United States Centennial Commission.

INTERNATIONAL EXHIBITION,
1876.

REPORTS AND AWARDS

GROUP XVI.

EDITED BY
FRANCIS A. WALKER,
CHIEF OF THE BUREAU OF AWARDS.

PHILADELPHIA:
J. B. LIPPINCOTT & CO.
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SYSTEM OF AWARDS

[*Extract from Circular of April* 8, 1876.]

Awards shall be based upon written reports attested by the signatures of their authors.

The Judges will be selected for their known qualifications and character, and will be experts in departments to which they will be respectively assigned. The foreign members of this body will be appointed by the Commission of each country and in conformity with the distribution and allotment to each, which will be hereafter announced. The Judges from the United States will be appointed by the Centennial Commission.

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Reports and awards shall be based upon inherent and comparative merit. The elements of merit shall be held to include considerations relating to originality, invention, discovery, utility, quality, skill, workmanship, fitness for the purposes intended, adaptation to public wants, economy and cost.

Each report will be delivered to the Centennial Commission as soon as completed, for final award and publication.

Awards will be finally decreed by the United States Centennial Commission, in compliance with the Act of Congress, and will consist of a diploma with a uniform Bronze Medal, and a special report of the Judges on the subject of the Award.

Each exhibitor will have the right to produce and publish the report awarded to him, but the United States Centennial Commission reserves the right to publish and dispose of all reports in the manner it thinks best for public information, and also to embody and distribute the reports as records of the Exhibition.

ORGANIZATION AND DUTIES OF THE JUDGES.

[*Extract from Circular of May* 1, 1876.]

Two hundred and fifty Judges have been appointed to make such reports, one-half of whom are foreigners and one-half citizens of the United States. They have been selected for their known qualifications and character, and are presumed to be experts in the Groups to which they have been respectively assigned. The foreign members of this body have been appointed by the Commission of each country, in conformity with the distribution and allotment to each, adopted by the United States Centennial Commission. The Judges from the United States have been appointed by the Centennial Commission.

To facilitate the examination by the Judges of the articles exhibited, they have been classified in Groups. To each of these Groups a competent number of Judges (Foreign and American) has been assigned by the United States Centennial Commission. Besides these, certain objects in the Departments of Agriculture and Horticulture, which will form temporary exhibitions, have been arranged in special Groups, and Judges will be assigned to them hereafter.

The Judges will meet for organization on May 24, at 12 M., at the Judges' Pavilion. They will enter upon the work of examination with as little delay as practicable, and will recommend awards without regard to the nationality of the exhibitor.

The Judges assigned to each Group will choose from among themselves a Chairman and a Secretary. They must keep regular minutes of their proceedings. Reports recommending awards shall be made and signed by a Judge in each Group, stating the grounds of the proposed award, and such reports shall be accepted, and the acceptance signed, by a majority of the Judges in such Group.

The reports of the Judges recommending awards based on the standards of merit referred to in the foregoing System of Awards, must be returned to the Chief of the Bureau of Awards not later than July 31, to be transmitted by him to the Centennial Commission.

Awards will be finally decreed by the United States Centennial Commission, in compliance with the Act of Congress of June 1, 1872, and will consist of a special report of the Judges on the subject of the Award, together with a Diploma and a uniform Bronze Medal.

Upon matters not submitted for competitive trial, and upon such others as may be named by the Commission, the Judges will prepare reports showing the progress made during the past hundred years.

Vacancies in the corps of Judges will be filled by the authority which made the original appointment.

No exhibitor can be a Judge in the Group in which he exhibits.

An exhibitor, who is not the manufacturer or producer of the article exhibited, shall not be entitled to an award.

The Chief of the Bureau of Awards will be the representative of the United States Centennial Commission in its relations to the Judges. Upon request, he will decide all questions which may arise during their proceedings in regard to the interpretation and application of the rules adopted by the Commission relating to awards, subject to an appeal to the Commission.

A. T. GOSHORN,

Director-General.

[*Extract from Director-General's Address to Judges, May* 24, 1876.]

"The method of initiating awards which we have adopted differs in some respects from that pursued in previous exhibitions. In place of the anonymous verdict of a jury, we have substituted the written opinion of a Judge. On this basis awards will carry the weight and guarantees due to individual personal character, ability, and attainments, and to this extent their reliability and value will be increased. It is not expected that you will shower awards indiscriminately upon the products in this vast collection. You may possibly find a large proportion in no way raised above the dead level, nor deserving of particular notice. The standard above which particular merit worthy of distinction begins is for you to determine. In this regard I have only to express the desire of the Centennial Commission, that you should do this with absolute freedom, and when you meet with a product which you consider worthy of an award, we desire you to say, in as few words as you may deem suitable, why you think so.

"This, gentlemen, is all we ask of you in the Departments of Awards. Opinions thus expressed will indicate the inherent and comparative merits, qualities, and adaptations of the products,—information which the public most desires.

"Elaborate general reports and voluminous essays, though of great value as sources of general information, give little aid in determining the reliable or intrinsic merits of particular, individual products.

"The regulations which have been published divide the work of awards into three parts:

"1st. The individual work of the Judges.

"2d. The collective work of the groups of Judges.

"3d. The final decisions of the United States Centennial Commission in conformity with the acts of Congress.

"Each award will thus pass three ordeals, which, doubtless, will be ample and satisfactory."

GROUP XVI.

JUDGES.

AMERICAN.	FOREIGN.
S. C. Lyford, U. S. A.	Wm. H. Noble, R. A., Great Britain.
H. L. Abbot, U. S. A.	A. Lesne, Belgium.
Geo. A. Hamilton, St. Paul, Minn.	L. P. de Saldanha da Gama, Brazil.

GROUP XVI.

MILITARY AND SPORTING ARMS, WEAPONS, APPARATUS OF HUNTING, EXPLOSIVES, ETC.

CLASS 265.—Military small-arms, muskets, pistols, and magazine guns, with their ammunition.

CLASS 266.—Light artillery, compound guns, machine guns, mitrailleuses, etc.

CLASS 267.—Heavy ordnance and its accessories.

CLASS 268.—Knives, swords, spears, and dirks.

CLASS 269.—Fire-arms used for sporting and hunting; also other implements for the same purpose.

CLASS 270.—Traps for game, birds, vermin, etc. (For apparatus of fishing, see Group V.)

CLASS 204.—Explosive and fulminating compounds, in small quantities only, and under special regulations; shown in the building only by empty cases and cartridges. Black powder of various grades and sizes. Nitro-glycerine, and the methods of using and exploding. Giant powder, dynamite, dualin, trinitro-glycerine.

CLASS 205.—Pyrotechnics, for display, signaling, missiles, etc.

GENERAL REPORT

OF THE

JUDGES OF GROUP XVI.

INTERNATIONAL EXHIBITION,
Philadelphia, 1876.

PROF. F. A. WALKER, *Chief of Bureau of Awards:*

SIR,—The Judges of Group XVI. have the honor to submit the following general report upon the part of the International Exhibition committed to them for examination.

Very respectfully your obedient servants,

HENRY L. ABBOT,
Bvt. Brig.-General U. S. A., Chairman.

WM. H. NOBLE,
Major Royal Artillery, Secretary.

GROUP XVI.

MILITARY AND SPORTING ARMS, WEAPONS, