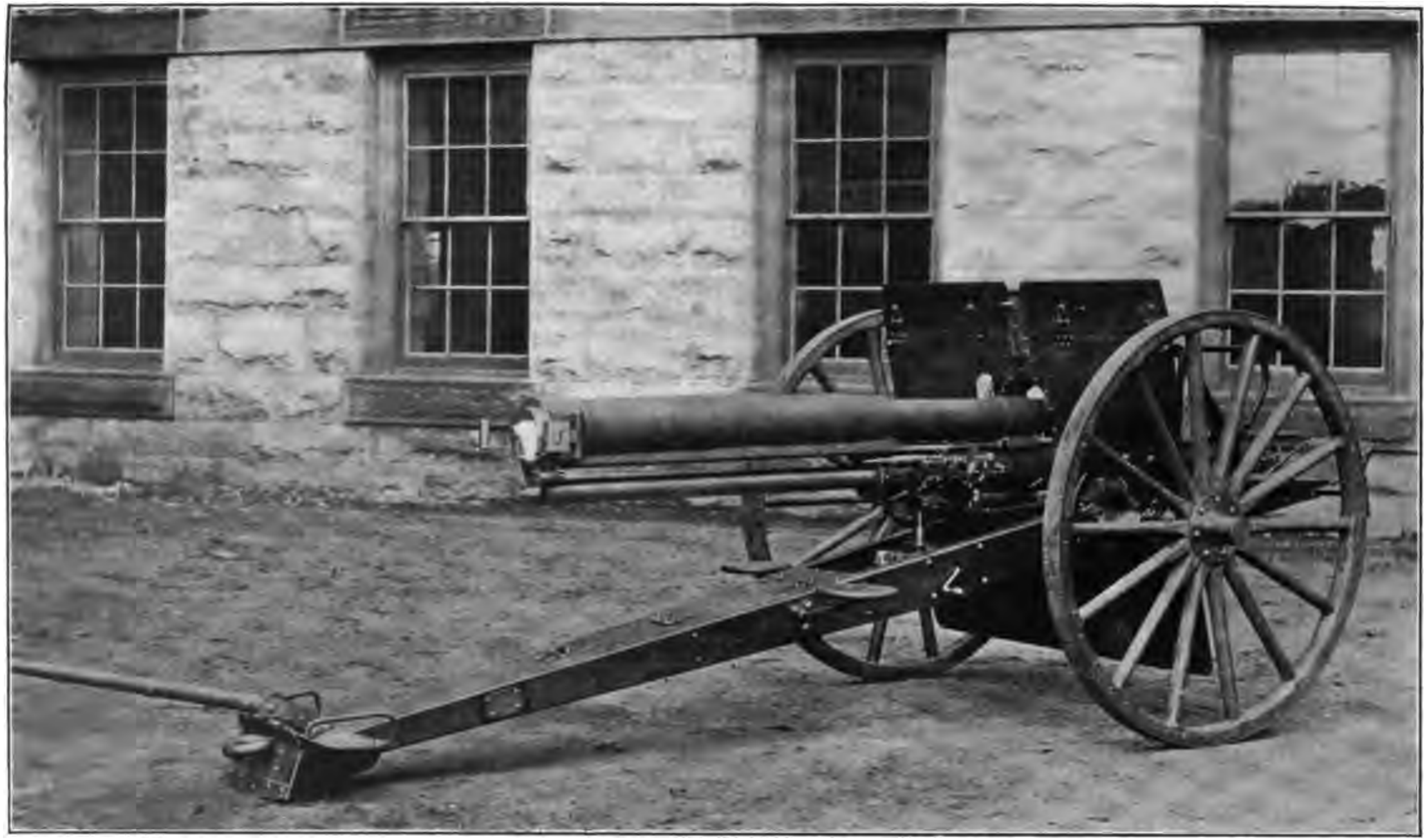
The elevating and traversing mechanisms are relieved from all strain in traveling by a stout lock which secures the cradle directly to one of the trail transoms.

An indicator for recording the length of recoil of the gun upon the carriage is attached to the right side of the cradle.

The gunner and the cannoneer operating the breech mechanism are seated during firing upon seats fixed to the trail. The gunner's seat is on the left with the elevating crank and traversing hand wheel within easy reach and with the sight directly opposite his eye. The sights are supported by standards attached to the left side of the cradle. Since the sights and carriage do not move during firing the operation of sighting may be a continuous one, the gunner keeping his eye to the sight and the line of sight on the target at all times. The piece can then, if desired, be fired as rapidly as loaded. The number seated to the right of the trail operates the breech mechanism and fires the piece.

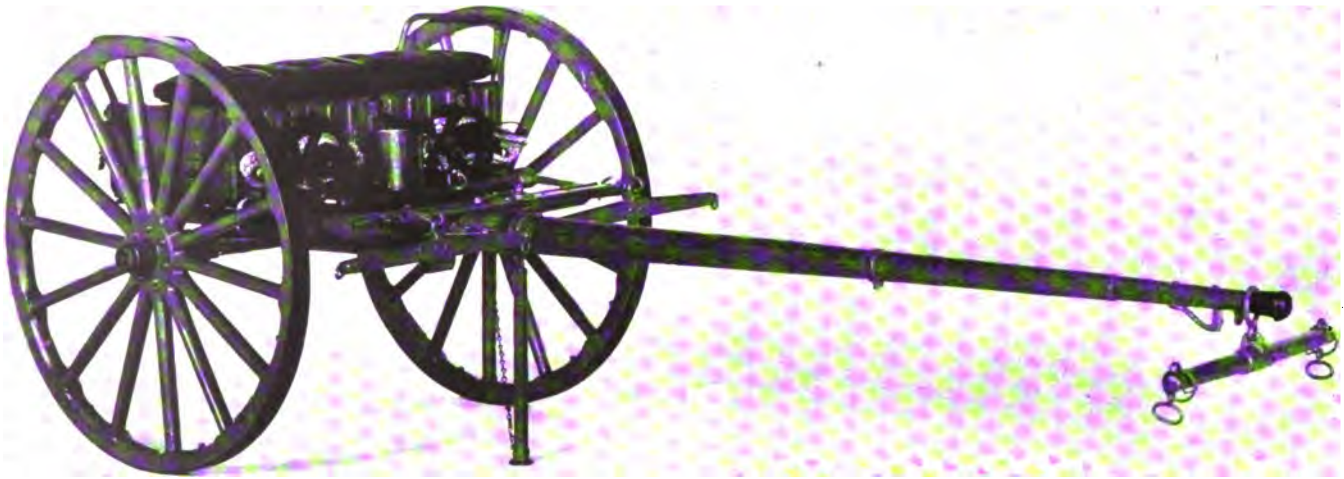
The duties usually assigned to the gunner are setting the sight for range and deflection and laying the piece by manipulating the elevating and traversing mechanism, which duties require great care and some time when accurately performed. When changes of range and direction are frequent as in the case a moving target, these duties, if attended to by a single number, would delay the firing much beyond the time required to load. Since in this carriage the elevating and traversing mechanisms are entirely independent of each other, the pointing of the piece may be much simplified and the time required to do it considerably lessened by assigning to one number the pointing for direction and to a second one that for range. Such a division of

1. CARRIAGE. Gun in firing position.

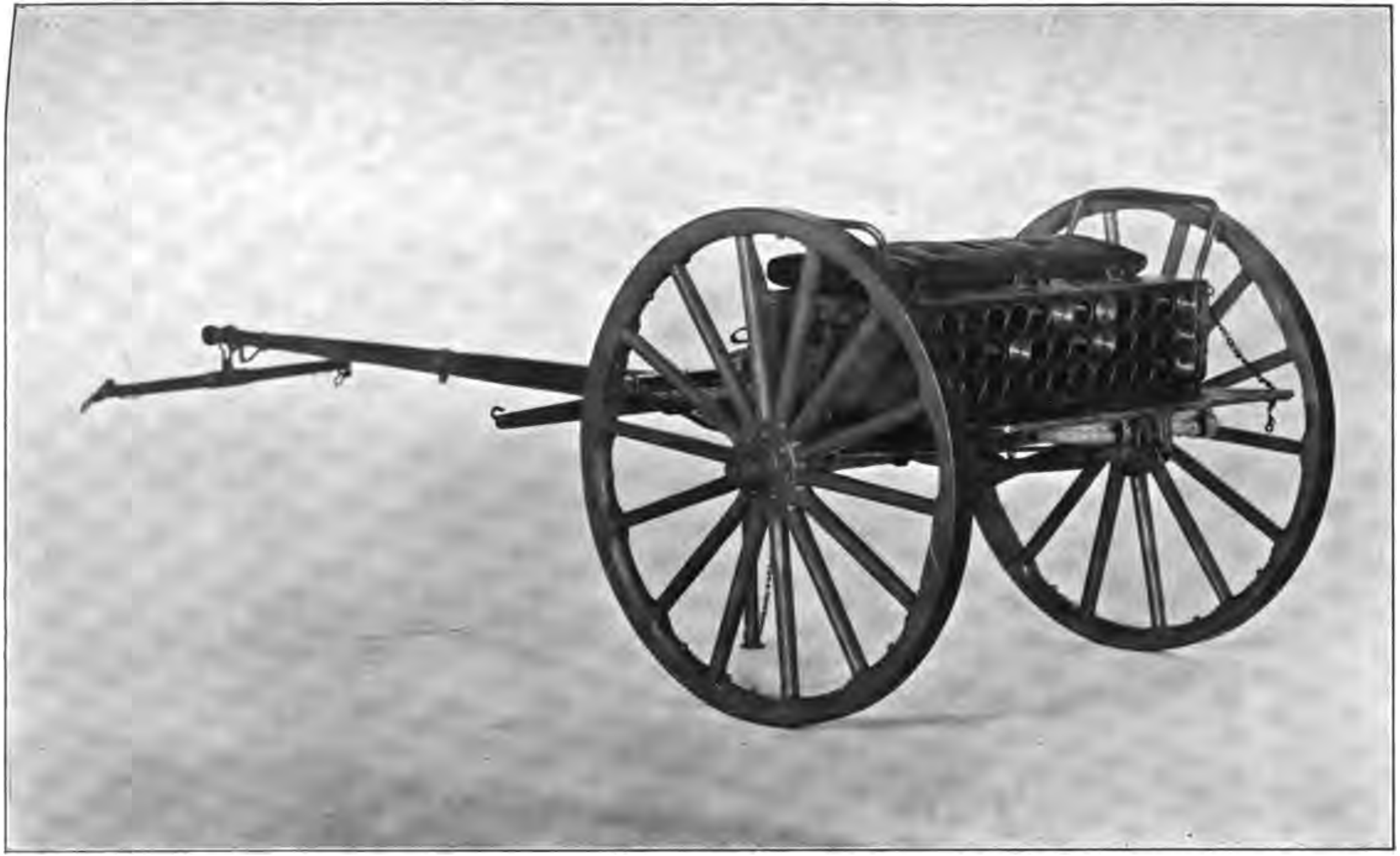


2. CARRIAGE. Gun in position of extreme recoil.

100-2



3. LIMBER. Front view.



4. LIMBER. Rear view.

5. CAISSON. Front view.

6. CAISSON. Rear view.

duties is provided for by the elevating crank at the right side of the trail and by a range quadrant attached to the right side of the cradle. By this arrangement the gunner on the left of the piece using the sight lays for direction only, while the operating number on the right gives quadrant elevations.

The *range quadrant* has a clinometer attachment and a range dial graduated in yards. By means of the clinometer the quadrant is corrected for angle of site (angle of target above or below gun); the range dial is then set at the required range and the bubble of the level brought to the center by turning the elevating crank.

This method of sighting will be especially valuable for use at a target moving across the field of fire, as it will leave the gunner free to concentrate his efforts upon following the target by means of the traversing arrangement. It is quite necessary in indirect laying when the target cannot be seen from the gun and an auxiliary aiming point is selected. It eliminates the personal equations of individual gunners and the errors is setting sights and in sighting for range. The quadrant elevations are so accurate and the arrangement withal is so simple that it is believed it will be used by our artillerists to the exclusion of the old method.

Much has been carelessly written about the great rapidity of fire possible with the new field artillery. The minimum possible time between succesive rounds depends upon the time required to load and fire and the time required for the gun to recoil and counter recoil.

The counter recoil must be comparatively slow and the gun must be eased into its firing position; otherwise the shock of return will derange the aim, which will take time for rectification. For a carriage possessing the requisite stability, the time of recoil and counter recoil may be stated at approximately two seconds. Expert cannoneers usually begin the service of the piece before it has returned completely into battery. Assuming such to be the case and allowing only one second additional for opening the breech, inserting the cartridge, closing the breech and firing the piece, gives an interval of three seconds between rounds, or 20 rounds per minute. This may be accepted as the maximum possible rapidity under favorable conditions and with trained crews. Under service conditions after the trail has been well set by one or two ranging shots, a rapidity of from 10 to 12 aimed shots per minute can be maintained for some time; while for a limited number of rounds the greater rapidity mentioned above may be expected. It should be noted that the limitation of the number of rounds which can be fired at maximum rapidity is due to the intense strain upon, and fatigue of, the crew and not to the material.

The weight of the carriage complete as above described with its necessary tools and equipments is 1308 pounds; the four rounds of ammunition on the carriage weigh 75 pounds, the gun weighs 832 pounds and the limber equipped and filled with ammunition (36 rounds), 1585 pounds, making the total weight of the carriage and limber equipped for service with 40 rounds of ammunition, 3800 pounds. The weight of the carriage complete, 1308 pounds, compares quite favorably with the corresponding weight of the 3.2-inch carriage, 1321 pounds, and refutes the statement frequently made that the special parts in the gun recoil carriage add largely to its weight.

In designing the carriage care was taken to have no parts project below the axle in traveling. The same remark applies to the limbers and caissons. The result is that the free height under these vehicles is about 25 inches.

The wheels are of large diameter, making traction easy, so that with a weight of 633 pounds per horse this carriage should possess great mobility.

THE LIMBER.

The limber is of metal throughout excepting the pole and wheels. The latter are the same as those used upon the carriage and are fastened to the axle in a similar manner. The doubletree and continuous trace system of draft which has proven so satisfactory in our service, is retained.

The frame of the limber consists of a middle and two side rails riveted to lugs on the axle and securely braced to it and to each other. The front end of the middle rail forms a seat for the pole; the rear end, one for the pintle. The latter swivels in its seat so as to reduce the bending strains upon the trail when traveling over uneven ground. It is provided with a stout latch, semi-automatic in action, instead of the usual pintle key so familiar to our artillerists. A foot plate is riveted to the front ends of the side rails,

The ammunition chest is supported by the side rails to which it is attached by four pins secured in place by split keys. The chest door is hinged at the bottom and opens downward to the rear to a horizontal position forming a shelf for the convenience of the ammunition servers. The cartridges are packed horizontally with projectile to the front. For this purpose the interior of the chest is fitted with three vertical diaphragms, each perforated with thirty-nine flanged holes, in three rows of thirteen each. The cartridges are supported in these flanged holes. The flanges of the perforations of the rear diaphragm form a stop for the rim of the cartridge case, while the door of the chest bears against its head, holding the ammunition firmly in place. The door is stiffened by vertical corrugations pressed in it and spaced so as to come opposite the cartridge primers and act as primer shields. When closed, the door is fastened by two shot bolts and a latch.

The thirty-nine flanged holes in the diaphragm afford means for carrying thirty-nine rounds of ammunition in each chest. It is intended, however, that only thirty-six shall be carried, the three extra spaces being occupied by three oil cans which are fashioned to fit the holes.

The ammunition to be carried with these batteries includes cast-iron shell, high explosive shell and shrapnel. The cartridges differ in length ; all of the ammunition chests are made of sufficient capacity and are arranged to take any of these cartridges. The proportion of the three kinds to be carried in each chest and in the battery is therefore not limited by the construction, but remains a matter for regulation by the proper authorities.

The top of the chest affords a seat for three cannoneers. It is provided with the usual cushion or paulin straps and grip straps and with chest rails at each end. Departing from the prevalent foreign practice, no backs are provided for these seats for the reason that in our service, cannoneers are frequently ordered to mount on the limbers while the battery is in motion. When limber chest seats have backs, this is a difficult and dangerous feat as the cannoneers have to climb up in front of and over the wheels, or else over the back of the seat.

In addition to the three oil cans mentioned, which have a capacity of five pints each and contain respectively cylinder, lubricating and kerosene oil, the limber is provided with suitable attachments for carrying an outfit of tools, viz: one axe, one pickaxe, one shovel, one hatchet, one pole prop, one lantern, two drag ropes and two watering buckets.

The weight of the limber, complete, without the tools and supplies mentioned in the paragraph above, is 816 pounds; the weight of the tools, supplies and equipment above, is 94 pounds ; the weight of the 36 cartridges is 675 pounds, making the weight of the limber, complete, with supplies and ammunition, 1585 pounds.

THE CAISSON.

The wheels of the caisson are interchangeable with those of the carriage and limber. The frame is diamond shape and consists of two pressed steel rails riveted to lugs on the axle, meeting in front of it at the lunette and in rear at the pintle. The seat for the latter is strongly braced and supported from the axle.

The pintle provided upon the caisson enables several to be coupled together as trailers, an arrangement which the increasing use of traction engines for transportation purposes indicates as necessary, and which also makes possible a most desirable saving of animal transportation in moving empty caissons to the rear or in forwarding loaded ones over good roads.

Opposite the front part of the wheels the two side rails are braced back to the axle and connected by a stout channel iron which forms a support for the road brake beams. The brakes are of the lever type and are modeled after those upon the carriage. The lever is placed at the right end of the ammunition chest and may be worked by a cannoneer from the chest or from the ground.

The ammunition chest is similar to that of the limber, but much larger, holding 70 rounds in five rows of fourteen each. Two chest rails are fastened to the bottom of the chest and project to the front as a support for the foot plate. These chest rails are riveted directly to the side rails of the frame. The door opens downwards to the rear. The top of the chest is fitted with cushion straps, grip straps and hand rails, and forms a seat for cannoneers. On the underside of the chest are carriers for three oil cans.

The caisson is provided with a prop to support the lunette when unlimbered, and with attachments for carrying one spare pole, one long handled shovel, one axe, one pick mattock and one wrench.

The use of a single ammunition chest with ammunition in one tier over the axle gives a well balanced caisson. The weight at the lunette with chest filled is the same as that at the carriage lunette and is practically unchanged as the chest is emptied.

The caisson frame is comparatively short so that the caisson limbered is a much shorter coupled vehicle than the carriage limbered. The turning angle of the caisson (75 degrees) is, however, somewhat less than that of the carriage (80 degrees) so that the ease of maneuvering of the two is practically the same and greater than that of the present 3.2-inch carriage, which has a turning angle of 60 degrees.

The weight of the caisson empty, without tool equipment, is 1047 pounds, the equipments, including spare pole and 15 pounds of oil, weigh 100.5 pounds; 70 rounds of ammunition weigh 1312.5 pounds. So that the weight of the caisson equipped and loaded is 2460 pounds; adding the weight of the limber equipped and loaded (1585 pounds) gives 4045 pounds for the total weight of the caisson and limber with 1987.5 pounds (106 rounds) of ammunition and 194.5 pounds of tools and equipments. The corresponding total weight for the 3.2-inch caisson and limber with 1890 pounds (126 rounds) of ammunition and 508.5 pounds of equipments, not including spare wheel, is 4437.5 pounds.

A comparison of the efficiency, as ammunition carriers, of the new material with the 3.2-inch material, will serve to emphasize the merit of the new designs. The 3-inch limber carries 675 pounds of ammunition, and weighs loaded 1585 pounds, giving an efficiency of 42.6 per cent; the 3.2-inch limber carries 630 pounds of ammunition in a total weight 1658 pounds, an efficiency of 38 per cent. For the new caisson the ammunition weight is 1312.5 pounds, the total weight 2460 pounds and the efficiency 53.3 per cent. For the 3.2-inch caisson, not including spare wheel, the corresponding figures are 1260 pounds, 2779.5 pounds and 45.3 per cent, respectively.

For the new limber and caisson together the efficiency is 49.1 per cent against 42.6 per cent for the old vehicles. In each case it will be noted that the new designs show a materially higher efficiency as ammunition carriers.

The prescribed organization of the new batteries calls for 4 guns and carriages and 12 caissons with the corresponding limbers. The ammunition carried per battery is as follows:

4 carriages, 4 rounds each, 16 rounds.
12 caissons, 70 rounds each, 840 rounds.
16 limbers, 36 rounds each, 576 rounds.
Total per battery, 1432 rounds.
Total per gun, 358 rounds.

THE FORGE LIMBER AND BATTERY WAGON.

The *forge limber* of the new material differs from the caisson and carriage limbers in the chest only. The frame is the same in every respect. The chest is of metal of the same size as the limber ammunition chest. It is opened at the top and contains a complete outfit of tools and supplies for a farrier's shop, in addition a limited number of machinist's tools.

The battery wagon frame resembles the caisson frame. The body is of wood with doors at front and rear on top. It contains complete outfits of wood workers' and saddlers' tools, with a miscellaneous assortment of materials for repairs, and supplies for general use similar to those at present issued to field batteries. In addition, it carries two spare wheels and a large number of spare parts. The weight of the forge limber and battery wagon, packed with all supplies ready for service, is about 3800 pounds.

In designing this new material an effort has been made to make similar parts of the different vehicles identical, so as to simplify manufacture and repair, as well as to reduce the number of different parts to be carried by the battery for repair purposes. Much attention has been paid to the subject of interchangeability, in order that parts sent out for repairs may be assembled in the place of those broken or worn out without the aid of skilled mechanics. To this end each and every working part is gauged and tested to insure its perfect interchangeability before it is issued to the service.

The above is a brief description of the new 3-inch field artillery material, with comment upon particular features, reasons for their adoption, and such comparisons as seem pertinent. It has been prepared in the hope that it would be of interest to the artillerymen of our service, into whose hands the new material will soon be placed for its final test.

Some photographic views of this material are appended. The first shows the carriage with gun in firing position, the second the same with the gun in the extreme position of recoil. Many of the details are so clearly shown as to require no special mention. Attention is called to the following: The range quadrants; the ammunition carriers, shown through the wheel, open and with a cartridge partly drawn from one of the tubes; the firing shaft shown in the second photograph; the small size of the recoil cylinder shown under the gun in the second view; the compactness and graceful appearance of the carriage as a whole.

The photographs of the limber and caisson are from one-tenth size models, and while not correct in all details, will serve to convey a good idea of the general appearance of these vehicles.

THE PANORAMIC TELESCOPIC SIGHT.

H. KORRODI, CAPTAIN OF ARTILLERY.

TRANSLATED FROM THE FRENCH* BY CAPTAIN C. T. MENOHER, ARTILLERY CORPS.

General Staff, U. S. A.

Inventors have been endeavoring for a long time to equip field and siege guns with telescopic sights of the same kind as are in service in the seacoast and marine artillery.

The optical axes of these instruments being of short length, the objection could be raised that the slightest derangement or the smallest error of construction would interfere with accuracy in aiming. However, this disadvantage, if it is confined within certain limits, is largely compensated for by important advantages. The telescope allows of clearly distinguishing targets which the naked eye perceives only with difficulty and of aiming always with the same precision from round to round.

There is no difficulty in adapting telescopic sights to guns of the marine, seacoast, or fortress artillery, since the sight, carried on a cradle or sleeve, does not recoil with the piece. It has not been the same with field guns until now in service. If, as in the case of the gunner's quadrant, it was necessary to remove the telescope before firing, the rapidity of fire would be interfered with.

If the sight were left during the fire, the strongest construction and the best arrangement of the lenses would not protect it against the derangements due to the recoil of the carriage and the rebound of the breech.

Guns with recoil on the carriage having replaced those with rigid carriage or with elastic spade, there is no longer any objection to the adoption of the telescopic sight for field artillery. Thus it is that the French have been the first to introduce, if not a telescopic sight, at least an optical sighting tube, the collimator, which renders the front sight superfluous.

In adapting to the sighting apparatus a goniometer movable around a vertical axis, it has been possible with the same instrument, to aim either directly or to orient the line of sight on an auxiliary "point of sight" situated at any point of the horizon.

Curved telescopic sights offer the same advantages but with

* REVUE MILITAIRE SUISSE, February and May, 1903, from which publication the plates have been reproduced.

this difference, that their reticule does not necessitate a displacement of the eye, as must be done in direct aiming with the collimator.

The target is seen more distinctly and the aiming, in consequence, is more accurate and more uniform. The telescope not being subject to the recoil of the piece, can be fixed on the standard sufficiently firmly and there is no risk of derangement of the optical axis.

The ordinary telescope with cross hairs offers, however, imperfections, which in certain cases nullify its advantages. It would often be preferable to sight with ordinary sighting notch and front sight, as when it is raining, or if, as in wet weather, the lenses are covered with moisture, or again if the target being large and distinct, the limitation of the field of view of the telescope is inconvenient. The telescope should then be combined with an arrangement of sighting notch and front sight, permitting its use at will and without any delay, and besides giving control at all times of the optical axis. If it is necessary to aim with the sighting notch and front sight, the telescope will give the layer the means of orienting himself accurately, whatever the nature of the target.

As the collimator and the telescope can be directed to any point of the horizon, there is no longer any need for a special instrument such as the German "richtfläche" or the Italian "plaque de direction," with which it is necessary to adjust or rectify the alidade. Unfortunately, in actual practice, the collimator and the telescope still do not present every desirable advantage.

If the angle between the direction of the target and that of the auxiliary point of sight exceeds certain limits, the layer, seated on his seat on the axle, must, in order to be in position to aim, leave his normal position. The wheel on one side and the piece on the other interfere with ready laying on a target situated behind in an oblique direction. The shield in certain cases increases this difficulty, or interferes with aiming altogether. If, in order to aim, the layer must leave his seat, the shield will cease to protect him, and the changing of position tends to interfere with the service of the piece. Another cannoneer must man the training cranks, which renders rapid laying impossible.

It is necessary therefore to impose upon the aiming apparatus of the new artillery, the condition of permitting aiming on any point whatever of the horizon without the layer having to leave his normal position.

300

ique.

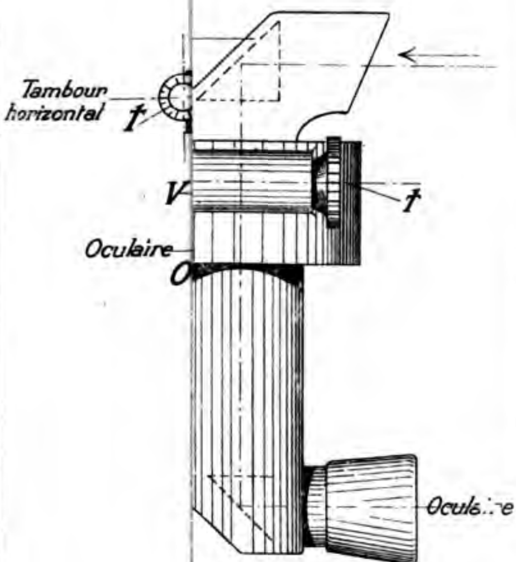
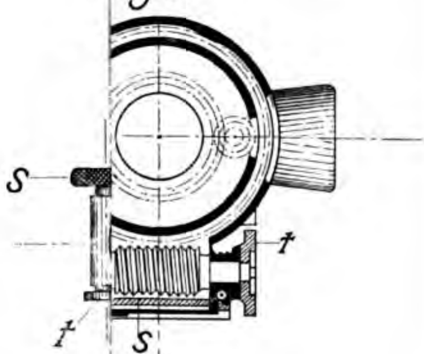


Fig. 7.



Such is the problem which has been solved by the firm of C. P. Goerz of Berlin-Friedenau. Figures 1-4 show the panoramic telescope placed on a curved bracket of the type adopted by the "Rheinische-Metallwaaren-und-Maschinenfabrik," of Dusseldorf. Figures 5-8 indicate some of the details of construction.

While the collimator and the ordinary telescopic sight can, in their entirety, be revolved about a vertical axis, the upper part only in the panoramic sight can be turned about a vertical axis and directed upon the auxiliary point of sight. The stem V of the instrument and the eye piece O do not partake of this movement of rotation, the former being fixed by a dove-tailed rib in a slot corresponding with the head of the bracket, and held in place by a spring bolt catch. The gearing S, which controls the rotation of the upper part, can be disengaged, thus permitting the angle of direction to be rapidly changed by hand.

The reading of the angles and consequently the adjusting for direction are done on two graduations, one on the vertical drum carried by the movable part and the other on a horizontal drum tangent to the first.

The vertical drum has on its circumference 64 divisions which are read through a window in the stem of the instrument and opposite a pointer. The horizontal drum is divided into 100 parts, one complete turn of this drum corresponding to one division of the vertical drum; so that one division of the horizontal drum corresponds to $\frac{1}{6400}$ of a circumference or approximately one millième. It is the same system as that adopted in France but with a different arrangement of divisions from that of the French goniometer.

When the two drums are at zero, the optical axis of the telescope and the line of sight passing through the sighting notch set at zero and the front sight are both parallel to the axis of the bore.

The construction of the panoramic telescope is such that the image of the point seen, whatever its direction on the horizon, is presented without being reversed or inverted, exactly as it would be seen with the naked eye. The vertical distance between the eye piece and the objective is such that the line of sight is not intercepted by the head of the layer when sighting to the rear. With a magnifying power of 5 and a field of about 8 degrees, the panoramic telescope responds completely to its target.

In direct aiming the elevation is given, then the lateral sight allowance by turning the lateral drum. The aim is then given by means of the handles of the training gear.

If found advantageous, the direction can be given approximately by means of the ordinary sights and the aiming afterward completed with the telescope. In indirect aiming, the panoramic telescope is used as are the German "richtfläche" and the Italian "plaque de direction."

By any process whatever, preferably with a light instrument of the same kind carried on a tripod, the captain, stationed near the battery, measures the angle between the direction of the target and that of the auxiliary point of sight visible from all the guns. This angle of direction, modified according to the position of the station from which it has been determined, is given to the guns which are then aimed on the auxiliary point.

The layer, retaining his normal position, can always easily manipulate the training handles. Indirect laying will not be delayed and the layer will remain covered by the shield, whatever the direction of the "point of sight."

The panoramic telescope can also be adapted to a sighting level like that which, placed on the left trunnion or on the cradle of certain pieces with curved fire, permit laying while the gun is in the loading position. Indirect laying being the rule with these guns, the panoramic telescope offers for them still greater advantages than for field guns.

The sight of which we have just read the description presents a peculiar interest. In the meantime we desire to invite the reader's attention to the following points:

The panoramic sight in question is in principle a reproduction, on a reduced scale, of the optic tube for enabling the submerged submarine boat to see the surface of the sea. The optic tube as used corresponds absolutely to the scheme of figure 6, pl. I. Its principal objection is that in turning the objective U without the sight piece O following the movement, the image is reversed; thus a deviation of 90° places it in a horizontal position, while it is inverted at 180°; between these displacements the image occupies intermediate positions.

Now it is no more admissible for the man at the wheel to see the vessel against which he is advancing, inclined on the water at 45° than it is for the gunner to see cavalrymen against whom he is firing, while keeping the piece in position, holding their horses reversed between the legs.

It is for this reason that the manufacturers of optical instruments in France and Germany have sought for some years an arrangement for rectifying the image. This has been found and there are different solutions to the question. The most important feature of the panoramic sight is certainly the apparatus for rectifying the image. Captain Korrodi refers to this matter (page 309) but does not give a description, and the figures of the plate do not give the key. Hence may we not ask if this apparatus will not be too bulky to be adopted for the field gun sight and render it too complicated and unfit for the service. There is finally the question of cost, which is important, for with such instruments we soon reach a sight as expensive as the gun itself.

Finally, an important point is that of the field of the telescope. It appears that one magnifying five times is too strong, because it gives too small a field. Eight degrees are, in effect, so much the more insufficient in that, by the definition itself, it is not possible to affix to the panoramic telescope a "finder." Hence there would necessarily be cases where the layer would have difficulty in finding again the auxiliary "point of sight," resulting in loss of time.

The panoramic telescopic sight, as it is presented to us, is incomplete and unserviceable. The most interesting point is that which the author does not state. Will he not consent to furnish us with some further details? De V.

THE PANORAMIC TELESCOPIC SIGHT AGAIN.

The "Revue Militaire Suisse" of February last published a description of the panoramic telescopic sight, accompanying the same with certain cautions in regard to the construction of the instrument itself and its practical use in field artillery.

Captain Korrodi has been pleased to furnish the data and the following plates. These show the panoramic sight adapted to an Ehrardt gun of 5 cm., of the system recommended last year by General v. Reichenau. We can vouch for the sights being compact and perfectly constructed, and not more cumbersome than other telescopic sights. Besides, the Goerz firm has been pleased to give us a description of the optical part of the apparatus, of which the following is an extract:

It will be remembered that the panoramic sight permits aiming at an auxiliary point of sight to the side of or even behind the piece, without the eye-piece being obliged to follow the circular movement of the objective. Consequently the layer can work as conveniently in these particular cases as if the point of sight was in front of him.

The details of the optical part of this instrument center particularly in the construction of the prisms which have the following qualities:

1.—They rectify the image, so that instead of long field telescopes, simple astronomical eye-pieces (magnifying glasses) can be used.

Lunette panoramique.

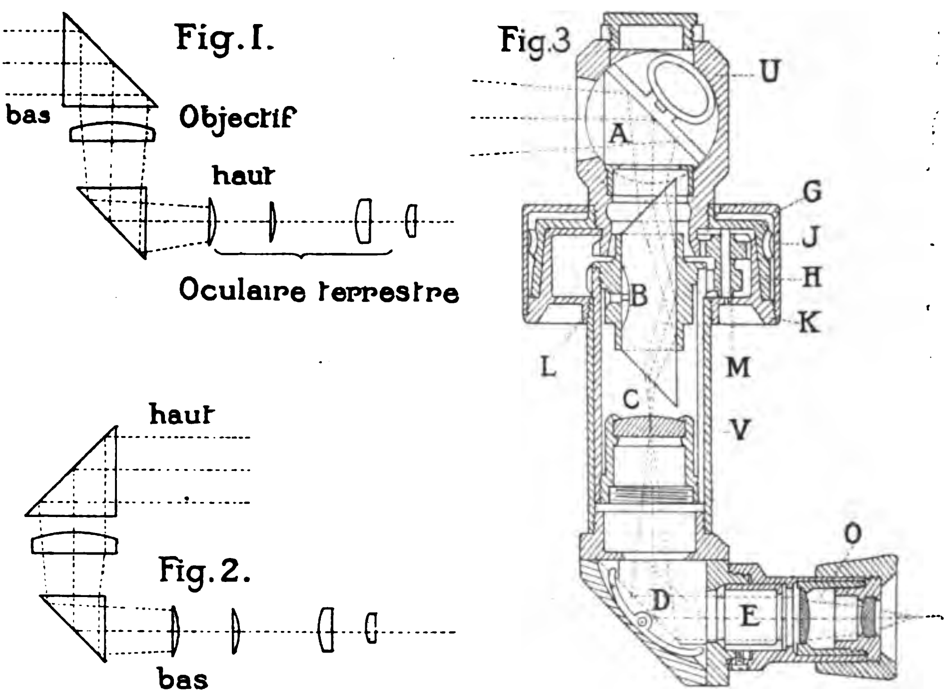


PLATE II.

2.—The image of the target is reproduced in its natural position, that is, the image is presented to the layer in the same position as to the naked eye, in whatever direction the objective is turned.

Here is the explanation of the system:

Suppose, in order to obtain the panoramic vision, we take a simple field telescope, supplied with the system represented by figure 1, Plate II, and that the prism of reflection, placed before the objective, is provided with a rotary movement around its vertical axis. The result obtained by a rotation of 180° is given in figure 2 which shows the reversal of the image.

The optic elements which prevent the inversion and are utilized in the panoramic telescope (figure 3) are the following: The prism of total reflection A, the rectifying prism B, the objective C, the roof-shaped prism (Dachkantenprisma) D, the astronomical eye-piece O.

The rays emanating from the object received in the prism A are refracted in the prism B, the function of which is to rectify them. After their passage to the objective C, the roof-shaped prism rotates them from right to left. Then there is produced in diaphragm E of the eye-piece, a rectified image, magnified and observed by means of the eye-piece.

The particular function of the prism B is to obtain a rotation of the image of 360° for a movement of 180° of the prism around its longitudinal axis. The image is propelled therefore at a velocity double the angular velocity of the prism. It is upon this detail that the construction is based. It is sufficient, in fact, that the prism B follow prism A with an angular velocity reduced one-half, in order to obtain a proper rectified image. The mechanical operations which bring about these results are as follows: Prism A is placed in a cover U which is provided with a gear. This covering is fixed on the box H movable on box K and also adjusted to the case V. The case V contains the tube L, the upper part of which, provided with gearing, engages on one side the frame of prism B and on the other the objective C.*

The toothed wheels M are coupled to the gearing A and L. Their development is so arraged that L receives movement in the same direction at an angular half-speed. The fixed covering G has a cap containing the helicoidal-screw which transmits motion to the prisms A, B and to the objective C.

The displacement can be observed, through the window F, by means of index J and a scale, while the exact reading is done with the aid of a drum.

A handle is used to disengage the helicoidal-screw in order to obtain a rapid rotation of the objective from either side.

The constants of the instrument are:

Magnifying power,	4.
Actual field,	10 degrees.
Apparent field,	40 degrees.
Diaphragm,	4 mm.
Illumination,	16 mm.

*See Plate I.

This description, and particularly the plates accompanying the same, removes the caution referred to on the subject. The dimensions permit of its adaptation even to field guns. It goes without saying that its use will be particularly serviceable in the artillery, both for position and fortress artillery, in the occupation of sheltered positions where the laying on an auxiliary point of sight is inevitable. Finally the price of the apparatus is between 500 and 600 frs.

THE CARROUSEL OF 1903 AT THE SCHOOL OF APPLICATION FOR ARTILLERY AND ENGINEERS AT FONTAINEBLEAU.

By Captain T. BENTLEY MOTT, Artillery Corps.

Military Attaché American Embassy, Paris, France.

Each year at the end of the school term, in the last days of July, the schools of Fontainebleau and Saumur hold what is called their Carrousel or equestrian fête, when during two or three hours the students and instructors go through their various paces on the best horses of the School and a close observer can get a very good idea of the quality of the horses, the methods used and the horsemanship taught at the School. Last year I attended the Carrousel at Saumur; this year I saw that at Fontainebleau.

There are 185 student officers of artillery and engineers at Fontainebleau; their riding instruction is assured by six instructors, majors and captains, and six assistant instructors, non-commissioned officers. It must not be supposed that the latter are without authority or prestige; they are veritable riding instructors for the student officers and being excellent horsemen their situation is in no sense equivocal.

Up to the present, Fontainebleau has received its students direct from the Ecole Polytechnique. Upon being graduated at the latter school they were commissioned and went, after a few months leave, to Fontainebleau for a two years course. This rule has been changed lately and the class that just graduated from the Polytechnique will spend a year with their regiments and then go to Fontainebleau for one year's course in all that pertains to their respective arms.

It is not intended here to make a formal comparison between the horsemanship seen at the Cavalry School of Saumur and that of the Artillery School at Fontainebleau, but to those who know both places it is sure to creep in. The methods, however, are visibly the same, the horses of nearly similar types and the standards both of riding and horseflesh set before the students are equally high.

We are all accustomed to speak of the high standard of honor set and maintained for all men at West Point and we are proud to see it preserved at the Academy and to note how it clings to and marks the graduate through life. Now, the same idea of setting a high standard of horsemanship and horseflesh at the French Cavalry and Artillery Schools is carried out and with similar results. The graduate, having not merely seen and been surrounded with, but having ridden for two or more years only the best types of military horses, has his taste in horseflesh formed, his standard of horsemanship fixed and his ability to judge of both directed by association and practice. It would be hard for him in after years to lose these high standards in what concerns the horse, just as it is seldom that a West Pointer loses the high idea of honor inculcated in him at the Academy; but the graduates of Saumur and Fontainebleau are fortunate in being able to continue, throughout their whole service, to cultivate the tastes and improve the standards thus early formed for them at the Schools.

The Ecole Polytechnique is not equipped to give much instruction in riding, and thus its graduates upon starting in at Fontaïnebleau have only a rudimentary knowledge of horsemanship. Then, the theoretical courses for these artillery and engineer officers are most exacting in time and study and the students get only about 1¼ hours mounted work per day for six days in the week. This during two school years of 10 months each.

It would not therefore be surprising if a wide difference were observed between the horsemanship at Fontainebleau and that at Saumur, where the students come already prepared by a course of 720 hours of riding in the two years at St. Cyr, and then spend, during ten months, six hours a day with horses. But this divergence is actually not at all comparable to the difference in time devoted to horsemanship at the two places, though it must be admitted that the artillery graduate does not leave Fontainebleau with such knowledge of the horse and his training as the cavalry graduate possesses when he leaves Saumur.

But the former can ride and he showed it at the Carrousel this year.

These tournaments are arranged with the unerring taste which the French show in such matters, and if a great deal of it is pure show, it is show that bespeaks much training of horses and men and no mean skill. The place chosen was one of the carrières or open air riding schools in the heart of the beautiful forest of Fontainebleau. This carrière is about 600x300 feet, is floored with a mixture of sand and loam and surrounded by a wall of sod three feet high. The accompanying illustration gives a very good idea of the place. A covered stand was erected along one

The Carrousel or Open Air Riding School.

side for the Minister of War, the officers, their families and guests.

The sixty-four student officers taking part were divided into four quadrilles of sixteen each. Each quadrille was mounted on horses of the same color, and I have never seen horses more evenly matched. The sixteen grays were beautiful specimens of the Tarbes (Anglo-Arab) horse, and not one of them taken alone but would have been thought an ideal light cavalry mount. The sixteen chestnuts were nearly all thoroughbreds, the other quadrilles seemed to be about evenly divided between Tarbes, thoroughbreds and half breds. The heavier type of horse seen at Saumur was absent, as these are only used for dragoons and cuirassiers.

For about twenty minutes a number of riding school figures were executed at a slow gallop, all without any word of command whatever and with the utmost ease and elegance. Then, while the student officers rested, the six instructors, magnificently mounted, executed the most difficult tricks of the riding school, such as following the close letter S down the length of the carrière at a slow gallop, changing the foot in each case just before the turn ; executing the traverse at a slow trot, haute école work, etc. Consummate ease and quite control marked these exercises.

A Thoroughbred. Haute Ecole. The old French Manège Saddle.

The student officers then picked up paper heads with the point of the sabre, rode at rings and performed other familiar work. Afterwards, hurdles were brought in (not very stiff ones) and jumping of no unusual character followed. Several charges in mass the length of the carrière showed perfect control of the horses.

During the two hours that I watched this mounted work, no horse was ever seen to toss his head or worry at his bit, and while many of them were blooded and spirited animals, they seemed under absolute control. Some of the riding was at a very fast run, but in no case did I see a man obliged to use his right hand to pull up or at any other time except in haute école and changing foot. In other words, the training as to mouth and manners was all that could be desired. This was certainly due to the fact that the men had manners as well as the horses.

Picking up heads.

Whenever the slow gallop was ordered, every horse galloped and not one of the seventy ever fell to a walk or changed to a trot; when the trot was ordered, all trotted.

For these exercises the old French manège saddle was used, except for the jumping, which was done with English saddles.

There are three riding halls at Fontainebleau, three carrières or outdoor schools (one very large—perhaps 600x1000 feet) and one large maneuver field provided with a training track and every kind of obstacle. As there are only 185 students, it can be seen from this and the twelve instructors and assistant instructors maintained, how much attention is given to horsemanship.

In the riding hall the French manège saddle is exclusively used, for other work the English saddle. The regulation army saddle is only used for maneuver work, service in campaign and troop drill.

In general, it may be said that all the riding was good, and showed excellent methods of instruction. No such variety of horses or horsemanship as was seen last year at Saumur was to be noted, nor, as was explained above, could it be expected. It is to be remembered that when they join their regiments these young officers will continue to receive instruction in riding from a captain selected for the purpose, and then after five or six years the best horsemen amongst them will begin to go to Saumur for a course chiefly in equitation. Upon graduation they return to their regiments and furnish the colonels the instructors who continue the education in horsemanship of lieutenants just joining.

French saddle. Tarbes horse.

Thus it is seen that the cavalry arm is not alone in receiving most generous encouragement from the government in the matter of horsemanship, nor can it make any claim to a monopoly of horse knowledge in the army.

It may now be useful to trace the beginnings and the progress of the modern methods which reign to-day at Fontainebleau and which have made of the school not only a modern nursery for all branches of the artillery service, but a place where two years are spent with contentment and even enthusiasm by young artillery and engineer officers. This spirit is due to the horse.

Formerly the School of Application for Artillery and Engineers was as exclusively technical, as physically monotonous, as are our Artillery School at Fort Monroe, and our Engineer School at Washington. Book learning, lectures and study were not varied with much mounted exercise, and the artillery officer joined his regiment with little taste for horses and even less practical knowledge. Moreover, the monotonous grind of study immediately succeeding two years of cramming at the Polytechnique, made the average student loathe the course and think only of the time when he would escape to a more varied existence.

In 1876 the command of the school fell to General Schneegans, a man of much independence of spirit, convinced that the most useful artillery officer was the practical man who could do things in the field, rather than the student who only knew how they should be done. His first care was to acquire the means of making good horsemen of the young officers, both in order that they might have that dash and freedom in action which no mounted officer, however brave, can possess unless he be a good rider, and in order to vary the monotony of study with agreeable and useful exercise. He believed too that the artillery officer had as much need know the horse as his brother of the cavalry, and he wished to unify the methods of mounted instruction throughout the arm.

So well did General Schneegans do his work and so evident were the results for the artillery service, that no successor of his (and some of them have been merely scientific men) has ever let the work go backwards. His choice of Captain de Bréon, a steeple-chase rider of great renown, as the first riding master was a most fortunate one. This passionate horseman, seconded by his chief, started the riding instruction on a firm basis, enlisted the enthusiasm of the student officers and began to turn out men who commenced to make names for themselves in the military horse world, where cavalry officers had been accustomed to a monopoly. Thus, in 1882, Lieutenant Fraville, on a troop horse that had been unmanageable until trained by him, won the steeple-chase of the Croix de Berny; in 1883 the Lauréat prize was awarded Lieutenant Daru at the Paris Horse Show, and in 1885 Lieutenant de la Jonquière won the Prix des Dames and the Cup.

A decided advance was made later when Major Durand became the Ecuyer en chef. This energetic horseman secured for the school the same type of horses which the rejuvenated Saumur was already using, increased the riding halls from one to three, built two carrières and induced the government to allow him 400 horses, many of them thoroughbreds and Anglo-Arabs, instead of the 200 indifferent mounts he had at the beginning.

From that time on until recently, when the reduction of the course to one year has diminished the number of students and instructors one-half, the riding masters consisted of a major and ten captains chosen from the best artillery graduates of Saumur, when formerly the number had been only four. Moreover, there

Taking the rings at a fast run.

was adopted the system of instruction which seems to have given most satisfactory results at Saumur and St. Cyr. Instead of letting each riding instructor take a turn at the students as chance dictated, these were divided into sections and each section was confided exclusively to one riding master for the whole two years. He was responsible to his chief for their instruction, and knowing each man thoroughly could better guide his education.

A class of non-commissioned officers, assistant instructors, was also added, and the "instructor's ride" instituted. This "ride of the instructors" is a feature of Saumur, the Ecole de Guerre, St. Cyr and Fontainebleau. The instructors at each school are formed in a squad and drilled by their chief in all the things they are required to teach, thus ensuring uniformity of methods. It is no mere formality, and each man finds himself compared with the best in his class and he cannot afford to rest on a reputation already gained for horsemanship ; he must regularly prove that he deserves it. Moreover, these "reprises d'écuyers" give the higher officials and the public a chance to judge of the qualities

A "Sauteur" : Trained kicker. French saddle. No stirrups.

of the instructors as horsemen. At the great carrousel of 1900, at Paris, for the first time the "écuyers" of Fontainebleau were seen side by side with those of Saumur and they stood the comparison without discredit. It was an instructive experience to see the riding masters of each school, mounted on magnificent horses, execute separately and then all together the most difficult movements of the riding school: Artificial gaits, jumping, haute école, work without stirrups on trained kickers and buckers, the traverse at the trot and every difficult evolution. Comparisons were plentiful, but admiration seasoned all.

It must not for a moment be imagined that these tricks are the object of French horsemanship. In no degree. They represent simply the trills, runs and high notes of the musician who wishes thus to show his complete mastery over his instrument before gliding into the melody that is to delight his audience.

These écuyers whose purpose in the riding hall seems to be to make a horse do the most difficult things with a repose of manner that betrays not the slightest effort, will break and train a colt, ride at or over anything and show on a suitable occasion all the dash desired by the most exacting.

An American officer of artillery can hardly conclude this description without making some observations applicable to his own service and arm.

Are we fair, it may be asked, to the enlisted men and the horses of our field artillery when we give the officers who are to command them, no opportunity to learn anything more than the rudiments of riding? Even if a majority of our artillery officers were graduates of West Point, it is idle to pretend that they come from the Academy with a knowledge of the horse sufficient to equip them to take charge, even under a good captain, of a platoon of field artillery, instruct the new men and the green horses and have that knowledge of their business which ensures respect from the men and produces good results in the esprit of the battery.

I tried at some length in a report since published in the Cavalry Journal of January, 1903, to show why and in what respect the graduate of West Point is not equipped with the horse knowledge, the skill and the standards of horsemanship, necessary to a mounted officer called upon to drill and instruct his command. It is not fair to the young officer, to the enlisted men, or to the horses, it is a distinct evil to the service, that the graduate or recent appointee should have no preparation for his responsibilities before going to a field battery. Because he has learned to be a pretty good rough rider at West Point is no guarantee whatever that he knows enough about horses, their training, bitting, endurance or qualities, to be an instructor; because he can stick on and use his weapons does not make him a horseman or a judge of horses. A mounted officer, whether of cavalry or artillery, should be both.

Again, when we come to that large class of officers recently appointed to the artillery from the volunteers or civil life, the matter is still more serious. There is no reason to suppose that any great number of these men are horsemen, and even those who know how to ride would need at least a year two of training before they are fit to perform properly the very important duties of an officer in a field battery. It would certainly be bad management and destructive of all discipline to place an officer on duty with a battery and expect him to learn to ride after he joins it. Surely the enlisted men, the horses and the captain are entitled to be spared this ignominy.

Since all officers of artillery are liable to detail with a field battery, and since our system demands that practically all the subalterns in the arm should be, to a certain extent, prepared for this service, it would seem only intelligent, at this time especially when the numerous new appointees are still young and pliable, to look around and see how the younger officers of artillery can, from this time forward, be given a course in riding sufficient to enable them to serve with credit in a field battery, while at the same time not interfering with other equally needed instruction.

Can a more natural or more advantageous time be found for this work than when the officer is passing through the course at Fort Monroe?

It is presumed that within a year after being commissioned, all second lieutenants of artillery and as many of the recently appointed officers as possible, will be sent to the Artillery School at Fort Monroe. To give these men a course in equitation there, consisting of at least one hour mounted, five days in the week, and a whole day of mounted reconnaissance every other Saturday, would not interfere with their technical education, or take from study any time whatever. On the contrary, it would be a healthy exercise much needed under the conditions obtaining at Fort Monroe, and doubtless the student officers would eagerly accept the proposition. Those who have passed through West Point would be glad to continue and perfect their horse knowledge, and the appointees from civil life would surely hail an opportunity to learn military riding.

But the instructors and the horses must be first-class and selected for the purpose. It is not only that riding must be taught, but there must be created in the student's mind a good standard of horsemanship and a high ideal of what an officer's mount should be. The great trouble with our mounted service to-day is that it is suffering from having had for long years too low a standard in the matter of mounts both for men and officers; the result is that not one officer in twenty owns a really fine cavalry horse, the vast majority are wholly contented with a most indifferent animal, and perhaps one-half do not own a private horse at all. This is largely due to the poor examples of horseflesh set before our future officers at West Point. All their riding has been done on miserable "plugs," and if they aspire to something better it is mostly a vague instinct that prompts the feeling instead of a keen desire founded on knowledge and habit. To this man the idea of paying from three to five hundred dollars for a horse, the idea that this is his right and his duty to himself and the service, presents itself as might the thought of buying a house in Fifth Avenue. And yet it *is* his right and his duty.

These bad conditions must not be repeated at the post graduate schools. If Fort Monroe is provided with the means of giving riding instruction, the horses should be selected as are those at Fontainebleau. There should be good types of the thoroughbred and the cross country horse that the students may have their taste and their knowledge formed by riding good horses. A few common hacks could be provided for the absolutely ignorant to learn on.

It is in no sense useful that any field artillery instruction should be combined with this course in equitation. The thought should be to teach men to ride, to know the horse, and as far as time will permit, to train him. To this end, each year a few colts, two and a half years old, should be bought for the school and trained by the instructors and students under the instructor's eye, that some knowledge may be had of what training a saddle horse means. These animals would later be useful additions to the stable, replacing those condemned, and officers who had ridden such horses for a year would not be ever again content with a poor mount. To have a good one is always within his power if he wants it badly enough.

If the French War Department, with all its difficulties in making both ends of its budget meet, can afford to keep 490 horses at Fontainebleau, many of which cost from $300 to $600, we, with all our wealth, might do at least half as much.

The cost of installing a riding school at Fort Monroe would be less than in most places, and a little more than what is necessary to provide the horses, equipments and grooms. It is possible that some of the present buildings would do for stables, for a time at least. Then, the climate of that region is such that an open air riding school, or carrière, could be used nearly the year round, and give far better satisfaction than a hall. In time, simply as a protection against rain and sun, a shed could be built over a smaller carrière for use in very bad weather. But it is important to begin (if we must, as usual, do so in a small way) at the right end, by spending, not for buildings, but for horses, and good ones at that.

If it be suggested that Fort Riley is our school for mounted artillery officers, and that, therefore, the above scheme is unnecessary and a duplication, I think a moment's reflection will be convincing that such is not the case. If we suppose that, with a modern organization, we have two groups of three batteries of four guns each, or six batteries in all stationed at Fort Riley and constituting the Field Artillery School, the officers would number roughly 30. As there are 455 officers of artillery, it is evident how impossible it will be for any large proportion of them to receive instruction at Fort Riley, even if it were intended that all artillery officers should go through that school.

But the object of the Fort Riley School is not to teach riding, but many other things that pre-suppose a thoroughly good education in horsemanship; on the other hand, Fort Monroe is, or should be, a school of preparation for service at Fort Riley, as well as at other artillery posts, and a course of riding instruction at Fort Monroe would prepare those officers, who will later go to Fort Riley, and aid in the selection of the most promising subjects for that detail, as well as for the detail to other field batteries. An officer who, at Fort Monroe, had not shown real aptitude for horsemanship, should not be detailed for a field battery until after those who had shown aptitude. This would often mean not at all.

It is more than probable that when the Field Artillery School is established on a firm basis at Fort Riley, and especially when the Cavalry School there is developed into what it should be—a school of equitation as well as of cavalry methods—the commandant of the Field Artillery School will inevitably create a class of higher instruction in horsemanship for the benefit of the 30 or more officers in his school. If especially good horses are given to Fort Riley for instruction purposes, such a class is bound to be developed if the officers have to do it voluntarily, and this class, both in the Cavalry and the Artillery Schools of Riley, will be in time the fountain of inspiration for the mounted service of our whole army, just as Saumur is for the French army. Officers who have distinguished themselves as horsemen at the Field Artillery School would naturally be selected as riding instructors at Fort Monroe, and thus unity of method would be assured to the whole mounted service.

It seems indisputable that the efficiency of the arm demands that a taste for horses and the practice of riding should be encouraged in the artillery. The fact that so much of an artillery officer's life is spent in coast battery service where mounted work is not demanded, makes it all the more important that in his youth he should have gone through a thorough course in equitation. He cannot outlive these lessons, he is most likely, indeed, to be led by them to practice riding for its own sake; thus when suddenly called upon for service with mounted troops he needs only a little training, and, as in swimming, the old trick comes back to him.

This needed instruction can be given with the greatest profit at Fort Monroe, since all artillery officers must pass through that school, since they generally go there very young and since at no time would they profit more by the instruction than when it comes as a relaxation after the day's confinement and study.

If it be suggested that the instruction in all that concerns the horse given at West Point, makes a course in equitation unnecessary at Fort Monroe, I can only ask those who hold this opinion to read the paper on this subject published in the Cavalry Journal of January, 1903. Leaving aside the fact that most of the present lieutenants of artillery have not had the benefit of West Point riding instruction, a perusal of the arguments offered in the paper above referred to will, it is believed, be convincing that West Point does not graduate accomplished horsemen in the sense of the word applicable to an officer, instructor of his platoon. If the writer had any lingering doubts on this subject, they have been dissipated by the generous testimony of very many cavalry officers supporting the accuracy of his statements.

A LECTURE TO CADETS ON THE USE OF REFERENCE BOOKS.

Prepared by direction of the Superintendent U. S. M. A.

BY EDWARD S. HOLDEN, Sc. D., L.L.D.

Librarian, U.S.M.A.

INTRODUCTORY NOTE.

By direction of the Superintendent lectures are given to Cadets of the U. S. Military Academy upon the arrangement of the Library, the use of Reference Books, the methods of recording information on cards or otherwise, etc., etc. The following pages represent a lecture on Reference Books etc. delivered to the Third Class U. S. M. A., September 12, 1903. The information it contains is useful to everyone who has occasion to consult collections of books, to officers as well as Cadets. It may therefore be of interest to graduates of the Academy in general. It is here printed by the courtesy of the Editors of the ARTILLERY JOURNAL.

Many matters of importance have been omitted for lack of space, but enough is given to serve as a basis for further inquiry. The habit of using books must be acquired at the Academy if at all; and every Cadet should, if only for the sake of his future usefulness, familiarize himself with its Library. Thorough knowledge of the sort will be of the greatest aid in his career as an officer, as well as a source of the highest pleasure for his whole life.

For out of the olde feldis, as men saieth,
Comith all newè corne, fro yere to yere,
And out of oldè bokis, in gode faieth,
Comith all this newè Science, that men lere.

THE LIBRARY OF THE UNITED STATES MILITARY ACADEMY: 1777–1903.

History: In the year 1777 Congress authorized the formation of a "Corps of Invalids" to be composed of veteran soldiers which was "to serve as a military school for young gentlemen previous to their being appointed to marching regiments." The Corps was organized at Philadelphia under the command of Colonel Lewis Nicola, its chief, who was a man of science, a member of the American Philosophical Society, etc. In 1781, at the request of Washington, the Corps was ordered to West Point. Its school was known as "the Military Academy at the Army." Provision was made for establishing and maintaining a library for the school by assessments upon the monthly pay of the officers of the Corps. This library was the parent of the Library of the United States Military Academy at West Point.*

The library was housed in the "old" (that is, the second) Academic building from 1815 until it was destroyed by fire in 1838. The lines of the foundations of this building may be seen on the Plain in any dry season, north of the trees in front of Cadet Barracks. The books were then moved to the dining-room of the Hotel, and from thence to the south end of the "old" (that is, the third) Academy. The third Academy stood on the site of the present Academic Building. In 1841 they were moved into a part of the present Library building, where they remained until 1899, when they were moved to a large room on the ground floor of the "new" Academic Building (the present structure) some of the least used volumes being stored in Memorial Hall. In 1901 all were once more more moved into the Library Building,

A building to contain the Headquarter offices, the Department of Natural Philosophy and the Library was completed in 1841 at a cost of about $50,000. In 1899 the sum of $70,000 was appropriated for its renovation. Furniture and book-stacks were provided in 1901 at a cost of $15,000, and the new building was occupied in October, 1901.

Librarians and Assistants: Officers of the Academy, usually Professors, were appointed as Librarians from 1802 until 1902, when a Librarian was appointed from civil life.

The Assistant Librarians were enlisted men from the beginning until 1894, when Dr. Otto Plate was appointed, who served until 1901. Under his care the present card catalogue system was adopted and the Library was improved in very many respects.

Congressional Appropriations: Acts of Congress have appropriated for the increase and expense of the Library, exclusive of salaries, during the years 1830-1903, the sum of $126,889.22.

The Library Books: The books of the Library have come from various sources. Colonel McRee and Major Thayer of the Engineers, were sent to Europe in 1815 to inspect fortifications, manufactories and military schools, and a sum of $5000 was allotted to them for the purchase of books, maps and instruments for the use of the Military Academy. The Marquis de Lafay-

*See the map of West Point in 1783 in the frames at the North window of the Library.

ette is said to have presented a large collection also. They are probably the books bound uniformly in calf with side titles

U. S. MILITARY ACADEMY,
WEST-POINT.

A considerable number of our books came from the sale of the library of the Jesuit College in Paris.

An Act of Congress of 1856 provides that a copy of each Senate Document shall be deposited here, and our collection of Government Documents is very full (about 4000 volumes) though many blanks still remain to be filled.

Catalogues of the Library: The first catalogue of the Library was printed in 1822, and included 830 books. The Library contained no work of fiction at this time. Since this date the number of books, pamphlets and maps has increased to about 50,000.

The printed catalogue of 1882 (1027 pages) will be found useful; as well as the printed finding-lists of Military Works (1892), of Biography and French History (1898), and of English Fiction (1901), prepared by Dr. Plate. The most important aid in using the Library is, however, the card-catalogue.

Card-catalogues: Every book is represented in the *Author-catalogue* by at least one card. The names of biographees are also included. The quickest way to find a book whose author is known is to search for its card in this catalogue. The letters U. S. M. A. after an author's name indicate that he is a graduate of the Academy.

The *subject-catalogue* contains the names of the topics treated by the books of the Library; and one volume may be represented here by a dozen or more cards. The *titles* of all important books are also included in this catalogue. For example: the volume

> Savoye (Charles de): Règlement sur le service des armées en campagne annoté d'après les meilleurs auteurs.........ouvrage approuvé par la Comité d'Etat-major de France. Quatrième Edition. Paris, 1875, 1 vol. O. pp. 786.

is represented in the author-catalogue by one card, and in the subject-catalogue by cards under the *catch-words*: Organization of armies: General Staff: Artillery, General Staff: Engineer General Staff: Military Intendence: Supply departments: Orders: Orderlies: Depots: Camps and cantonments: Regulations: Army of France—its organization and administration: Police guards: Pickets: Grand Guards: Detachments: Reconnaissances: Outposts: Reports: Partisans: Flankers:

Marches: Combat tactics: Tactics: Convoys: Subsistence: Transportation: Camp-followers: Safeguards: Sieges: Defense of fortified places: International Law: Laws of War: Martial Law, etc.; and also by its title; Règlement etc. etc.

N. B. Cards must not be removed from the catalogue-drawers by Cadets under any circumstances.

Arrangement of the Books: The books are arranged on the shelves under numbers which represent subjects. as follows:

000 to 100; General works, Cyclopaedias, Dictionaries, etc.

100 to 200; Philosophy, Metaphysics, Logic, Ethics, etc.

200 to 300; Religion, Religious History, etc.

300 to 400; Sociology, Political Economy, Law, Administration (Armies and Navies are under 355 to 359).

400 to 500; Philology, Languages.

500 to 600; Natural Sciences, Astronomy, Botany, etc.

600 to 700; Useful Arts, Engineering, Ordnance, Manufactures, etc.

700 to 800; Fine Arts, Architecture, Music, Sports.

800 to 900; Literature of all countries (American 810-819, English 820-829; French 840-849, etc.)

900 to 999; History, (European 940-949, North American 970-979, Philippine 997-4, etc.) and Geography.

Examples: Breech-loading guns are under 683.
Bridal customs under 392.6; Bugles under 738.46; Burglary under 343; Burgundy's history under 944.4; Business Ethics under 174; Infinitesimal Calculus under 517 etc. etc.

Periodicals have shelf numbers P1, P2, P3, etc. English *Fiction* has shelf numbers F1 to F9999. Books on *Biography* are numbered 8551 to 9254.

Books on *Military Science* which are kept in the Officers' Study have an M prefixed to their shelf numbers, as M 355.07.

Books lent by the Association of Graduates have the letter G before their shelf numbers.

The foregoing numbers denote the subject of a book, as 942= history of England; and all books under 942 relate to that history. To describe a particular book it is necessary to add something more, and the addition is usually (since 1901) of four figures which stand for the author's name. These four figures are taken from a printed table of which the following is a small part: Freed = 4201, Freedm = 4202, Freel = 4203, Freem = 4204, Freer = 4205 etc. Freeman's History of England receives a shelf number 942 (4204) and so in like cases. All books are placed on the shelves first in the order of their class numbers —as 942; second in the order of their author numbers—as (4204); that is alphabetically by authors, except in a few cases where the shelf numbers are so assigned as to arrange them chronologically or (occasionally) by countries.

LIBRARY ROOMS.

The Reading and Writing Room: contains the collections of books on Philosophy, Religion, Language, Fine Arts, Reference Books, the special collection of books on West Point and the U. S. M. A. and a number of military works. The writing table and its stationery are for the use of Cadets and visitors. Silence is required in this room, which is intended for study and reading only.

The Periodical Room: contains the current numbers of all literary and scientific periodicals. Most military periodicals are kept in the Officers' Study. A complete list of periodicals subscribed for is posted in this room. The library attendants will bring any desired volumes to readers. Silence is required in this room, which is intended for literary, not for social uses. The wall cases contain works on Biography, Literature, etc.

The Main Room: is intended as a general meeting-place, and conversation that will not disturb readers is allowed. Cadets are advised to show their visiting friends the Mss. displayed in the swinging frames near the north windows, and other objects of interest. Works of English fiction are arranged in the apse alphabetically by authors. All books of Travel and of History are in this room as well as the cases containing the latest books received. These books are arranged in the same order as the books of the general library. Cadets are advised to examine these cases frequently so as to know, at least by sight, the new books of each year. All rooms in the second story and the basement are off-limits to Cadets and to civilians.

Officers Study: The east room of the second story contains all professional military books except the duplicates which are displayed in the lower rooms. Cadets should consult the catalogues for desired books of the sort which will be brought to them by the attendants.

Map Room: The west room of the second story contains maps and charts. All are catalogued and will be brought to readers on request.

Care of Library Books: The attention of Cadets is called to the necessity for care in the handling of the books of the Library. They are Government property and for this reason alone Cadets should see to it that no damage is done to them. Many of our volumes are costly, and a considerable number are unique. All are freely open to readers, but only on condition that they are treated with respect. If they are roughly handled it will be necessary to cover the cases with locked doors.

Paintings and Statuary: The Main Room contains

1. a marble bust of Washington after Houdon.
2. " " " " Lafayette " ?
3. " " " " Napoleon " Canova (all belonging to the Academy) and
4. " " " " Napoleon by Canova lent by the heirs of Hon. James Kirke Paulding.

This same room contains five noble paintings by Sully as follows:

1. full length portrait of Jefferson.
2. " " " of Monroe.
3. bust portrait of Gen. Armistead, Inspector U.S.M.A. 1818-21,
4. " " " Gen. Macomb, " 1821-28,
5. " " " Gen. Gratiot, " 1828-38.

The Academy owns oil paintings of nearly all its Superintendents, which are displayed in the Academic Building, and Memorial Hall contains a great number of portraits and medalions of famous graduates.

There are besides, in the library

6. bust portrait of Gen. Totten, Inspector U.S.M.A. 1838-1864 by Weir,
7. " " " Gen. Scott, by Robt. W. Weir, Professor U.S.M.A. 1838-1864.
8. " " " Gen. Warren, by A. Lawrie.

The portraits of the Academic Board, 1802-1903, are to be removed to the Library shortly.

The Library owns two interesting oil paintings of West Point by George Catlin (1828) and a water-color of the same subject (1800), the latter the gift of Mr. S. P. Avery of New York. These, with engravings, lithographs and maps of West Point are exhibited in the hallways. A number of plaster casts (busts) of classic sculpture were transferred to the library by the Department of Drawing in 1901.

Engraved portraits and photographs of graduates: The Library owns the Class albums of graduates since 1857 (with the exception of 1858-60-61-62-67-72-73-74) and a large number of groups and single photographic portraits and views. The Association of Graduates has a large collection of such portraits also. It is desired to obtain at least one portrait of every graduate.

Books relating to West Point: A special effort has been made to purchase every book and pamphlet relating to the history of West Point and of the U.S.M.A. and to collect and bind all books and Mss. of the sort already in our collections. The case devoted to this special department now contains 341 volumes. It is very important that the Library should own a copy of every book and pamphlet written by officers of the American Army and especially by graduates of the Academy, All such persons are earnestly requested to send to the Library a copy of every work published by them.

The best books on the History and Organization of the U. S. M. A. are by Park, Boynton and Farrow. The Guide to West Point by Tripp is often useful. The current history of the Academy is given in the Bulletins of the Association of Graduates U. S. M. A.

Periodicals: The list of all the periodicals received by this Library, by the Libraries of the Departments of the Academy, and by the Cadet societies (Y.M.C. A and Dialectic), by gift and subscription, includes about 300 numbers. It is posted in several of the Library rooms.

Military Manuscripts: All the Military Manuscripts belonging to the Academy have been collected and bound, and special efforts have been made to collect others relating to the history of West Point, of the Academy, of the Wars of 1812, Mexico, the Civil War, the Spanish-American War, the insurrection in the Philippines and the China expedition.

Among the most important manuscripts at West Point are

—Copies of all important War Department Mss. relating to the U.S.M.A. dated before 1838.

—The Records at Headquarters U.S.M.A., which are complete since 1838.

—The Cullum Mss. in the possession of the Association of Graduates U.S.M.A. These include many letters by Colonel Thayer, Superintendent of the Academy, 1817-1833.

—The Swift Ms., deposited in the Library by the heirs of General J. C. Swift, who was the first graduate (1802) of the Academy.

—The Ms. papers of Captain Alden Partridge, Superintendent U.S.M.A. 1815 to 1817.

—Many miscellaneous Mss. as well as Orderly Books kept at West Point between 1784 and 1829.

It is expected that the following series of Mss. will be deposited here.

—The Ms. papers of General George B. McClellan, U.S.M.A. 1846.

—The Ms. papers of General H. W. Halleck, U.S.M.A. 1839.

—A number of the Ms. papers of General W. T. Sherman, U.S.M.A. 1840.

—The Ms. papers of General W. S. Hancock, U.S.M.A. 1844.

—The Ms. papers of General S. P. Heintzelman, U.S.M.A. 1826.

—The Ms. papers of General J. M. Schofield, U.S.M.A. 1853.

—The Ms. papers of Gen'l Alexander Stuart Webb, U.S.M.A. 1855.

—The Ms. papers of Colonel Gratiot, Inspector U.S.M.A. 1828 to 1838.

Maps: The Library owns a large number of Maps and a special collection of maps (originals, photographs and copies) of West Point which is practically complete. A printed list of the contents of the Map-cases is posted in the Reading Room.

Bibliographies: The following Bibliographies are in Ms., on cards, in the Library, and can be consulted:

1st. A bibliography of West Point 1694-1902—its history, maps, views, etc. (about 1000 titles).

2nd. A bibliography of the U.S.M.A. 1776-1902 (about 3000 titles).

3rd. A bibliography of the writings of all the graduates U.S.M.A. from 1802 to 1902 (about 4000 in number) including lists of their portraits and references to their obituary notices (about 17000 titles). Routine official reports are not included in this list.

4th. A list of the names of all members of the Board of Visitors U.S.M.A. 1819 to 1902 (about 1000 titles).

5th. The ARTILLERY JOURNAL Bibliography of articles on military subjects printed in periodicals (serial) since 1896.

All of these should be examined by Cadets in order that they may know what sort of information is thus made available and how it is indexed.

The printed bibliographies of our collection are referred to in subsequent pages of this article.

How to look up a subject in the Library: The books of the Library are arranged on the shelves by subjects. A general view of any subject may therefore be obtained by looking over the volumes themselves. For special information it is best to consult the card catalogues. If the work of any particular author is wanted, as Darwin, consult the author-catalogue first. If the title of a book is known (and not the author) consult the subject-catalogue which also contains the titles of books. If only the subject is known consult the subject-catalogue. All books received since 1901 are catalogued under several catch-words. If a desired book can not be found, apply to the Library attendants.

Aids to Readers: The Library shelves contain many books of reference that will answer out-of-the-way questions. They are on the shelves under the numbers 028 to 030 and (for Literature) under 803. The Index volumes of periodicals will often give a needed clue. An astonishing amount of information (indexed more or less well) is to be found in the Almanach de Gotha (annual), the Statesman's Year-book (annual), Whitaker's Almanack (annual), the Almanacs yearly printed by the New York Tribune and World and very many other books of the sort.

Reference Books: Many questions can be answered at once by consulting standard reference books without going to original sources. For the convenience of Cadets a few of the more important are mentioned in the following pages under captions which name the subject of inquiry. The best books are mentioned in these lists and along with them others not so good but easily accessible.

Bibliographies and Indexes: The card-catalogue contains, under the catch-word *Bibliography*, a list of all such in the Library. For each there is a special card as:

DANTE: bibliography of his writings, etc.

It is worth while for Cadets to examine the cards in question and to obtain an idea of how readily required information may be found even on recondite matters; and also to remember that

Index-learning turns no student pale,
Yet holds the eel of Science by the tail.

Encyclopaedias: Haydn's Dictionary of Dates and the Century Cyclopaedia of Names (of persons and places) will be found useful in answering simple questions off-hand. For details, larger works must be consulted, as the International Cyclopaedia, with its year books; the Encyclopaedia Americana; the Britannica, with its supplements, (use the Index volumes); Larousse Grand Dictionnaire (in French—it is very suggestive but not always accurate) and its continuation; Brockhaus, Conversations-Lexicon (in German); and others. Cadets should be familiar with these books of reference, and understand something of the peculiarities and advantages of each one.

Cadets will find it to their advantage to look at articles in encyclopaedias that treat of the subjects which they are studying in the Class-rooms. An encyclopaedia is a book written by experts for the use of general readers. Every effort is made to render its articles accurate and clear and to give general and wide views of the subjects treated. It is precisely this kind of information that is needed by Cadets to supplement that acquired from text-books which are, necessarily, condensed and special and which seldom present the full history of a subject for lack of space.

The traveller who complained that he "could not see the forest for the trees"—which got in his way—is exactly in the position of a Cadet puzzled by special problems of Descriptive Geometry, Optics or Engineering, who needs to clarify his vision by getting away from specialties and to seek a large and general view. The encyclopaedias afford precisely such views. There are special encyclopaedias of Architecture, Economics, Railways, Money, Education, Music, Antiquities, Religion, etc. etc. etc. in the Library.

Military and Naval Encyclopaedias: Farrow's Military Encyclopaedia (3 vols.)

Hamersly's Naval Encyclopaedia, (1 vol.)

Encyclopédie des Sciences Militaires, (by a committee of officers of the French army—in French) is especially valuable and accurate.

Frobenius' Militär-Lexikon, (in German).

Bibliography of Military Art and Science: THE JOURNAL OF THE UNITED STATES ARTILLERY regularly prints an index to all articles appearing in all important periodicals on military matters. This index may be consulted in the JOURNAL itself or, more conveniently, on the cards of the U.S.M.A. library, which reproduce it. It is indispensable that every Cadet should familiarize himself with its classification and method during his stay at the Academy. Other Bibliographies of military subjects are noted in the card-catalogue under the catch-word Bibliography as well as under the special subject. Consult also, the War Department Catalogues of Military Works; Sources of Information on Military Subjects (Military Information Division); Catalogue of the Library of the Artillery School; Catalogues of the Libraries of the General Staffs and Military Schools of Foreign Countries.

The Engineer and Ordnance Departments, U. S. A. publish separate indexes to their annual reports.

Dictionaries: Each Cadet has an English dictionary in his room in Barracks. Dictionaries in nearly all languages will be found in the Library. Dictionaries of synonyms, Americanisms, slang, rhymes, Poetical and other quotations, etc., are owned by the Library. Every Cadet during his course should look over the books relating to the languages and history of the Philippine Islands. Anything learned of them here may come to be of high value to him later on. The safety of his command may depend upon knowledge of the sort.

Every officer who expects to serve in the Islands should understand the principles of Malay grammar. The Dictionary of Islam, the Koran, and other Moslem books should be read by every officer who expects to serve among the Moros of Mindanao. To govern them justly it is indispensable to comprehend their own ideas of justice which are singularly different from those that we inherit.

French Books: The power to read French readily is easily acquired and is a never-ending source of pleasure. Most military books of importance are translated into English or French soon after their appearance; with a reading knowledge of the two languages at command nearly all Science is open as well as vast fields of Literature. Cadets are advised to lose no opportunity of perfecting themselves in the reading of French and of Spanish as well.

Biography: The works on Biography are arranged on the shelves (in the Periodical room) alphabetically by biographees.

Consult among other works of the sort in the Reading room:—

Appleton's Cyclopaedia of American Biography. (7 vols);

Dictionary of National Biography (English) (64 vols.); look at its Index volume first;

Michaud's Biographie Universelle (45 vols.);

Who's who in America (annual);

Who's who (in England) (annual);

The Century Cyclopaedia of Names (persons and places) (1 vol.);

Gidel and Loliée's Dictionnaire des Ecrivains (1 vol.);

Vapereau's Dictionnaire des Contemporains (1 vol.);

See also the card-catalogue under the titles: Autographs, Mss., etc. as well as the personal name.

Government officials of the United States:

The Official Register of the United States.

Congressional Directory (annual).

Officers and Ex-officers of the United States Army:

Powell's list of officers U.S.A. 1776-1900.

Cullum's Register of Graduates U.S.M.A. 1802-1902 (4 vols.)

The Annuals of the Association of Graduates U.S.M.A.
Army Registers (annual).
Army Lists (monthly).
Rosters of Troops serving in Departments (usually quarterly).

Cadets of the United States Military Academy:

Lists of Cadets admitted U.S.M.A. 1802-1901 (1 vol.).
The Cadet Register (annual).

Officers and Ex-officers of the United States Navy:

Callahan's List of Officers U.S.N. and Marine Corps 1775-1900, (1 vol.)
Hamersly's Records of living officers (1902), (1 vol.).

Officers of Foreign Armies:

See the Army Lists of the different countries (annuals).

Portraits of Officers of the U. S. Army and Navy:

Hamersly's officers who served in the Civil War. 2 vols (1892).
Hamersly's officers who served in the Spanish-American War. 1 vol (1902).
Hamersly's Companions of the Military Order of the Loyal Legion. 1 vol. (1901).
Portraits owned by the U.S.M.A. are catalogued under the name of the person and also under the word Portrait.
A list of portraits owned by the Association of Graduates U.S.M.A. is printed in its Bulletin No. 3 (1902.)

Civilians in the United States:

Who's who in America (annual); and city directories.
The Social Registers of New York, Boston, etc. (annual).
Appleton's Cyclopaedia of American Biography.

Civilians in England:

Who's who (annual),
Whitaker's Titled Persons (annual),
The Dictionary of National Biography (first consult its Index volume).

Civilians in France:

. Paris-Hachette.

Quotations, Americanisms, Proverbs, Slang, etc:

Bartlett's Familiar Quotations, King's Classical and Foreign Quotations, Allibone's Poetical and Prose Quotations (2 vols.), Wood's Quotations for Occasions, Bartlett's Dictionary of Americanisms, Barrère and Leland's Dictionary of Slang, Christy's Proverbs and Maxims of all Ages (2 vols.), are often useful.

Geography:

Since 1902 every room in Cadet Barracks is supplied with a good atlas.

Consult Lippincott's Gazetteer (1 vol.)

St. Martin's Dictionnaire de Géographie (8 vols.)

Stanford's Compendium of Geography (14 vols.)

Stieler's Hand Atlas (in German) and other atlases.

Guide Books to various countries: Those of Murray, Baedecker and Hartleben are among the best.

Consult also the card-catalogue under the headings *Military Geography and Maps.*

American History:

Larned's Literature of American History (1 vol.) is a very convenient manual, and

Sabin's Bibliotheca Americana (19 vols.) is exhaustive.

Winsor's Reader's Handbook of the American Revolution (1 vol.)

General History:

Larned's History for Ready Reference (6 vols.)

Adams (C. K.): Manual of historical literature.

The Annual Register (of events) has been published annually since 1748.

Indexes to United States Government Documents:

General Greely's Public Documents of the first fourteen Congresses 1789-1817.

Poore's Descriptive Catalogue (1 vol) of the Government Publications of the United States 1774-1881, with index.

Table and index to the Congressional series of United States public documents (XV-LII Congresses).

Several of the Government departments, as the Bureau of Education, the Coast and Geodetic Survey, the Engineer Department, the Ordnance Department etc., have printed indexes to their own publications.

Indexes to Scinetific Literature:

The Royal Society of London publishes an author-index to all important scientific papers printed in periodicals since 1800, and has begun the publication of annual subject indexes of different branches of science, as astronomy, botany, and the like. There are also many special indexes to scientific literature which can be seen by consulting the Librarian, among them the following:

Lalande: Bibliographie Astronomique (1803).

Poggendorff: Biographisch-literarisches Handwörterbuch (3 vols.)

Wislicenus: Astronomischer Jahresbericht (annual since 1899).

Houzeau: Vade-mecum de l'astronome (1862).

The Best Books:

Porter's Books and reading (1 vol); Sonnenschein's Best Books (1 vol.) Baker's Guide to the Best Fiction (1 vol.); A.L.A Library Catalogue (1 vol.) and many other volumes of the sort give lists of the best books. It may be said in general that Cadets cannot go wrong in reading any book in the Library that interests them.

The Librarian of Harvard University has this to say on the subject of courses of reading: "I am no great advocate of courses of reading. It often matters little what the line of one's reading is, provided it is pursued, as sciences are most satisfactorily pursued, in a comparative way. The reciprocal influences, the broadening effect, the quickened interest arising from a comparison of sources and authorities, I hold to be marked benefits from such a habit of reading. It is at once wholesome and instructive, gratifying in this pursuit, and satisfactory in the results." With this view I thoroughly agree.

Every military man should be familiar with Military History, and especially with the lives of great soldiers of his own country. Cadets are earnestly advised to read the biographies of Washington, Scott, Grant, Sherman, Sheridan, Thomas, Warren, Hancock, Schofield, Lee, Jackson, Longstreet, and others, as well as the lives of the great commanders of Europe from the century of Alexander the Great until our own. In no other way can they acquire that intimate and exact knowledge of military affairs which is essential to every military man.

The weekly and monthly Army journals should be looked over regularly. Cadets are on the threshold of an honorable service. Everything that relates to the past and present history of the Army will be interesting to them.

The Army of the United States 1789-1896 (1 vol.)

Barrie's Army and Navy of the United States (3 vols.)

Legislative History of the Staff Departments U.S.A. 1775-1901 (1 vol.)

Birkhimer's History of the Artillery U.S.A. (1 vol.)

The history of the various regiments of our own army.

The history of foreign armies and regiments is treated in books of the same sort, of which the library owns a large collection.

To keep abreast of the history of the times Cadets should regularly read a weekly journal: Harper's Weekly, The Nation, The Outlook, and many others, have summaries of each week's events. The American Review of Reviews and other magazines print monthly summaries of the same sort. It is doubtful whether it is worth while for a Cadet to use any considerable amount of his very limited leisure time in reading a daily newspaper. It will, in any event, be sufficient to note the most important matters only. If they are, in fact important, they will be discussed again and again in the weekly and monthly magazines. The latter should be looked at each month, and read when they really interest, and only then. It will be best to give most of the very short time available for discursive reading to books. The Virginians, Faust, the Thoughts of the Emperor Marcus Aurelius and a hundred other great books of past centuries have far more to do with present realities than most of the articles in most of the magazines; and this is true in the strictest sense. The general principles of life are taught in the world's great books. In the long run success will come to a life founded on general principles, and will be withheld from lives founded on temporary expedients.

Information respecting books: is to be sought in special treatises, in encyclopaedias and bibliographies and in the printed catalogue of Libraries like those of the Astor, the Peabody, the British Museum and many others. The Catalogue of the London Library (1903) is a catalogue of 220,000 well chosen books arranged under authors' names. The British Museum subject-index to Modern Books (1880-1895) will often be found useful, as well as Sonnenschein's Best Books and Reader's Guide (3 vols.)

Indexes to Periodicals:

Poole's Index with its supplements gives all the articles printed in a large list of periodicals from 1802 to date. To find an article enter the Indexes with the subject of the article as a catchword.

The Annual Literary Index continues Poole's Index in yearly volumes for 137 English and American periodicals from 1892 to 1902.

Several weekly and monthly magazines publish indexes at intervals, as the North American Review, Popular Science Monthly, Atlantic etc.

"The Library is the principle of life of every institution of instruction, whose tone can never rise higher than the means for teaching its instructors."

—*Report of the Board of Visitors U.S.M.A. 1826.*—

NEW FORMS OF ARMORED FORTS. *

BY VICTOR TILSCHKERT, COLONEL IN THE AUSTRO-HUNGARIAN ARMY.

TRANSLATED FROM THE GERMAN † BY MAJOR JOHN P. WISSER, ARTILLERY CORPS.

Modern accuracy of artillery fire no longer permits of crowding guns close together in a fort with strongly profiled ramparts without armor protection, because the easily attained hit after hit against so large and well marked a target will in a short time produce such destruction in the work that any further fire action on the part of the latter is out of the question.

This element of weakness was exhibited by the South Forts of Paris under the Prussian fire. On the 5th of January the fire of the first batteries (1-17) was opened at 8:30 a.m., and at 12:30 p.m., Fort d'Issy was silent. The French (according to *R. V.* in his essay *"Die Festungen und die Kriegführung"*) were completely surprised; a hail of shell fell in the terreplein, so that the unprotected barracks were soon uninhabitable. In two hours 24 guns were dismounted. The passage ways in the ramparts were rendered impassable by the openings made by the shells. It was impossible to get the cannoneers to the guns. Fort d'Issy was destroyed in two hours, says Admiral Roncière, the Commander of the Defenses of the South Front. Forts Vanves and Montrouge fared in a similar way. *On the other hand, the batteries hidden in the terrain,* and lying behind the line of forts, *fired on, and remained uninjured to the end of the bombardment.* Even under the subsequent fire from the more advanced artillery position (batteries 18-23, which opened fire on January 11th,) at 1094 yards from the forts, although the silencing of the forts was completed, *the secondary batteries could not be silenced.* But what will be the effect on such a work with high relief and bare rampart to-day, when 9.45-inch high explosive shell carry their destructive action into it! Even the armored turrets built into such forts will probably experience serious surprises.

The mass of projectiles striking in the vicinity of the cupolas on the *mass of concrete,* will throw pieces of wall and fragments of projectiles against the cupolas, their ports and openings, and against the projecting muzzle of the pieces, so that on one or

* This article presents some of the latest views of European military engineers on *land fortifications* of a permanent character, and will be of use in indicating to us some of the methods of fortifying seacoast forts on the land side, or at least in illustrating what the rest of the world is doing in this line. It is also possible that some of the ideas suggested by these new forms of *land* fortifications may find application, under particular circumstances, even in *seacoast* fortifications. J.P.W.

† Neue Formen der Panzer-Fortification. Von Victor Tilschkert, k. u. k. Oberst. Wien: L. W. Seidel & Sohn. 1902. Price 3 marks (90 cents with postage).

other of the armored turrets there will soon be disturbance in the movement of the cupola or the piece. And what can the rampart designed for the infantry, or the narrow communications for the latter, expect in the way of effect of fire, if this be true for the main rampart! From this consideration, it is evident that, even for guns under armor, an isolated position, with wide intervals between, is the most advantageous, which, *when combined with a low parapet*, offers a target not very prominent, and therefore difficult to hit.

In regard to the value of the older, strongly profiled types of forts, R. V., in the study above referred to, expresses himself as follows regarding the Paris forts:

They have proven themselves entirely inadequate for resisting an artillery attack. In the north, south and east attack the forts were *put out of action in a few hours*. The guns could no longer be served, the garrison crawled into the cellars, and all action toward the exterior was out of the question. On the other hand, the German guns, the emplacements of which were placed far apart, and adapted to the configuration of the ground, had easy work, for they were difficult to take under fire. In regard to their fire on the south side, an eye-witness writes as follows in the *Spectateur Militaire*, according to the essay above mentioned:

"On the plateau of Chatillon, near Meudon and Fontenay, flashes appeared at regular intervals; white smoke clouds, which disappeared quickly, alone marked for a short time the position of the batteries, then the firing disappeared altogether, and it was impossible to tell where it came from, so that it was impossible to contend properly against these batteries, so carefully hidden in the accidents of the ground".

The eye-witness consequently approves of the modern method of fortification, and writes:

"In imitation (but very wide of the mark) of this dispersion of the fire, as accepted by the Prussians, we have accumulated in 2 or 3 forts (on one front) such an enormous number of guns, that a single hostile shot can put several guns out of action at the same time." Accepting this opinion, R. V. says:

"The interior area of the forts, therefore, constitutes a veritable witches' cauldron of bursting shell, making all stay there impossible. It is incomprehensible, after the experiences of Paris and the improvements in destructive material, how we can continually come back to the old fortification scheme, which finds its ideal in a continuous girdle of forts. Even the strengthening of these by iron armor will not change their character.

What can be better, in principle, than to apply to fortifications the same idea that gives the attack its superiority, namely: *Broad, widely extended inter-spaces, such as the great numbers of the forces engaged require anyway, and batteries hidden in the configuration of the ground, and scattered over wide areas*".

Lieutenant-Colonel Schumann, of the Prussian army, the well known authority on armored forts, endeavored to meet the difficulties in the old forts by separating the armored guns and arranging them in small groups; he found an able advocate and a worthy successor in Captain Meyer, of the Swiss army, who went even farther in this matter. The Bavarian General Sauer proposed only two lines of isolated armored cupolas (with 500-yard intervals) in place of the forts, but his adversaries opposed this on the ground that fire control and direction was impossible by this system. On account of the difficulty of protecting the guns, in their widely separated positions, against sudden assault and capture, modern engineers were not prepared to go farther in the matter of separating the guns and making their emplacements conform to and take advantage of the configuration of the ground, than to take the heavy guns out of the forts and place them in separate adjoining batteries. Both forts and batteries still retain the characteristics of the older constructions, although a number of efforts have been made to overcome the objections to them. For example, they now have low reliefs, and guns under armor are widely separated. Some engineers, like Colonel Leithner, also divide the close range guns into groups, so that, instead of one gun by itself, 2 or 3 are placed together, which can more easily be made to conform to the configuration of the ground, and therefore, like the batteries of attack, show less prominent targets and command the ground better.

In a system in which the guns of a fort are behind a continuous parapet, the interval between guns is necessarily limited, because the extent of the enciente must be kept within reasonable bounds, in order to avoid too great cost of construction as well as too large a garrison to man the parapet. Even if the flanks are made very short (as is now largely the custom) the gorge or rear of the emplacement will still necessarily increase in length in proportion as the front becomes more extended. The gorge, moreover, if closed, acts as trap to catch projectiles, and therefore increases the effect of the bursting of shells on the front line. In the narrow interior of these modern forts the explosive effect of ecrasite shell will soon make itself felt, and render the communications in them, leading out of the casemates, particularly on the steep and narrow ramps, impracticable. Fragments of concrete will soon impede the way. Moreover, the hard concrete, with its weak and readily broken edges, will increase the effect of the shell. An extended line of gun positions, utilizing the configuration of the ground, such as the system with attached, adjoining batteries, does not offer *all* the disadvantages of the closed forts (with continuous enceinte).

An extended line of guns, utilizing fully the configuration of the ground, is therefore of great advantage in protecting them against hostile fire. The system of Leithner, placing the works in groups at supporting distance, shows a tendency toward the linear system, but these works, on account of the weak obstructions involved, offer no security against direct assault, and also possess many of the disadvantages of single works. A linear arrangement, satisfactory in this respect, can only be attained *when each gun is separately (or when the guns are in groups of not over 2 or 3) mounted in a hollow structure safe against assault, from which like a small block house, the enemy, after arriving at close range, can be met with infantry or machine gun fire.* In case each gun has such a position, insured against assault, and capable of resisting the enemy's artillery fire, then and then only is the linear arrangement possible. The guns may be placed in long or short lines, separately or in groups. In this case their arrangement in long lines offers only advantages.

In order to obtain possession of a point of support arranged in this linear form, and composed of a group of separate guns individually safe against assault, the attacker will be compelled to demolish or capture (that is, take by storm) *each one separately*. The mounting of the guns in independent armored turrets offers the possibility of such a desirable linear arrangement. It is only necessary to place the armored cupola for the gun on a sufficiently high iron tower (instead of placing it on masonry as now customary) and the security against assault is attained. In this position the gun can act toward all sides, front, flanks and rear; and it can only be taken by assault after the enemy has made a wide enough breach through the armor walls, and even then it will still be supported against attack by the infantry or machine gun fire of the lower floor of the armor tower. *With a view to exposing only a small portion of the armored turret or tower to direct fire, it is placed free behind a cover of earth parapet.* Behind it are grouped several such armored towers, sufficiently separated to diminish the effect of the enemy's fire, but close enough to facilitate fire direction and control.

The most advantageous arrangement is in a ditch, covered in front by a glacis, over which the tower guns fire. But they may also be placed behind ordinary parapets with a ditch in front. When placed in a ditch the surrounding space in the ditch is the place for wire entanglements, leaving only a narrow way for covered passage from gun to gun, for fire control and to relieve the detachments. Or a narrow ditch for communication between the separate towers may be constructed behind the ditch serving as obstruction.

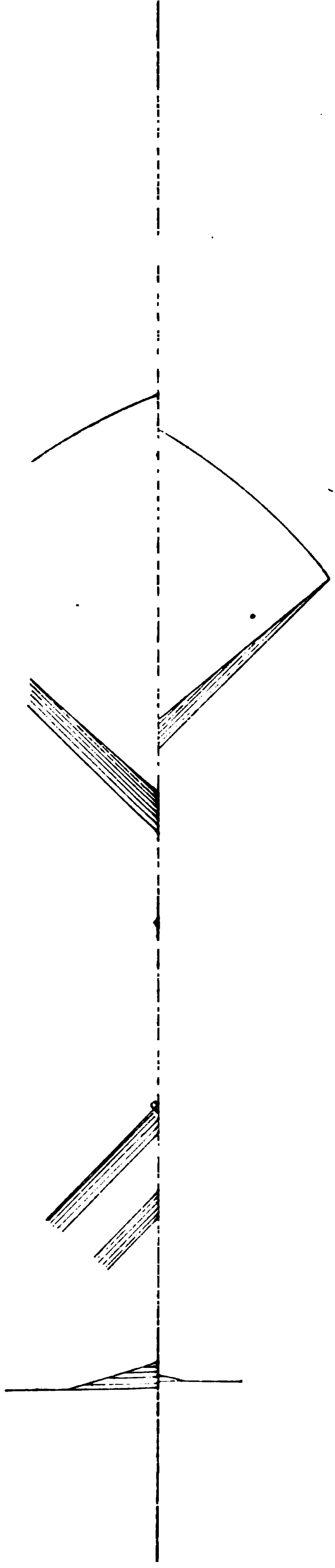
In figure 1 is sketched the profile of such an isolated armored tower secure against assault, representing at the same time an iron block house with 3 stories, or a narrow iron Montalembert tower. It is located in a ditch 3 metres (9′ 10″) deep, and is covered by an earth glacis 2 metres (6′ 7″) high, which latter, conforming to the shape of the tower, surrounds it on its front in a curved form.

Figure 2 shows the ground plan. It was assumed in this case that the enemy's guns entering into action against the tower could only be placed in a sector of 90° in front of it. With a range of 1500 paces they would have to take up a position about 1125 paces to one side of the capitol of the tower, which would bring them to 1125 paces from the neighboring works. The flanks of the tower are consequently at an angle of 90° to each other, and unite in rear in a circular arc of 90°. In these sides, which can be hit only by glancing shots, the tower walls are kept vertical. The ground plan of the armored tower is, therefore, a 90° arc rounded at the corners. Under certain circumstances the sector may be greater, even up to 180°, and in mountainous country may even show its front profile on a complete circle of 360°.

Vertical walls, visible from the side of the enemy, even when made of the best armor, are not admissible, because of the possible density of the hits on them and their consequent rapid destruction. The visible, or exposed, parts of the tower, wherever projectiles moving with high velocity can strike, must be inclined at 45°, at which angle even cast iron cannot be breached by steel projectiles hitting close together or even several in the same spot, since it was shown by experiment that 40 steel projectiles (15 cm., or 5.9-inch) fired against the armor plates of an Austrian armored cupola, made of Skoda cast iron, held in position at an angle even greater than 45°, could not appreciably injure the latter. The front surface of the armored tower at its upper portion is therefore inclined at an angle of 45° to the horizontal, as low down as projectiles can pass over the glacis and reach the tower at a slope of 1 on 3. Brialmont protects concrete casemates, not armored, for a slope of 2 on 5. Projectiles striking at a steeper angle, on account of their small terminal velocity, are no longer sufficiently effective against the armor, which can therefore be kept vertical and of comparatively small thickness in its lower part. Since, in the case of towers, even at the upper level of the vertical part the angle of fall of the projectiles is at least 20°, and with reduced velocity and against iron, there is nothing to fear for the tower walls. In order to make it difficult to climb, or surmount, and to preserve the necessary space for several stories in the tower, the vertical wall is made 3 metres (9′ 10″) high outside and 4 metres (13′ 1″) inside. It is therefore buried 1 metre (3′ 3″) deep in the concrete foundation, which also gives it the necessary stability against the turning moment of striking projectiles. The cupola of the tower cannot therefore be scaled except by the use of ladders, since the rear opposes a vertical wall 6 metres (19′ 8″) high, the sides, one of from 3–6 metres (9′ 10″ to 19′ 8″) high, and the front, one 3 metres (9′ 10″) high, above which is an iron surface, inclined at an angle of 45°, 5 metres (16′ 5″) high, as an obstacle.

On the latter no foothold can be obtained even with leather boots, unless a ladder is used. But how can the enemy mount on the cupola, isolated as it is and flanked by the neighboring towers and defended by its own fire from the casemates? And even should this be accomplished, and one or more men reach the cupola, how can they force the tower unless they have time to lay and ignite a strong explosive charge at or near the port? Even a blank shot would sweep them away from the port, and seated on the cupola they can hardly hold out very long against the fire of adjacent guns, and can be easily reached with a revolver or a lance through one of the small ventilating openings. Preparations for setting up ladders at the foot of the tower can be easily interfered with by means of revolver shots, hand grenades, etc., from the tower casemates. Loop-holes for revolvers and rifles are therefore cut not only on the flanks and rear, but also on the front of the tower. In the latter position they should be located at the upper edge of the vertical wall, and protected against gun projectiles. The tower contains in the uppermost part the cupola space, and below this two tiers of casemates, the middle tier being armed on one flank with a machine gun, and on the other with a rapid-fire gun (2.3-inch) or with a 4.7-inch rapid-fire howitzer, which guns replace in modern works the

348-1



flank defense and counterscarp guns of the older works. In some towers it will be sufficient to place on each flank four infantrymen with rifles, or with 1.5-inch rapid-fire guns. With this armament the separate towers effect a mutual flanking. Or, if necessary, four infantrymen can be used, in the ground floor, on each flank for flanking purposes.

Consequently, the armament of the tower usually consists of: 1 rapid-fire gun or howitzer in the cupola, 1 rapid-fire gun or howitzer, together with 1 machine gun, in the middle casemate, 8, or in some cases 16, infantry rifles, or a few 37 mm. (1.5-inch) machine guns on the flanks, and 4 revolvers in front of the tower, sweeping the base of the latter from above.

Compared with the masonry towers of Montalembert or Archduke Maximilian, this tower shows a considerably smaller ground plan to the latter, for example, it stands in the ratio $\frac{1}{80}$ or less, although the latter tower had 11 guns on an *open* platform and 4 guns in the upper tier.

The tower is very roomy and has on its two lower floors about 40 square metres (430 square feet) of floor space, sufficient for accommodating a garrison of 20 men. The latter are only temporarily detailed to the tower, the men being permanently quartered in bomb proof casemates alongside of or behind the groups of armored towers. On the cupola floor there is plenty of room for a large supply of ammunition. Cooking cannot be done in the tower, since there is only one small hearth—using petroleum or kerosene as fuel—built on the lowest floor, for warming vegetables or canned meats. In a small board structure an earth closet is installed. Iron winding stairs or ladders serve as means of communication from floor to floor. The tower, therefore, constitutes a perfectly complete and independent defensive object, secure against assault, which may safely be left to take care of itself for a certain time. It commands with its cupola guns the entire surrounding terrain on an arc of 360° (or entire circumference) and with machine guns or infantry fire protects the flanks and gorge (or rear.) On the front the attacker is kept back from the tower wall by means of revolver fire. Neighboring towers mutually flank one another.

Only the low cupola and the inclined upper surface of the armor, about 4 square metres in vertical elevation, are exposed to direct fire, and the tower therefore presents a much smaller target than the armor of the often proposed and recommended armored batteries, even if only the shields in the inclined cut stone front are taken into consideration. The entire exposed front, however, is several times as large as that of the tower, and the latter, being curved in the horizontal plane, is also far more difficult to breach.

Experiments in Austria have shown that in Pilsen such a cupola of Skoda cast iron, although struck by about 40 15 cm. (nearly 6 inch) steel projectiles, was by no means breached, indeed, it showed only a few hair cracks on the interior of the cupola. The upper part of the tower, inclined at 45°, can be made so strong as to be practically indestructible. A thickness of 25 cm., (9.8-inch) of armor will more than suffice here. The projectiles, which occasion at this part penetrations and abrasions 3 cm. (1 inch) deep, glance off without appreciable effect. Even those striking at an angle of fall of 1 on 3 still strike the armor inclined at 45°. More inclined projectiles, striking consequently with smaller terminal velocities, can only hit the vertical armor obliquely, and therefore glance off from the latter, which is here about 15 cm. (nearly 6 inches) thick.

If we assume that about 30 hits to the square metre (10.8 square feet) of the vertical elevation of the exposed inclined armor (4 square metres) and to the square metre of the cupola (1 square metre)—that is, 150 hits to the entire 5 square metres of target —are necessary to destroy the tower, about 10 × 150 shots must be fired to effect this, and the necessary steel projectiles will weigh 1500 × 40 = 60,000 kg. (132,000 lbs.) and cost some 60,000 florins or $24,000.

Four attacking guns firing 50 shots a day will therefore have to be in action for 8 days to accomplish this result.

Against 10 armored tower guns of a point of support 15,000 shots will therefore be required, and against the 30 guns of 3 armored forts exposed to attack, 45,000 steel projectiles, that is, 1,800,000 kg. (about 4,000,000 lbs.) 6-inch calibre will be required. Projectiles of smaller calibre, or of cast iron, are without effect on the armor.

The 108 guns placed in action against the south forts of Paris in January, 1871, fired 52,852 shells, besides 328 shrapnel and 347 bombs. In Fort Vanves, of the 16 guns in service 9 were put out of action on the first day. How much greater will be the resisting power of isolated armored turrets sufficiently far apart! In the latter the small target area, projecting above the glacis, can, moreover, be readily masked by means of shrubbery, so that the tower offers a target very difficult to hit, and one probably less distinctly visible than the open earth batteries of the attacker, composed of from 4 to 6 pieces placed side by side.

Besides the 30 almost impregnable armored guns of the front attacked, there are scattered along between their emplacements the heavy guns of the open batteries to reply to the fire of the attack, and these must first be silenced. The attack cannot therefore concentrate its fire exclusively on the towers. As shown in figure 3, *a* and *b*, in which 3 armored towers for guns are combined in one group with 2 armored towers for mortars, the towers are placed 20 or more metres apart, so that shots missing one tower will not necessarily hit the neighboring tower. Every shot that passes 3 metres to the right or left of the turret (or tower) center, will go on through the air without any effect; whereas, in the older works it would hit the concrete mass, the gorge embankment, or the interior of the work, and would therefore scatter its fragments, as well as fragments of concrete, in and about the fort. The same effect will be produced on the batteries of attack, in which a shot missing a piece by 3 metres strikes in the traverse. The *open* communication from turret to turret along the ditch in these new forts, is consequently less exposed to danger than the covered communications in the older fort. In the latter, communication is therefore kept up entirely by concrete casemates or galleries, a precaution that is not at all necessary for isolated armored turrets. Only very highly inclined shots can reach the defender in the ditch, the bottom of which is 5 metres (16 feet 5 inches) below the glacis crest. Assuming that the interval between turrets is 20 metres (nearly 22 yards), this distance can be crossed in 10 seconds.

If the commander of a group of 4 turrets personally inspects the fire after every fifth shot, or (since 50 shots per day is to be considered the rate per gun) 10 times per gun, and 40 times for the entire group, he will have to pass 400 seconds in the open ditch, or about 7 minutes during the 10-hour bombardment, and is therefore for nearly the entire time under complete protection. How little protected, in comparison, does the commander of an open battery appear! But even in the latter the danger is not very great, considering the fact that, in the bombardment of Strassburg, which lasted 30 days, and was conducted by 168 pieces (111 guns and 57 mortars) firing in that time 150,000 shots, there were but 17 killed and 107 wounded among the artillery of the attack, so that for every 10 guns there would be but 1 killed and 7 wounded in a month.

How much smaller will be the casualties in an armored turret? The armored turret with its height of 3 metres above the terrain, will also furnish the commander of the neighboring open batteries (the pieces of which should not rise more than 1 metre above the terrain) opportunity for observation and cover for making calculations and giving orders and directions, and thus insure for him better protection. A covered way from turret to turret appears therefore unnecessary. It would be very expensive, too, for a distance of 20 metres or more between turrets, and would involve (on account of the great thickness of ceiling required) such a depth of ditch as to require steps in the latter, which would take more time than is required to hurry through the open ditch. As shown in the example given, the turret is constructed with flank walls inclined 90° to each other. They cannot therefore be hit by the attacker, for, even at the farthest position of the attacker to one side, along the prolongation of the flank, he will, at a range of 1000 metres, come within 750 metres of the adjacent guns of the interval, and can there also be taken in reverse.

A nearer position, about 375 paces nearer the neighboring fort, (covered by a high side parapet) will permit the guns of the attack to hit the side armor of the turret, but only under an angle of fall of 22½°, at which, however, no effect against 10 cm. (4-inch) of iron is to be expected. The arched bottom of the turret, and the concrete foundation, in which the latter is imbedded, are a sufficient protection against explosive shell.

As already stated, an armored turret of this kind, made of Sköda or Teschen cast iron which has recently been much used for Austrian armor, will offer sufficient resistance to modern artillery. The new Ganz chilled iron, manufactured in Leobersdorf, is also excellently well suited to this purpose, especially for the thicker front pieces.

Even the earlier material of this firm, which has been greatly surpassed in quality by the more recent, proved itself an excellent material for armor. Six hits with 21 cm. (8.3-inch) shell, mostly at 78° to 88° angle of impact, on a mortar cupola of chilled iron, weighing only 12,100 lbs., produced no effect whatever. Only the paint was rubbed off at the points of impact, and after repainting, these points could not be again located. 100 shots against the high and prominent object, with constant corrections depending on the results at the target, were required to give these 6 hits. In other words, 22,000 lbs. of projectiles were fired against the 12,100 lb. cupola (without sub-structure) without injuring it in the least. An observation stand, weighing only 5,500 lbs., of the same material, received 8 shots of steel projectiles from the 15 cm. (5.9-inch) gun, and 4 shots from the 12 cm. (4.7-inch) gun, including some flat-headed projectiles, without showing the least crack on its interior. This material, in quality, particularly in resistance to shock, is, however, far surpassed by the new chilled iron, which contains additions of Swedish iron and is annealed for a longer time. Chilled iron car wheels of this material will stand shocks which the best steel wheels are not equal to. There is, therefore, no doubt but that this chilled iron furnishes an armor material particularly well suited for land fortifications.

If the earlier material of a weight of only 5,500 lbs. (the observation cupola above referred to) showed so great a power of resistance, what is to be expected from the new, much more compact material, in pieces weighing over 22,000 lbs.! The latter is to be particularly recommended in the constructions proposed by me to withstand the great penetrative power of the modern steel shells of the 21 cm. (8.3-inch) and 24 cm. (9.4-inch) mortar, which are capable of penetrating a short distance into cast iron at an angle of impact of 90°, but which cannot penetrate the chilled iron, the latter causing the shell to break up from the shock. The new chilled iron material will probably also be cheaper than cast iron armor, according to the present market price, since it will probably be about 30 fl. ($12.00) per 100 kg. (220 lbs.) as against 40 fl. ($16.00) for cast iron. Moreover, in all probability the cast iron for the entire sub-structure can be delivered for 30 fl. per 100 kg., so that only for the cupola and the parts containing the toothed wheels, etc., will the higher price of 40 fl. have to be paid. By the use of the chilled iron the armor surfaces divided into strips, can be arched more between ribs, as Gruson proposed some time ago, which conforms better to the characteristics of the material (great resisting hardness) and facilitates the glancing of the projectiles from the sloping, curved surfaces.

The weight of a turret like figures 1 and 2 (without the attached mortar turrets) is about 290,000 kg. (638,000 lbs.) and its cost, therefore, $30 \times 2900 = 87,000$ fl. ($34,800) or (at 40 fl. per 100 kg.) 116,000 fl. ($46,400) and including the concrete foundation, etc., about 95,000 fl. ($38,000) or (at 40 fl.) 124,000 fl. ($49,600). Six such armored gun turrets at one point of support will therefore cost about $228,000. In fig. 1, at II., the howitzer turret is inserted, the gun of which has its line of zero elevation on a level with the glacis crest. It weighs about 506,000 lbs., and costs about $27,600 as armor, and about $30,000 set up in position. The 4 howitzer turrets will therefore cost $120,000. In the same figure, at III., is inserted a mortar turret, weighing about 198,000 lbs., costing $10,800 as armor, and $14,400 set up in position.

The fortification of a point of support, containing 6 armored guns, 4 armored howitzers and 4 armored mortars in revolving turrets, the armored turrets of which contain in addition 10 guns and as many machine guns in the casemates for fire action on the flanks and in the gorge (rear of emplacement), will cost, therefore, about $400,000, or, per long range gun with 360° sector of fire, about $28,800. According to Baron Leithner's *Bestaendige Befestigung und Festungskrieg* (1893) the cost of a main girdle work (long, medium and short range point of support) with four 15 cm. (6-inch) howitzers in revolving turrets and four 7.5 cm. (3-inch) rapid-fire guns in revolving turrets, besides six 7.5 cm. (3-inch) rapid-fire guns in the ditch and in gorge casemates, hence for 8 long range guns, is about $240,000, or $280,000, or at least $30,000 per gun. In the above 14 turrets, however, there are far more casemate and flank defense guns than in the Leithner work.

It is true that in the fortification with the 14 isolated turrets only about 200 men $(6 \times 20 + 8 \times 10)$ are quartered in bomb proof shelters, whereas in the main girdle work with concrete casemates 330 men can be so quartered. The casemate quarters for 130 men can be built for about $28,000, or per gun, an additional sum of $\frac{28000}{14} = \$2000$ must be counted on, or a total cost of $28,000 + 2000 = \$30,800$ per gun. According to the same work, the cost of an intermediate work, with only four 7.5 cm. (3-inch) rapid-fire guns in revolving turrets and 50 infantrymen, is $80,000, while a group of 4 isolated armored turrets (with 4 guns in revolving turrets and 4 flank defense guns, besides 4 machine guns) in which 80 men can have bomb proof quarters, costs $152,000, which is considerably more. But if we consider the 4 flank defense guns as important fighting elements for commanding the intervals between turrets and the gorge, and add them, we have per gun $\frac{152000}{8}$, or $19,200, hence not more than in the present close range work ($20,000).

But how much higher in value is to be rated the all-around fire of the isolated armored turrets, their security against assault, and the difficulty of breaching them, as compared with an armored concrete work. Until *every* turret is silenced or captured, the position is not lost, because even a single turret, with its cupola gun, its two casemate guns and the infantry fire from the casemates, commands well the position it occupies and the surrounding ground.

[To be Continued.]

PROFESSIONAL NOTES.

ARTILLERY MATERIAL.

Capped Shell.

The British Government intend to use in future caps on the armor piercing projectiles employed for testing Krupp cemented plates, a decision which we hope is a prelude to the extensive use of the cap in the naval service; for, although the Admiralty are not without apologists for rejecting this recent acquisition in the contest of guns *versus* armor, especially as regards shell, the fact that France, Russia, Germany and America have adopted the system certainly suggests that it has advantages. It is therefore important to weigh the reasons urged against its use against those advantages. It is long since artillerists recognized that the interposition of a soft substance between the projectile and plate increased the effect of the hardened ogival shot, or weakened the resistance of the plate. As far back as 1879, Major English placed a 2-inch wrought iron plate in front of compound armor, and the projectiles used for attack, which were defeated under ordinary circumstances, passed, in this case, right through the wrought-iron shield and the armor. But there seemed then no effective means of fixing the cap. Later, however, with the assistance of the engineer, this difficulty was overcome. The Russians were the first to direct prominent attention to the efficiency of capped shots by trials at Ochta in 1894; and a few weeks afterwards the British Government had some tried, when the results against Harveyized armor excelled all previous records. But although results have improved, due to greater uniformity and reliability in manufacture, there has thus far been little official recognition in this country of their value.

The superiority of capped armor piercing shot when fired at right angles or a few degrees from the normal against a plate of a thickness equal to one calibre of the gun, is admitted on all hands. Recent results, indeed, show that with velocities of over 2000 f.s., perforation can be insured at angles up to 20 degrees from the normal line of fire. Some of these results may be quoted. A 6-inch gun, firing a 100-pound shot, attacked a 6-inch Krupp cemented plate at an inclination of 20 degrees to the normal. With a velocity of 2097 f.s., the uncapped projectile did very little damage to the plate at that angle; it penetrated it to the extent of 2½ inches, and was then broken up, the whole of the projectile being left in front of the plate. Had it been directed against the side of a ship, there would have been no material result. A capped projectile was next fired at the same inclination with a velocity of 2107 f.s. It passed completely through, perforating the plate, the backing and the skin plate; and in actual warfare it would have done a vast amount of damage. In another test, a 6-inch plate was fired at with a 100-pound projectile, at a velocity of 2071 f.s. This is a fairly high velocity for normal attack, but under these conditions the plate was not perforated. The projectile had no cap, and penetrated to the extent of only 4 inches. At the same trials the same plate was inclined at 20 degrees, and fired at with a capped projectile at a velocity of 2097 f.s., and then the plate was completely perforated.

This test represented the actual effect of attack on a plate at an inclination of 20 degrees. In another trial, conducted in America, a Carnegie-Harveyized nickel-steel plate, not Krupp cemented, was fired at with a velocity of 2100 f.s.; the capped shot penetrated it completely, but the uncapped shot did not do so. In the trials carried out recently at the Vickers works, against a 7-inch Krupp cemented plate, picked from a large batch intended for the warship Libertad, four shots were fired with a velocity of about 2100 f.s. The damage done to the plate was practically immaterial, the maximum penetration having varied between 1 inch and 1½ inches, the plate remaining uncracked. A capped shot was fired, with exactly the same velocity. This shot completely penetrated the plate, the skin plate, and the backing, and went several feet into the sand-butt. This is a clear proof of the advantage of the cap at normal firing.

It has been questioned, however, whether shell can attain the same efficiency, even with right angle fire. It is scarcely necessary to indicate the difference between shot and shell, but, as practice differs with regard to the latter, it may be pointed out that a shot, even although supposed to be solid, has a cavity which may be filled with a very small bursting charge never exceeding 2 per cent. The British shell carries a 5 per cent. charge, but foreign governments find that a 3 per cent. bursting charge gives an effective armor piercing shell. This latter preference is important, as 7.5-inch shells, with a bursting charge of 3.3 per cent., to satisfy foreign government requirements, have been made in this country, and when fitted with caps have completely perforated the 7-inch armor already alluded to. The shell weighed 200 pounds, and was fired at the same velocity as the 6-inch proof shot. It contained a 6-lb. 12-oz. bursting charge—a very good charge for a shell; the point of the shell had possessed sufficient strength and weight for the shell to go right through the plate backing and skin plate and the sand-butt behind, punching out from the back of the plate a large piece half the weight of the shell, which, with the pieces of the projectile, had travelled a further 300 yards. The fragments had all been picked up together. In the battery of a battleship or cruiser, the havoc wrought by that shell would have been terrible.

As to the question whether the difference between 5 per cent. and 3 per cent. in a bursting charge is of sufficient importance in action to stand in the way of the adoption of the capped shell, with its advantage in penetrating power. It was at one time considered better for the shell to break up into many small fragments after passing through the plate, in order to effect the greatest damage to mechanism and *personnel* in the interior of the ship; and here a high bursting charge may have been justified. The tendency now, however, is to secure a shell which breaks into a few small fragments, as each unit is then more destructive to mechanism and the "integrity" of the ship. According to experts, the aim in the future will probably be to secure an armor piercing shell which will remain whole until after it has passed completely through the plate, breaking up owing to the ignition of the bursting charge; and in such case there seems little doubt that the 3 per cent. charge will suffice.

This question of charge raises the interesting point of the strength of the walls of the shell as an element in its penetrating power, and it also justifies consideration of the somewhat academic subject of the reason why the cap weakens the resisting power of the plate. The simplest explanation of the latter is probably that given by Mr. David Carnegie, in an interesting paper he read at the Institution of Civil Engineers, on "The Manufacture and Efficiency of Armor Piercing Projectiles." His view seemed to be that the cap breaks the cemented coating and makes bare the plate at the point of impact; that it is perhaps more effective at the instant of impact in diminishing somewhat the sudden violence of the blow, which otherwise tends to shatter the body of the projectile the moment it strikes the plate. He continues: —"It is thought by some that the cap acts as a lubricator, and that, by being driven before the projectile, it melts with the extreme heat generated, and hinders the hard cemented portions of the plate from scoring the head of the projectile, thereby diminishing the resistance to its passage." Most will agree with this theory, especially that the cap reduces the shock to the projectile, leaving it to follow with all the remaining energy utilizable for penetration. But in considering the relative efficiency of shot and shell, one must consider the stress upon the projectile and on the plate. We have it from Major Wolley-Dod that a 6-inch projectile striking a 6-inch plate with a velocity of 2000 f.s.—not considered a high velocity nowadays—passes through a plate in about one two-thousandth part of a second; and the point to be determined is whether in this short time stresses can spread over a great area from the point of impact, and as to whether the vibration of the plate can do anything to weaken its resistance. What is the difference in the stress influence on a separate plate and a plate worked as an integral and fixed part of a ship? At what rate is the stress distributed to the projectile, and does the thickness of the wall of a shell or shot influence this time rate of distribution? It is almost possible to conceive that the projectile has done its damage to the hard face of the plate before the stress has passed from the nose to the base, and that little of the area of the plate and therefore none of the resisting power of the ship's structure helps the plate. More time must be taken by the capped projectile in penetrating the armor than is the case with uncapped shot; the momentum is not destroyed so quickly, so that the intensity of the effect on the capped projectile is less than with the uncapped shot or shell. The time difference is therefore an important factor in the problem. Again, as Mr. Carnegie pointed out in replying to the discussion on his paper, since less time is taken in destroying the momentum of the uncapped projectile, the rate at which its kinetic energy is destroyed is higher, and therefore the rate of generation of heat is higher. "Before the point of the uncapped projectile had penetrated a few inches, the heat generated was sufficient to extract from it the very property of hardness upon which successful penetration largely depended, thereby preventing the projectile from completing its work. This fact had been clearly demonstrated in trials at the Eskmeals Range, wherein the heat generated had been sufficient to fuze the point of an uncapped projectile in the plate before penetrating 3 inches." In any case, it would appear from the discussion that it is not so much a question of the thickness of the walls of the shells, but rather of the efficiency of the cap.

The quality of manufacture also affects the effectiveness of attack at high angles. It is surprising that there should be difference of opinion on such a question, as the effect of projectiles fired at angles from the normal, when a solution could be arrived at by tests. This difference of opinion may be due to the fact that results of the tests of armor have been too frequently accepted as determining the efficiency of projectiles. This point was raised in the discussion by Mr. J. H. R. Whinfield, who pointed out that when armor plates are tested, they are proved for the purpose of their reception as armor plates; and as one plate, of limited area, is required to resist attack from four or five projectiles, it is not necessary that the velocity or energy of attack should be so great as to penetrate the plate. Indeed, this velocity is usually fixed at a point actually below that at which the plate might be perforated, because the chances are that a plate withstanding five successive shots within a limited area will have proved itself capable of withstanding attack from a gun of higher velocity, where there is little chance of repeated attack within a similarly small area. Many tests of armor piercing shot have been made on plates at an inclination of 20 per cent. from the normal line of fire, and with muzzle velocities of only 2000 f.s. to 2100 f.s.; and the results proved that whereas the uncapped projectile only penetrated to a depth equal to 35 to 40 per cent. of the thickness of the plate, the capped projectile got completely through. Lieutenant Dawson very properly stated, in the course of the discussion to which we have already referred, that the quality of the projectile was a very important point in the question as to whether the shot passed through intact or broken up. The quality of the material is of paramount importance, because if the shell does not hold together, the bursting charge does not get through the plate; and this quality is much more severely taxed in the case of angle fire, as then, in addition to penetrating the plate, the projectile has to overcome the resultant force tending to break the body of the shell transversely. Major Minchin, who has conducted many armor piercing trials on behalf of the Government, pointed out in regard to this question that it was difficult to tell from the plate, after the attack, in which direction it had been inclined, especially thin plates, as the attack then appeared almost invariably to be normal. As reported in the discussion, "he thought one of the causes of that probably was that the plates sprang tremendously at the moment of attack; and when a plate sprang very much, it was natural to expect that the action on it would be normal. But if the action on the plate was entirely normal, what became of the component of the energy in the direction tangential to the plate? That energy, he thought, was expended in breaking up the projectile. If the holes in the plates were examined closely it would be seen, on the side to which they were inclined, that the edges of the hole were very much bruised. The reason was that the projectile struck the edge of the hole in the plate and was broken up. Of course, when the plate was inclined at 30 degrees to the normal, the tangential component would be equal to half the total energy of the projectile; and no armor piercing projectile would stand such a blow." But we understand that projectiles have passed completely through plates when fired at an angle of 30 degrees, although in these cases the muzzle velocity approached 3000 f.s.

The value of the cap is thus, from first to last, dependent largely on the velocity as well as the process of manufacture. A capped shot or shell will go through any plate equal in thickness to the calibre, if sufficient energy is developed, and if it is of satisfactory make. If we take the 6-inch gun as a case in point, we find that while capped shot fired at an initial velocity of 1895 f.s., will penetrate a plate the thickness of which is only 98.5 per cent. of the calibre; an increase in velocity to 2500 f.s., will increase its penetrating power to 146.5 per cent. of the thickness of the calibre; and in the case of velocities of 2900 f.s., the penetration will be 182 per cent. of the thickness of the calibre. In the case of the 10-inch gun, again, an increase from 2200 f.s. to 2800 f.s. adds 33 per cent. to the penetrating power, whilst a corresponding increase in the velocity of a 12-inch shot adds 35 per cent. to the penetration.

As velocities of 2800 f.s. and over are developed in guns manufactured in this country for foreign Governments, there seems no reason why the best results should not be achieved for capped shot. Thus a 7½-inch gun should be able to perforate 7-inch armor at 4600 yards range, and a 12-inch gun ought to be able to do the same against 10-inch armor. As regards shells, the United States, like the principal Continental Powers, are very strong in the belief that capped shell will be most destructive, especially against thinly armored cruisers; but it must be noted that in their case the muzzle velocities and energies are much higher than those attained in this country. In this matter of gun fire our Navy does not seem to have excelled foreign practice as it ought to do, and this is partly due to lack of appreciation of nitro-cellulose as a propellant. But that is quite another matter.

—*Engineering*, October 16, 1903.

Armor-Piercing Projectiles and Critical Velocities.

It was noticed as far back as 1893 that there was a velocity at or above which an armor-piercing projectile produced less effect on a plate than when striking at an immediately lower velocity, and that this diminution of effect was accompanied by a complete smashing up of the projectile, In one of the earliest recorded instances, projectiles which penetrated from 7-in. to 8-in. intact into a 6-in. hardfaced steel plate with velocities from 1400 to 1600 foot-seconds broke up completely when the velocity was raised above 1600 foot-seconds, only inflicting superficial injury on the plate. The late Captain Orde Browne's deduction from this was that a certain striking velocity was necessary for the shot points to be broken, and that, once this was accomplished, the projectiles failed to perforate, and broke up. This break-up could doubtless be explained by the hypothesis that a certain striking energy is necessary for perforation proper (boring). When the shot point is broken boring cannot take place, and the action is a punching action. Obviously more energy is required to punch out a disc than to bore a hole, and until the striking energy is sufficient to produce the latter acttion—boring being impossible, owing to the broken point—it will do work in breaking up the projectile rather than the plate.

More recently, however, there have been instances where a similar failure at higher velocities has been observed, but which the foregoing explanation does not cover. In these cases the action has been a punching action at both velocities; and yet whereas the projectile has got through broken at the lower velocity, it has altogether failed at the higher. The striking energy was sufficient to produce punching, and also to smash up the projectile in in doing so at the lower velocity; but when the striking energy was increased, instead of the fragments of shot getting through with increased remaining energy, they did not get through at all. It seems evident that the break-up of the shot at the higher velocity took place very much quicker than at the lower, so much so that the plate had not time to give way.

In order to explain this curious behaviour a theory has been advanced—we believe it was originated by Captain Tresidder—that for every projectile there is a critical velocity—or, rather, a series of velocities depending on the plate attacked—at which it will inevitably break up on impact, and will in doing so, inflict less injury on the plate than at the velocity immediately below. In other words, for every projectile there is a velocity at which it reaches its maximum efficiency, relatively if not absolutely. If this be so—

and there seems small reason for doubting it—we have yet to account for such a seeming paradox. The phenomena in question cannot be explained as simply the effect of compressional, torsional, or other stresses on the projectile, though these are likely enough factors in the case. The most reasonable explanation seems to be that the main factor in the case is the condition of molecular vibration in which the projectile is immediately after impact. This vibration may be altogether, and to some extent must be, in the form of heat. Metals heated to a certain point crumble readily when struck, the temperature at which this occurs varying with the nature of the metal and of the blow. A similar effect may be produced by vibrations other than heat, as when a glass rod is shivered when rubbed in a suitable manner; or when a glass vessel is shivered through the vibrations set up in it when a certain note is struck. Again, a Rupert's drop, which, when intact, resists a very considerable pressure, flies to pieces when its point is broken or scratched with a file. Here the glass of which the drop is composed is in a state of internal stress -- *i. e.*, ready to assume a condition of abnormal molecular vibration, and the slight jar caused by breaking the points is sufficient to effect its complete disintegration.

Now assuming, what is, however, doubtful, that all armor-piercing projectiles are in a state of non-molecular stress when at rest, they are certainly not so immediately after impact, and the vibration set up then will depend on the striking velocity. In these circumstances it would seem extremely probable that for a given plate and projectile there is a striking velocity at which the molecular vibration set up in the latter will be at a maximum consistent with its holding together. At this velocity it will produce a maximum effect on the plate. Immediately this velocity is passed the projectile will break up, and little or no work will be done on the plate. There will obviously be a series of such critical velocities varying with the nature and thickness of plate attacked; for instance, a projectile may have a critical velocity of 1800 foot-seconds against a K.N.C. plate, and only 1600 foot-seconds against a K.C. plate of the same thickness.

It is quite in accordance with the hypothesis put forward that the cap should confer an advantage above a certain velocity. Apart from any cushioning, which would, of course, lessen the jar on impact, and from the mere mechanical support afforded to the point, which keeps it intact until well into the plate, so enabling the projectile to do its work as a boring tool rather than as a punch, the cap by preserving the point prevents that complete and instantaneous smash up of the projectile which would occur, as with the Rupert's drop, when the striking velocity was high enough. Below this velocity the uncapped projectile may have its point broken, and so be handicapped in getting through; but its smash up will not be so instantaneous, and it will have time to do more work on the plate. The cap has never yet conferred marked advantage below a certain velocity—somewhere about 1800 foot-seconds—although it it tolerably certain that the mere point-breaking velocity is below this. The cap practically raises the critical velocity—though it would be more accurate, perhaps, to say that the want of a cap lowered it. In the case of the 6-inch gun it appears to raise it by about 1000 foot-seconds.

The moral would appear to be this: Cap all armor-piercing projectiles that are strongly enough designed to benefit by the cap; and in order to secure this it would seem desirable to sacrifice where necessary a per cent or two of bursting charge capacity. At velocities considerably below 1800 foot-seconds it is true that an uncapped shot may produce more effect than a capped one, but against armor of anything approaching the calibre of the gun in thickness the effect produced would in either case be negligible.

—*The Engineer*, October 30, 1903.

SMALL-ARMS AND EQUIPMENTS.

The New Cartridge Belt.

For over a year past, while experiments with the new Springfield rifle, model of 1903, have been in progress, the Bureau of Ordnance of the War

FIGURE 1.

Department has been engaged in devising a substitute for the present regulation double-loop cartridge belt, which is not adapted to carry the ammunition for the new rifle, for the reason that the cartridges are carried in clips of five each. The Department, itself, was engaged at Rock Island Arsenal in experiments to produce a russet leather carrier, and meanwhile invited various manufacturers to experiment with other materials.

Last winter a board of officers, consisting of Captain Foltz, of the Cavalry,

FIGURE 2.

Captains Rawson and Munson of the Infantry, and Captain Dickson of the Ordnance, was organized, and assembled at Sandy Hook to experiment with the different carriers there presented. None of them were found to be entirely suitable, but experiments were continued, and finally The Anson Mills Woven Cartridge Belt Co. of Worcester, Mass., produced a suitable woven carrier and suspenders, which the Department adopted for future use, not only with the new Springfield rifle requiring clips, but also as a carrier for the single cartridges used by that portion of the Army which may continue temporarily to use the Krag.

The new belt is 3½ inches wide, and has nine pockets, each of the proper size for holding two clips, giving a capacity of ninety rounds in the entire belt. One pocket, however, will be used for carrying the First-aid package, thus reducing the number of cartridges to eighty.

In the accompanying illustrations there are shown in figure 1, a front view of a soldier, equipped with the new carrier and suspender, in the act of inserting a clip of cartridges in the magazine of the new Springfield rifle; in figure 2, a back view, showing the belt with its pockets filled with clips; and figure 3, showing the carrier detached from the suspenders.

Both the carrier and the suspenders are formed wholly of woven fabric, the only sewing being on the points of the pocket flaps, and at the ends of the belt, which are further finished with metal end pieces. On the suspenders there is no sewing whatever. The pockets are integral with the belts, and are formed by weaving only, the threads of which they are composed

FIGURE 3.

being continuously interwoven with the body of the belt. This enables the manufacturer to produce pockets absolutely uniform in size, not only on a single belt, but on all belts that may be woven, and which are separable from the belt only by destroying the fabric. Neither of these features is obtainable on any belt formed by sewing one piece of material to another.

The fabric of both belt and suspenders is woven from a specially hard twisted cotton yarn of great durability, which is dyed in the same shade of khaki color as the service uniform.

The flaps covering the pockets are of separate pieces of fabric eyeletted to the body of the belt. They are provided with a strong ball-and-socket glove fastener, by means of which the flap may be buttoned over the pocket, thus holding securely in place the clips or cartridges therein.

The ends of the belts are provided with fasteners which engage eyelets, set at intervals in the body of the fabric, to enable the soldier to accommodate the length of the belt to his girth. Near the lower edge of the belt are fixed a series of eyelets from which the canteen and the haversack may be suspended; and near the upper edge are eyelets through which pass the hooks of the suspenders.

The suspenders are of the same kind of woven fabric as the belt itself. The web resting on the shoulder is 2¼ inches wide; the supporters attached to this, which are of fabric one inch wide, end in hooks which engage the eyelets in the belt. Three adjustments are provided; two in front and one in the back, thus enabling the tallest or shortest soldier to bring the belt itself to the proper position about his waist. To prevent the suspenders slipping off the shoulders, one of the branches of each of the two front lugs may be hooked in an eyelet on the further side of the belt, as shown in figure 1, and the belt may then be worn unbuckled to afford ease in strenuous marching.

All the metal parts are made of brass and are bronzed to the same shade as the buttons on the service uniform. The buttons on the pockets are embossed with the regulation device of the eagle.

The carrier is shown in the illustration with the regulation hook fastener of the present service belt, but, before being issued to the Army, each belt will be equipped with a new form of buckle, which the Department will produce at Rock Island Arsenal.

The total weight of the new carrier, exclusive of the buckle, is fifteen ounces, and that of the suspenders is eleven ounces.

In bringing the belt to its present perfect form, great assistance has been given the manufacturer by the Bureau of Ordnance, particularly by Captain Dickson who has made many valuable suggestions.

The patents covering the woven pocket device, the fastener and the belt itself, are owned by the Anson Mills Woven Cartridge Belt Co., of which F. R. Batchelder is manager; and the Department has entered into a contract with this firm for the immediate manufacture at the rate of about 1,000 per day, of 100,000 carriers and 100,000 suspenders. In addition to this a contract has been awarded the same firm for the manufacture of 6,000 pistol cartridge carriers for the Field Artillery. These latter carriers are of the same style and color as the rifle belt, but are only 2¼ inches wide, aud have but eight pockets each, the capacity of each pocket being six .38-calibre pistol cartridges. No suspenders are required for this belt.

The factory of the contractors, located at Worcester, Mass., is equipped with looms specially designed for the weaving of the fabric of which the carrier and suspenders are composed, together with an extensive plant of special machinery for the production of the metal trimmings and the finishing of the new belt. Several novel machines have been recently constructed expressly for finishing the new belt.

It is the intention of the Department to equip the regular Army, the Marine Corps, and the National Guard, with the full equipment of new rifles, cartridge carriers and suspenders, as fast as the rifles can be manufactured.

BOOK REVIEWS.

Principles and Problems of Imperial Defence. By Lieut.-Colonel Edward S. May, C.M.G., R.A. London: Swan, Sonnenschein & Co., Limited; New York: E. P. Dutton & Co., 1903. Pp. 332. $3.00 net.

The subject of *Imperial defense* has long been regarded as of vital interest to Great Britain, but the value of the army as an *essential* element in the force which secures the safety of the nation has never before been adequately presented; although Major-General Muarice, in his work on *National Defences* has brought the necessity of an army into prominence, yet he does not touch all the points here considered, and still regards the army as not only secondary but also as less important than it really is; moreover his work relates more particularly to *the rights and responsibilities of the English citizen* in the defense of the nation.

Colonel May is particularly well equipped for the work he has undertaken. His position as professor of Military Art and History at the Staff College naturally led him to the study of this subject, and, as he tells us himself, "in addition, an even more powerful motive actuated me: a constant examination of the history of past campaigns had impressed on me the value of a habit of examining war, and the preparation for war, from the business point of view." Moreover, Colonel May's literary work (and he is an author of international reputation) has led him along the same path. So that he is in every way fitted to write on this great subject, and it is not surprising that he was induced by others to do so, since his views would naturally command attention.

The standpoint of the present work is set forth in the following assertion by the author:

"Imperial defense, although it cannot be carried out at all without a navy, cannot be accomplished by a navy alone."

That is the gist of the whole matter, and the author insists upon this truth throughout his elaborate treatise.

The *introduction* deals with some general principles which it would be well to have instilled into the public mind, for they are often lost sight of. For example, in searching for the causes that lie at the root of success or failure, the author has come to the conclusion that, "whereas the glowing pages of history often attribute victory to the personal courage or readiness of invidiuals, triumphs have most frequently been arranged for at the desk." Again, as to the lessons gleaned from the experiences of the South African war, the author says:

"The great truths of strategy have again asserted their immutable and inexorable force. Politics and strategy go hand-in-hand. The plan of campaign should be adapted not only to the force of the enemy, but to that with which we can take the field. The security of lines of communication, the danger of an open base—these are absolute lessons, and no matter where we may next fight we shall infringe them at our peril. But beyond them we have been given lessons equally absolute, more original, and, for us, even more important. The need for cultivating, not only the intelligence but the characters of both officers and men, the inculcation of soldierly virtues, self-reliance, determination, discipline, patience—what may be termed the moral qualities of a good soldier, these must not be left out of sight. And we have learnt the importance of training for war, not for any particular nature of warfare, but for war generally—principles and not rules, maneuver and not drill, military instinct and not pedantry."

Finally, he has this to say on the great principle of co-operation :

"If intelligent and genial co-operation be demanded on the battlefield, how much more are they to be sought and secured when land and sea forces join against a common danger ?

"The co-operation of the services is, indeed, the corner-stone of Imperial defense ; co-operation, above all, in the council-chamber. It can be readily learnt in actual practice. We have had some experience, and the results have been encouraging ; but far-reaching and not quickly to be amended are the misunderstandings of great principles. Co-operation in conception is more important even than in execution, and in weighing the relative importance of naval and military needs it is the fate of the nation which is often swinging in the balance."

These great truths cannot be too generally known, or too often insisted upon, and, as is seen, the author presents them in a perfectly definite form and with proper emphasis.

The opening chapter relates to the Foundations of Empire, and in it the author discusses the subject of the origin of England's greatness as well as the causes that have preserved that greatness :

"That the basis of our Empire is sea-power, and that the first essential of Imperial defense is command of the sea, it is happily no longer necessary to demonstrate. I may assume that the writings of Captain Mahan, Sir George Clarke, Mr. Thursfield, the late Admiral Colomb, and the many others who have labored to bring this fundamental principle home to our minds have not been in vain."

The Empire of Great Britain is primarily a commercial organism, and this idea is developed in this first chapter, which closes in the following words :

"Of late years our awakening from a selfish dream, where we figured as the sole heirs of the world's wealth, and other nations were to accept the situation, and allow our operations to be unmolested, has been somewhat sudden. The spirit of commerce has informed other great nations not disposed to accept our supremacy unchallenged : has worked its influence in the same manner as history has taught us to expect ; and in quite recent years another great sea-power, which is also a land-power of the first magnitude, has been called into being by commercial necessities.

"Such striving for sea as well as land strength evidences to us the need a great Empire feels for both."

Next in order is discussed the analogy between land and sea warfare, a very interesting chapter, containing numerous illustrations from military history. We will call attention to but one of the many important principles set forth :

"A few words on the 'fleet in being'—that portentous phrase that has played so prominent a part in the discussions on national defense, can scarcely however, be avoided. * * *

"There is no more magic in the fleet than in the phrase. The force of the threat which the fleet in being holds over us depends on the relative size of the fleets engaged, on its being too strong to be masked—to put the matter in a nutshell, on its being able to carry out what it threatens to do. Its power at sea is precisely that of a force jeopardizing the safety of a line of communication on shore, and is exerted in just the same manner. * * *

"No general will invade a country while a hostile force can fall on his lines of communication. * * * But that does not mean that because there is a hostile force somewhere in the field upon your flank it is not possible to neutralise it and pursue your forward progress undisturbed. * * *

"The 'fleet in being' has no more the intrinsic and absolute properties of an amulet or talisman to shield from harm than any other fundamental principle of strategy."

The Predominance of the British Navy is the next subject considered, and its closing words lead us naturally to the part of the work relating to the *army*, to which the greater portion of the volume is devoted :

"The navy must keep the highways of the ocean and communications of the Empire always open to us, and must acquire, as early as possible after war breaks out, such a mastery over the fleets of our opponents, that it may be possible to send our land forces on expeditions across the waves.

"When the navy has done that, it will have attained what we know as command of the sea, and until it has established that essential condition in all schemes for the defense of the Empire, the task it is called upon to execute will remain unperformed, and the army must stand and wait for its accomplishment."

Next in order Function of the Army is fully considered in all its aspects,—garrisoning the Imperial fortresses, coaling-stations and defended harbors, as well as furnishing the means (in the form of a mobile field army) for an energetic counterstroke by offensive action beyond the seas.

"While, therefore, we may be clear in our judgment that the command of the sea must always be the basis of all schemes of defense, and while we may have complete confidence that our ships will obtain it for us when the enemy is at our gates, we must still recognize that even a predominant navy has its limitations and restrictions, and cannot alone produce decisive results. * * *

"Our army and navy are, in fact, complementary to each other. To get the fullest effect from either they must work in unison, and their co-operation must be genial and intelligent. In any broad view of Imperial defense their interests are seen to be in common rather than antagonistic, and while the Empire would perish without the one, it could not exist without the other."

In regard to the question of the navy alone being responsible for the naval bases and ports, Colonel May has very decided views, which admit of no misunderstanding. In discussing the *extreme* views on both sides of this question, he says:

"A saner view seems to teach us that the ports of our empire held for the refuge, replenishment, refitment, or repair of our ships should be rendered secure by such means as will obviate the depletion of our fighting strength in the actions where the great issues of the war must be decided."

The succeding chapters relate to Combined Operations, Naval Bases and Coaling Stations, the Great Cable Communications of the Empire, Food Supply in time of War, Protection of Commerce, Defense of Outlying Dependencies, Home Defense, and Organization for Imperial Defense, each one of which is treated with the same care and thoroughness as the preceeding ones here more fully discussed. Each one is a carefully considered essay on the subject of which it treats, by a student of history as well as a soldier and a strategist. There is one curious error, however, which is a little surprising from such an author, viz: (p. 235), "During the Spanish-American war the *New York*, a merchant-vessel, flew the flag of Admiral Sampson, the United States Commander-in-Chief."

Probably the fact that we did use several ocean liners as auxiliary cruisers is the explanation of this mistake.

In regard to the last chapters, we have space only to call attention to the fact that the author evidently favors some form of compulsory service for the army (and, indeed, what else is left to a nation when it comes to the struggle for existence?), and he considers the proper land army of Great Britain to be three army corps and a cavalry division ready for immediate mobilization, and behind these, three other army corps, largely composed of auxiliary forces, to be organized to furnish drafts and train troops in war time for the establishments abroad, provide for home defense, and reinforce the armies engaged with the enemy. These forces do not include the garrisons and mounted infantry required at and near home, nor the Indian and Colonial garrisons, nor do they consider the forces that the Colonies must raise.

Moreover, as the author states:

"A system of coast fortification sufficient to free the fleet, give confidence to the civil population of the country, and prevent any of our important seaports falling by a *coup-de-main* and being utilized as a base of operations by an enemy, is a first necessity in home defense."

Such are the principal features of this important work, and the outline we have given will be sufficient to indicate its worth not only to the army officer or the naval officers, or in fact to military students in general, but also to the legislators and to the public at large, especially the citizens who take at interest in the higher developement of the country. It deals broadly with great subjects, its reasoning is strong and convincing, and the sincerity and earnestness of the author are evident on every page. In principle, it is quite as important a study for us as it is for Great Britain.

J. P. W.

History of the Peninsular War. Charles Oman, M.A., Professor of Modern History in the University of Oxford. Vol. II. Oxford. At the Clarendon Press. London, Edinburgh and New York. 1903. Pp. 684. Price $4.75.

The second volume of this splendid work carries the *history* to the end of the Talavera campaign (September, 1809) and rivals the first in interest to the reader as well as in the variety of its subject-matter. This volume, like the first, maintains the character of the work as one of the most important recent additions to *general* as well as to *military* history. The author is evidently perfectly familiar with his subject, and his investigations have been most thorough. Consequently he speaks with confidence and authority. As a contribution to general, political and military history, it ranks among the best and highest, and no previous account of the Peninsular war can be considered complete without the addition of this work. For Napier's *History* (the accepted authority for more than half a century and still the classic on the subject) this work is the necessary complement, and certainly no military student can any longer accept the former without correcting every account and statement by means of the latter.

The author's style is clear, simple and straightforward, yet withal forcible and entertaining; he has entered upon his work in a spirit worthy of his subject; and he has executed his task ably and in many respects brilliantly. The characterizations of persons, events and scenes are always graphic and strong, and generally admirable. The strategy and tactics of campaigns and battles are set forth in a manner somewhat surprising in clearness and grasp, particularly coming as they do from the pen of one who is not a *military* student in the restricted sense.

The period covered by this second volume (from the battle of Corunna to the end of the Talavera campaign) presented many and great difficulties for the systematization of the subject-matter, because the fighting, after the departure of Napoleon, became local and isolated, so that six or seven campaigns, each entirely independent of the others, were going on at the same time, and it was not until Wellesley appeared that the hostile forces once more entered into a single scheme of operations. Nevertheless, the author has succeeded in evolving out of the complicated material what system was possible, and has placed before his readers a clear and satisfactory account of what was in reality a period of turmoil in Spain.

The book opens with a description of the state of affairs in Spain after Corunna, including the consequences of Moore's Diversion, the rally of the Spanish armies and Napoleon's departure. After carefully analysing the effect of Moore's Diversion, the author concludes:

"It is not, therefore, too much to assert that it was Moore's march on Sahagun, and that march alone, which paralyzed the main scheme of the Emperor for the conquest of Spain".

The introductory chapters prepare us for the complication of events that follow, and these the author has systematized as follows:

The autumn and winter campaign in Catalonia.

The second siege of Saragossa.

The spring campaign in La Mancha and Estremadura.

Soult's invasion of Portugal.

Wellesley's campaign in Northern Portugal.

Operations in Northern Spain.

The Talavera campaign.

To illustrate the author's style we desire to give two brief quotations, one a description of an episode in the siege of Saragossa, the other a small portion of the author's splendid characterization of Wellesley; which, however much opinion may differ as to the ability of Wellesley as a strategist and tactician, must be admitted to be a most interesting description of the man.

"In the flush of success, after San Augustine had been stormed, the 44th regiment, from Grandjean's division, tried to push on through the streets towards the centre of the town. They captured several barricades and houses, and struggled on till they reached the Coso. But this sort of fighting was always dangerous in Sarragossa. The citizens kept up such a fierce fire from their windows, and swarmed out against the flanks of the column in such numbers that the 44th had to give back, lost all that it had taken beyond San Augustine, and left 200 dead and wounded behind. Even the formal official reports of the French engineers speak with respect of the courage shown by the besieged on this day. The houses which they had lost in the afternoon they retook in the dusk, by an extraordinary device. Finding the French solidly barricaded in them, and proof against any attack from the street, hundreds of the defenders climbed upon the roofs, tore up the tiles and entered by the garrets, from which they descended and drove out the invaders by a series of charges which cleared story after story. Many monks, and still more women, were seen among the armed crowds which swept the assailants back towards Santa Monica". * * * * * *

"Arthur Wellesley was now within a few days of completing his fortieth year. He was a slight but wiry man of middle stature, with a long face, an aquiline nose, and a keen but cold grey eye. Owning an iron constitution on which no climate or season seemed to make the least impression, he was physically fit for all the work that lay before him—work more fatiguing than that which falls to most generals". * * * * * *

"Considered as a man, Wellesley had his defects and limitations; we shall have ere long to draw attention to some of them. But from the intellectual point of view he commands our undivided admiration as a practical soldier.

"As to tactics indeed, there are points on which it would be easy to point out defects in Wellesley's method—in especial it would be possible to develop the two old, but none the less true, criticisms that he was 'pre-eminently an infantry general,' and that 'when he had won a battle he did not always utilize his success to the full legitimate end.' The two charges hang closely together, for the one defect was but the consequence of the other; a tendency to refrain from making the greatest possible use of his cavalry for breaking up an enemy who had already begun to give ground, and for pursuing him *à outrance* when he was well on the run, was the natural concomitant of a predilection for the use of infantry in the winning of battles. * *

"A far more serious charge against Wellesley than any which can be grounded on his tactical faults, is that, though he won the confidence of his army, he could never win their affection. 'The sight of his long nose among us on a battle morning,' wrote one of his veterans, 'was worth ten thousand men, any day of the week.' But it was not personal attachment to him which nerved his soldiers to make their best effort; he was feared, respected, and followed, but never loved. He was obeyed with alarcity, but not with enthusiasm."

The appendix to this volume contains many accurate data regarding the strength of the various arms, and some interesting papers on the intrigues at Oporto and on the Talavera campaign.

The volume is tastefully bound, the paper and typography leave nothing to be desired; the maps and plans are excellent and adequate, and the illustrations add to the beauty, as well as to the utility of the work.

J.P.W.

Der Küstenkrieg. By Sigmund Mielichhofer, Hauptmann in k. und k. Festungs-Artillerie-Regiment Nr. 4. With 25 illustrations and 1 map. Wien: Verlag von L. W. Seidel & Sohn. 1903. 251p. O. Paper, M. 6.

In this work Captain Mielichhofer has finally been able to bring together all his previous writings on this subject and thus to present in a single volume a complete and logical exposition of the principles governing the attack and defense in seacoast warfare and all questions involved in the defensive organization of coast fortifications.

The author has devoted much time to the study of this subject and has had, in addition, the practical experience of many years' service in coast works. His earlier writings consisting of pamphlets and essays on different features of coast defense,—the submarine defense, attack and defense of coast fortifications, defense of open coasts, aids to coast artillery fire, and coast artillery,—have formed a series which taken together present a scientific deduction of the principles and a systematic discussion of the subject. These writings have been well received and have established his reputation as an authority on this all-important subject.

The present work possesses the advantage of combining all the essential elements of the former series, which are here re-arranged, properly co-ordinated and presented with great clearness, conciseness and thoroughness. The author has taken this opportunity to incorporate, also, the later developments warranted by his experience, and has revised his former works, in accordance with the views of some of his critics, as far as has been thought proper.

He divides the whole subject of coast warfare into two divisions: 1, the attack and defense of coast fortifications; 2, the attack and defense of open coasts.

Under the first head, after some general remarks on the value of coast fortifications, the author discusses the means of attack and defense, including first those common to both, such as the floating material and its armament, offensive and defensive: the ram, naval artillery, the torpedo, mines, torpedo nets, search lights, etc; secondly, the special means of defense: mines and obstructions, coast artillery and fortifications, torpedo stations, electric lights, range finders and means of communication. The nature of these elements and the principles governing their use and installation are briefly stated.

Then follows a full discussion of the attack of coast fortifications: blockade, bombardment, and direct naval attack in all its phases from the reconnoitring and removal of the outer mines, etc., through the reconnaissance in force, the artillery combat, forcing the entrance and the run past, illustrated by examples of the attack on Forts Jackson and St. Philip in 1862 and forcing the entrance of Mobile Bay in 1864.

In a similar manner and with the same completeness the defense is treated. The author takes up each kind of attack and considers its proper form of defense. Each phase of the naval attack by sea is separately discussed and under each are set forth the functions and duties of the coast artillery, the the navy and the infantry forces of the defense. The defense of Charleston Harbor serves as an illustration of this part of the subject.

Landing operations and considerations of the measures of the defense against these modes of attack form the concluding portion of the book under the head of the attack and defense of open coasts. They are illustrated by the operations at Wei-hai-wei and Santiago de Cuba.

In conclusion, after remarking on the exceedingly great importance of coast artillery in the defense, and the quickness with which in these days a strong fleet may be mobilized and then suddenly appear prepared for active operations against some fortified harbor, the author justly says: "The coast artillery must also in a very short time after mobilization be thoroughly effective, and, opposed to a resolute, daring adversary, must often in only a few hours justify its existence. For the performance of such a severe task, however, recourse can not be had to reserve forces—without mentioning that in the rarest cases is it possible to draw on them in due time. And from this follows one of the most essential results of the investigations of this study: that the coast artillery, like its principal adversary, the Navy, must even in times of peace be fully constituted and possess the organization suited to war conditions if it is to be able to accomplish that which the people have accustomed themselves to demand of it."

The work is a thorough and exhaustive treatise on its subject, a credit to its author in the systematic and logical presentation of its matter, the conciseness and clearness of its language, and constitutes an important study for the coast artilleryman.

Practical Gunnery in the Lecture Room and in the Field. A series of Lectures for all Ranks of Artillery. Compiled by Captain H. T. Russell, Royal Artillery. Illustrated, 20 plates. London: Gale & Polden, Ltd. 1903. 93p. D. Two-and-Six.

A very excellent little work containing much practical and useful information for all artillerymen. The author's aim has been to provide non-comissioned officers and men with materials for study to secure gunnery prizes, to supply officers with material for lectures for the instruction of their men, and to provide a full, yet succinct, text-book for junior officers attending courses of instruction. The result of Captain Russell's work is a convenient little book containing some nine well arranged lectures on everything pertaining to gunnery, written in a clear, practical and comprehensible manner, and thoroughly fulfilling the purposes for which it was intended.

Its subject-matter comprises definitions of terms used in gunnery, systems of rifling, forces which act on the projectile, recoil, laying and aiming a gun, accuracy of fire and probability factors, observation of fire including some very pertinent remarks and practical suggestions, ranging, methods of ranging and aiming, etc. The author has handled a technical subject in a very satisfactory manner, and those who study the book will certainly acquire a practical knowledge of gunnery.

Jahrbuch für das Eisenhüttenwesen. (Supplement to "Stahl und Eisen".) A report on the progress in all departments of the iron industries in 1901. Prepared by direction of the Society of German Ironmasters by Otto Vogel. II. Year. Dusseldorf: 1903. Kommissionverlag von A Bagel. 16 + 464p. O. 10 Mk.

The purpose of this year book is well indicated in the preface to the present volume by the maxim, "The next best thing to knowing a thing is to know where it can be found when wanted." It affords the specialist a general view of the world's iron-trade literature of 1901 and that of allied branches of the industry, chemical technology, metallurgy, etc., and enables him to pick out what is of value to him readily and without loss of time.

The book consists of some fifteen chapters, each including numerous sections which are in many cases further subdivided, the arrangement of the work being analytical throughout. Under these various headings and subsections are grouped information on the subject and references to articles that have appeared during the year in the technical press. A list of the periodicals of which the contents have been noted extends over seven pages and includes all the principal technical journals of the chief countries of the world. It is pleasing to note the number of references to the JOURNAL U. S. ARTILLERY under the heading "guns and projectiles". The references are quite full and indicate clearly where the original article can be found, if wanted. In addition, the editor adds critical notes in many instances and gives abtracts of the more important papers. A full authors' index, with a subject-index also, is added for further ease of reference. The book is well printed and serviceably bound in red cloth.

The work is thoroughly and accurately done, and the completeness and methodical arrangement of its subject-matter should make this excellent Annual of great practical value to engineers and others engaged in the iron and steel industries who desire to keep abreast of the progress and developments of the times.

The Rifle Gallery: Its Construction and Use. For the National Guard, Schools and Clubs. Also a Chapter on Revolver Shooting. By James E. Bell, Major and Inspector General of Rifle Practice, District of Columbia Militia. Wilmington, Del: Laflin & Rand Powder Co. 1903. 99p. D. Paper, 10 cents.

This excellent booklet has been published with the idea of conveying information concerning the erection and use of indoor gallery ranges. Written by one who is an enthusiast on rifle practice and thoroughly familiar with his subject, it contains a fund of practical information, given in the clearest manner, which will enable those whose commands are not provided with the means of training their men in this most necessary branch of instruction, to construct a rifle gallery with but slight expense and to maintain it, also to furnish every detail of its equipment; and, after the range is ready for use, to train the soldier to become expert in the use of the rifle.

A chapter is given on the loading mechanism U. S. magazine rifle, model 1899, its operation and care, and one on the National Rifle Association of America and the Schools, containing orders and regulations issued by the War Department governing the details of instruction, etc., and the supply of ordnance and ordnance stores to assist in the training of the young men connected therewith.

The chapter on revolver shooting gives some sensible suggestions that will undoubtedly assist the novice in learning the use of this weapon.

This little book should accomplish much good in leading to greater development in markmanship, as it will be found of great practical value in all details connected with gallery practice and its preliminary training, the importance of which for good shooting cannot be overestimated. The book is well printed and illustrated. It sells for 10 cents, the cost of publication, and can be obtained by addressing the Bureau of Advertising, Laflin & Rand Powder Co., P. O. Drawer 1001, Wilmington, Del.

EXCHANGE AND BOOK NOTICES.

Historischer Rückblick auf die Verpflegung der Armeen im Felde. Oberst Otto Meixner. IV. Lieferung 1904. Wien: L. W. Siedel & Sohn. 214 p. O. Mk. 6.

The Military Law Examiner: Containing questions in Military Law from 1890 to 1903, together with the answers to them. By Lieut.-Colonel Sisson C. Pratt, Royal Artillery, (retired). 5th Edition. London: Gale & Polden, Ltd. 1903. 14+292 p. D. 4 shillings and sixpence.

The Militia and Volunteer Officers' Guide to Promotion: From the Rank of Subaltern to Field Officer. By Major S. T. Banning. New Edition, revised. London: Gale & Polden, Ltd. 1903. 166 p. D. Three-and-six.

The Soldier's Pocket Manual of Useful Information is an interesting little handbook of Gale & Polden's Military Series, which, compiled by Major S. T. Banning, gives the soldier many hints as to points connected with his duties both in the field and in quarters, and contains much information of interest to the soldier on all subjects connected with the British service.

It is not until one reads **Cassier's Magazine** that one really knows how attractive engineering subjects can be made, even to the man not in the profession. All its subjects are handled by specialists, the engravings and typography are excellent and the reader feels well repaid long before he gets to the end of the number.

The December number contains the following attractive series of articles:

Recent Developments in Niagara Power. With nine illustrations. By H. W. Buck.

Multi-Cylinder Locomotives. A Review of the World's Practice in Multi-Cylinder Simple and Compound Locomotives. With twenty-two illustrations. By J. F. Gairns.

The Science of Steam Generation. With ten illustrations. By F. J. Rowan, Asso. M. Inst. C. E.

Some Aspects of the Labor Problem. Business Principles in the Conduct of Industries. With portrait of the author. By Dr. Robert H. Thurston.

Modern Factory Traction. Applications of the Telpherage System. With seven illustrations. By Clarence J. Messer.

Vickerstown. A Model Industrial Settlement. With six illustrations. By a staff correspondent.

Ex-Secretary of the Navy John D. Long's history of the "**New American Navy**," which the **Outlook Company** is to publish soon, not only has great value as an important and authoritative historical work, but also will arouse great interest on account of the author's personal reminiscences of happenings while he was at the head of the Navy Department. He devotes considerable space to the Sampson-Schley controversy, and his review of it, from the point of view of the Navy Department, throws added light on this much discussed question, and makes it clear that the final decision was inevitable. The two volumes are to be fully illustrated with drawings by Henry Reuterdahl, the wellknown naval artist, and with many portraits, photographs and maps.

To all interested in the developments in art, decoration and designing, house furnishing, building of homes, etc., the **Craftsman** will be found of the greatest interest and value. The articles on these subjects that have appeared in recent numbers have been excellent and in its house series many practical and useful suggestions have been given.

In its December issue a department for the schools is opened. Its aim is to give a general survey of the progress of the new art in the schools of America and the Old World; to co-operate with teachers and students to the end of encouraging original and varied work in design; to present drawings of the work done in schools; to afford suggestions to students; and to demonstrate that art training and handicraft have a direct disciplinary value for the young.

Beginning with the new year it is purposed to publish every month designs of detached residences, of moderate cost. The plans will comprehend simple landscape gardening, in harmony with the architectural scheme; also complete *motifs* for decoration, with colored perspective of interior.

The Craftsman is published monthly by the United Crafts at Syracuse, New York. Subscription price, $3.00 per year, or 25 cents per copy.

Among our advertising pages will be found the conditions governing the award of the **Enno Sander Prize** of the Association of Military Surgeons of the United States which for lack of space we omit here.

INDEX TO CURRENT MILITARY LITERATURE.

[For Abbreviations used in Index see first number of each *volume.*]

[Periodicals of August, September, October, 1903.]

ARTILLERY MATERIAL.

High explosives: their safe and economical method of handling.—**Iron Age**, August 27; **Eng. and Min. Jour.**, September 19.

Considerations on the choice and use of explosives in war.—**M. de Art.**, August.

A new safety explosive.—**Trans. A.S.C.E.**, volume 50.

Springs.—**Amer. Manfr.**, August 13, 20.

Lacquers and paints for metals.—**Eng.**, September 11, 18, October 16.

Target for training range takers with the D.P.F. in drill halls or other places where only a small space is available.—**Proc. R.A.I.**, April-June.

A useful light for Q.F. work.—**Proc. R.A.I.**, April-June.

Guns and armor.—**A. and N. Gaz.**, August 29.

Renewal of the struggle between guns and armor.—**A.S.M. Zeit.**, October 10.

New 16-inch coast defence gun.—**Page's Mag.**, September.

The Russian field gun, M/1900.—**Wochenblatt**, September 1.

Vickers Maxim dismountable gun.—**Scien. Amer.** Supplement, October 3.

Re-armament of the Swiss field artillery.—**Proc. R.A.I.**, April-June; **Int. Rev.** Supplement, 54.

New armament adopted for the Swiss artillery.—**M. de Art.**, August.

The material for the next field artillery.—**R. Artig.**, July-August.

The new Italian field artillery.—**R.M. Suisse**, August.

Field artillery re-armament, England.—**A. and N. Gaz.**, October 24.

Artillery harness, Austro-Hungarian artillery.—**R. Artillerie**, September.

Improved breech mechanism for heavy guns.—**Scien. Amer.**, August 29.

The Richards prismatic stadia as a range finder.—**Eng. C. Phila.**, July.

Instruments for aiming and laying guns and for range finding: coast artillery fire.—**M. de Art.**, August.

AUTOMOBILES, BICYCLES. AEROSTATION.

A military airship.—**U. S. Gaz.**, September 19.

Mechanical principles of the art of flight.—**Zeitschr. I.A.V.**, October 16, 23,

Military balloons in the British army.—**Genie M.**, September

The Spencer airship of 1903.—**Scien. Amer.**, September .

Experiments and observations on soaring flight.—**W. Soc. Eng.**, August.

Experiments with motor driven aeroplanes.—**Scin. Amer.**, September 19.

The flying machine and its slow development.—**Scien. Amer.** Supplement. September 12.

The Berliner aeroplane.—**Scien. Amer.**, September 26.

A new aeroplane.—**Scien. Amer.**, October 10.

Santos-Dumont airships to be used by the French War Department.—**Scien. Amer.**, October 24.

The Lebaudy airship.—**Scien. Amer.** Supplement, October 10.

Motor car trials, England.—**Eng.**, September 25, October 2.
Developments in automobile construction.—**Eng.**, September 25, October 2.
Mechanical traction in the 1902 maneuvers.—**Wochenblatt**, September 5.
Automobile construction.—**Amer. Mach.**, October 8, 15, 29.
New motocycles.—**Scien. Amer.**, Supplement, September 19.

BALLISTICS.

Corrections for the error of the day for the 15-pdr. gun.—**Proc. R.A.I.**, April-June.
Armor perforation formulas.—**Proc. R.A.I.**, April-June.
Armor for ships (tests, period 1897-1900).—**R. Maritt.**, August-September.
Armor piercing projectiles and critical velocities.—**Eng.**, October 30.
The Admiralty and capped shot.—**U. S. Gaz.**, October 31.

CHEMISTRY AND PHOTOGRAPHY.

The heat test.—**Arms and Explo.**, September.
Blue print paper, blue lines on white ground.—**Amer. Mach.**, September 3.
A rapid blue print frame.—**Amer. Mach.**, September 24.
Correction of various aberrations in a photographic lens.—**Photo. Jour.**, July.
Photomicrography of metals.—**Photo. Jour.**, July.
Highest development factor obtainable in any plate.—**Photo. Jour.**, July.
Blue print cloth.—**Amer. Mach.**, October 15.
Photography in colors—the three-color method.—**Scien. Amer.**, September 12.

DRILL REGULATIONS, MANEUVERS AND PRACTICE.

Draft of regulations on infantry drill and maneuvers.—**R. Inf.**, August, September, October.
Instruction of personnel in the artillery and actual fire for effect under service conditions.—**R. Artillerie**, August.
New scheme of firing instruction for infantry, etc., Austro-Hungary.—**R. M. Suisse**, September.
The new firing regulations for field batteries.—**M. de Art.**, August.
New "combined training" for the English army and recent tactical regulations, Italian army.—**R. Artig.**, July-August.
Battle training of the sotnia.—**Sbornik**, September.
Is our system of musketry instruction up-to-date?—**Sbornik**, September.
Training of infantry as skirmishers.—**Jahrbuecher**, September.
Infantry fire instruction with respect to battle conditions.—**Int. Rev.**, Supplement, 54.
Expert marksmen and estimaters of distances: their utility, means of training them and of employing them.—**R. Inf.**, September, October.
New small arms firing regulations for cavalry, France.—**R. Cav.**, October.
The French maneuvers, 1903.—**A. Marine**, September 13.
The grand maneuvers.—**Belgique M.**, August 23.
Autumn maneuvers.—**Exercito**, August.
Coast defense maneuvers, U. S., 1902.—**Eng. Mil.**, June.
Attacks on coast fortifications, French naval maneuvers, 1902.—**Eng. Mil.**, June.
Remarks on landing maneuvers in the bay of Eckenforde.—**Wochenblatt**, September 22.

ELECTRICITY.

Alternating current switchboards.—**Elec. World**, September 26, October 3, 10.
Electricity in the shop: connections in common use.—**Amer. Mach.**, August 13, 20.
Evershed testing set.—**Elec. World**, September 19.
Dispersion lenses for searchlight projectors.—**Elec. Rev.**, October 31.
Aluminum conductors for electric transmission lines.—**Eng. Mag.**, September.
New form of water rheostat.—**Elec. Rev.**, September 26.
Shop testing of motors and generators for commercial service.—**Elec. Rev.**, September 19, 26.
The grounded wire as protection against lightning.—**Trans. Inst. Elec. E.**, August-September.
Testing of electric apparatus for dielectric strength.—**Trans. Inst. Elec. E.**, August-September.
Use of automatic means for disconnecting disabled apparatus.—**Trans. Inst. Elec. E.**, August-September.
Speed regulation of motors.—**Amer. Manfr.**, August 27, September 3.
Electricity in the shop, care of apparatus and common troubles.—**Amer. Manfr.** September 17, 24, October 1.
Operation of rotary converters.—**Amer. Elec.**, September.
Measurement of power in alternating current circuits.—**Amer. Elec.**, September; **Eng. Cleve.**, October 1.
Practical storage battery operation.—**Amer. Elec.**, September.
Parallel working of alternators.—**Eng'ing**, October 2; **Elec. Rev.**, October 10; **Amer. Elec.**, October.
Three-phase power measurements.—**Elec. World**, October 10.
Motor and dynamo failures: their nature and causes.—**Eng'ing News**, September 3.
Regulation of transmitted power.—**Elec. Rev.**, September 12.
Total and free energy of the lead accumulator.—**Elec. Rev.**, October 31.
Simple alternating current booster.—**Amer. Elec.**, October.
Rheostats for dynamo load tests.—**Amer. Elec.**, October.
Curves as used in dynamo testing.—**Eng. Cleve.**, September. 1.
Charging device for batteries.—**West. Elec.**, October 24.
The Heyland induction motor.—**Jour. Eng. Soc.**, September.
The induction motor and its engineering capabilities.—**Frank. Inst.**, September, October.
An English Edison battery test.—**Scien. Amer.**, Suplmt., October 17.
Tests of the Edison storage battery.—**Elec. World**, September 12.
Commercial alternator design.—**Trans. Inst. Elec. E.**, August-September.
The storage battery in sub-stations.—**Trans. Inst. Elec. E.**, August-September.
New Edison storage battery.—**Umschau**, October 17.

ENGINEERING AND FORTIFICATIONS.

Report upon engineering education.—**Tech. Quart.**, September.
Action of sea worms on foundations in Boston Harbor.—**Jour. Eng. Soc.**, August,
Methods of making concrete impervious to water.—**Proc. A.S.C.E.**, September.
An alternative line for the Nicaragua canal and a proposed new method of dam construction.—**Trans. A.S.C.E.**, vol. 50.

ENGINES, BOILERS AND MECHANISM.

New oil engine.—**Aner. Manfr.**, August 27.
Combustion engines.—**Eng. Cleve.**, September 15, October 1, 15.
The Mietz and Weiss marine oil engine.—**Iron Age**, September 3.
Oil engines for electrical use.—**Elec. Rev.**, September 19.
Future of the steam engine.—**Amer. Mach.**, August 27.
Water and heat consumption of a compound engine at various powers.—**Eng. Cleve.**, October 15.
Development of the steam turbine.—**West. Elec.**, September 12, 19, 26, October 3.
Curtis steam turbine.—**Elec. World**, October 10.
Notes on safety valve practice.—**Eng. Cleve.**, October 1.
A new theory of heat power plants.—**Eng.**, August 14, 21.
Cylinder oil and cylinder lubrication.—**Eng.**, August 14.
Recent developments of the steam turbine.—**Eng. Mag.**, October; **Elec. World**, September 12.
Entropy, or thermodynamics from an engineer's standpoint.—**Eng'ing**, September 4, 11, 18.
Theory of lubrication.—**Amer. Manfr.**, September 24.
Fly-wheels.—**Eng. Cleve.**, October 15.
Alloys for bearing purposes.—**Eng. & Min. Jour.**, September 12.
A prony brake controller.—**Elec. Rev.**, October 24.
Experiments, formulas and constants of lubrication of bearings.—**Amer. Mach.**, September 10, 17, 24.
A new form of friction clutch.—**Amer. Mach.**, September 17; **Scien. Amer.**, Suplmt., October 3.
Indicator diagrams.—**Amer. Elec.**, October.

METALLURGY.

Micrographic study of cast iron.—**Page's Mag.**, August.
Nickel steel: its properties and appplications.—**Iron Age**, August 20; **Eng. & Min. Jour.**, October 10; **Amer. Mach.**, October 8; **Scien. Amer. Suplmt.** October 24.
The light aluminum alloys.—**Iron Age**, August 13; **Eng. & Min. Jour.**, October 3.
The naval gun foundry, U. S.—**Iron Age**, September 24.
Notes on the microstructure of steel.—**Iron Age**, October 29.
The great Krupp works.—**Mar. Rev.**, August 20.
Drop forging.—**Iron Age**, August 27.
Malleable cast-iron.—**Eng.**, August 21.
Metallography of iron and steel.—**Eng. Mag.**, September.
Some elements used in steel making.—**Eng.**, September 18.
Steel and the microscope.—**Eng.**, September 11.
Microscopic metallography and its use as a method of tests.—**Memories I. C.**, July.
Electrometallurgy.—**M. de Art.**, August.
Influence of silicon on iron.—**Eng'ing**, September 18.
German presses for armor plate.—**Amer. Manfr.**, September 10.
Crystallization of iron and steel.—**Amer. Manfr.**, September 17, 24, October 1.
Manufacture of steel by electricity.—**R. Artillerie**, September.
Researches on manganese steel.—**Genie C.**, August 22, 29.
Alloys of iron and tungsten.—**Eng'ing**, September 4, 11.

MILITARY GEOGRAPHY.

MILITARY HISTORY.

MILITARY SCHOOLS.

ORGANIZATION AND ADMINISTRATION.

Von Lobell annual reports, 1902.—**U. S. Gaz.**, October 31; **Jour. R. U. S. I.**, October.
The future of the army.—**U. Serv.**, November.
Departments in war.—**Jour. R. U. S. I.**, September.
Administration of the navy.—**Eng'ing**, October 2.
Bureaus and the general board, U. S. navy.—**A. & N. Jour.**, September 12.
Engineering in the navy.—**Mar. Rev.**, August 27.
The French naval program of 1900-1906.—**Jour. R. U. S. I.**, September, October.
The administration of the navy.—**Yacht**, September 5.
The control of the administration of the navy.—**R. Maritime**, July, August, September.
The naval establishment of Brazil.—**R. Marit. Brazil**, July.
Service and discipline on board our warships.—**R. Marit. Brazil**, July.
Notes on naval military art.—**R. de Mar.** June, July.
The Spanish navy.—**R. de Mar.**, June.
Gunnery pay in the U. S. navy.—**A. & N. Gaz.**, September 12.
The American fighting fleet.—**Cas. Mag.**, September.
Some weak points of naval administration.—**U. Serv. Mag.**, September.
Volunteer naval reserves in England.—**Yacht**, October 10.
French naval budget for 1904 and the mobile defenses.—**Yacht**, October 10.

SMALL-ARMS AND EQUIPMENTS.

Apparatus for limiting the angle of fire of rifles.—**R. Artillerie**, August.
Cap testing.—**Arms & Expl.**, September.
Retention of the saber as a cavalry weapon.—**Jour. U. S. Cav.**, October.
Extensible holster for fire-arms.—**Jour. U. S. Cav.**, October.
Trials of new small arms by troops, Austro-Hungary (automatic pistols etc.).—**Wochenblatt**, September 12, 24, 26.
New intrenching tool.—**Jour. M. S. I.**, November-December.
Webley-Fosbery automatic revolver.—**Jour. M. S. I.**, November-December.
Old and new weapons and arms factories in Japan.—**Wochenblatt**, August 25.
In what respect is improvement in the infantry rifle to be urged?—**Wochenblatt**, September 5.
New rifle for the United States army.—**R. of Rev.**, November.
Sight for U. S. Springfield rifle.—**S. & Fish.**, October 1, 8.
Telescopic sights for small arms.—**S. & Fish.**, October 29.
New Bergmann pistol.—**S. & Fish.**, October 29.
The hyposcope, instrument for taking aim behind cover without exposure. —**Scien. Amer.**, September 26.
The sub-target gun machine.—**Scien. Amer.**, October 17.
Individuality and invisibility in uniforms.—**Jour. U. S. I. India**, July.
Litters for carrying sick and wounded.—**Jour. U. S. I. India**, July.
The new uniform, France.—**A. Marine**, September 13.
Questions of uniform.—**Yacht**, September 19.
Goerz military field glasses.—**M. de Art.** August.
Does the 8-power Zeiss field glass answer all the requirements of war.—**A. S. M. Zeit.**, August 29; September 5.
Infantry equipment.—**Jour. R. U. S. I.**, August.
Uniforms of army officers.—**A. & N. Jour.**, October 33.
The new cartridge belt.—**A. & N. Reg.**, November 7.

STRATEGY AND TACTICS.

Strategy and tactics in mountain ranges.—**U. Serv. Mag.**, September, October.

The offensive in the defense of fortified positions.—**Int. Rev.**, Suplmt. 54.

England and the double alliance on the sea.—**R. Mil. Portugal**, September 15.

Heavy artillery of the army in the attack of fortified field positions, Germany.—**R. Artillerie**, August.

Employment of artillery according to the new requirements of the infantry battle.—**R. M. Suisse**, September; **R. Artig.**, July-August.

Machine guns.—**R. Mil. Portugal**, September 30, **A. S. M. Zeit.**, September 26.

Essay on focussing (discussion on cavalry tactics, formations etc.)—**R. Cav.**, August.

Cavalry machine guns.—**R. Cav.**, August, September.

Cavalry of the future.—**S. M. Blaetter**, August.

Role of cavalry.—**Int. Rev.**, Suplmt. 54.

Cavalry and the gun.—**R. Cav.**, September.

The transformation of cavalry.—**R. Cav.**, September.

Once more deep or broad lines of skirmishers.—**Wochenblatt**, August 29.

In the infantry (tactics, the attack, fire discipline, etc.).—**R. M. Suisse**, August-September.

Note on field service in the French army.—**R. M. Suisse.**, August.

Study of a question of tactics.—**R. Univ.**, September, October.

Applied questions of field service (tactical problems).—**R. Inf.**, August, September, October.

Tactics of today.—**Eng. Mil.**, June.

The way round a flank.—**U. Serv. Mag.**, September.

Initiative and responsibility.—**Cercle**, August 22.

Tactical problem.—**Cercle**, September 19.

How dense should skirmishing lines be?—**Wochenblatt**, September 22.

New and old tactics.—**A. S. M. Zeit.**, September 5, 12.

Tactical lecture on a catechetical system.—**Jour. R. U. S. I.**, August.

Method of intervention in battle.—**Jahrbuecher**, September.

The new field service regulations of the French army and their importance as regards tactics and army affairs.—**Int. Rev. Beiheft**, 43.

Tactics of the English after the Transvaal war, according to their latest regulations.—**R. Inf.**, October.

German ideas on tactics: influences of the South-African War.—**Cientifico**, September 1, 15.

The tactics of the gun.—**Page's Mag.**, August.

SUBMARINES, TORPEDO BOATS AND WARSHIPS.

The submarines Farfadet and Korrigan at Bizerta.—**A. Marine**, September 13.

England and the modern submarine.—**R. G. de Marina**, September.

On the use of submarines.—**Seewesens**, 10, 1903.

New type of submarine boat.—**Schiffbau**, October 8.

Submarine navigation.—**Mar. Rev.**, September 3.

Success of British submarines.—**U. S. Gaz.**, October 31.

The torpedo.—**A. Marine**, August 30.

The Whitehead torpedo.—**Club Mil. Nav.**, July-August.

CONTENTS BY NUMBERS.

NO. 1.

NO. 2.

CONTENTS BY NUMBERS.

NO. 3.

INDEX TO VOLUME XX.

JULY—DECEMBER.

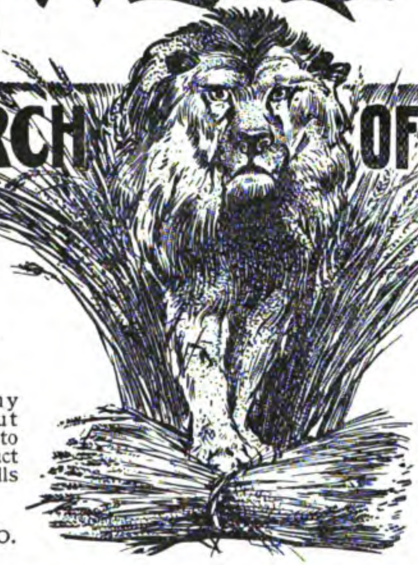
I. Authors.

II. Subjects.

III. Book Reviews.

WHEATLET

MONARCH OF CEREALS



Thousands Say This:

Have tried many breakfast foods, but never found one equal to Wheatlet — the product of the Franklin Mills Company.

Mrs. W. M. AMOS,
Columbus, O.

The Consensus of Opinion;

I find Wheatlet one of the very best foods extant and would be almost lost without its aid in catering to a rather hard-to-suit family.

Mrs. E. L. WILLIAMS,
West Medway, Mass.

The cereal food question ceases to be important unless you discriminate among the mass of worthless cereals on the market. In WHEATLET you obtain the result of 20 years' scientific investigation—a food containing the maximum amount of energy possessed by the Worlds' choicest wheat, from which only

WHEATLET

is made. Nature commands you to eat Wheatlet morning after morning—constantly and regularly—by endowing Wheatlet with a delicious taste that never palls on even a fickle appetite.

Everyone should write us at once for a copy of U. S. Government Official Cereal Analyses, showing falsity of the claims of many widely advertised cereal foods and the superiority of WHEATLET.

All leading Grocers sell Wheatlet. Be sure of our name on the box.

The Franklin Mills Company,

"All the Wheat that's Fit to Eat,"

729 FRANKLIN SQUARE, LOCKPORT, N. Y.

Holidays

Waterman's Ideal Fountain Pen

L. E. Waterman Co.

Main Office

Johnston's HOLIDAY STOCK

CUT GLASS, CHINA,
LAMPS,
CHAFING DISHES

BRUSHES and COMBS
SHAVING SETS
MILITARY BRUSHES

Now Ready

FOR YOUR INSPECTION

JOHNSTON'S,

NORFOLK, VA.

Take a Sea Trip

COMFORT, PLEASURE, and RECREATION

Merchants and Miners Trans. Co.

"QUEEN OF SEA ROUTES"

APR [illegible] 1914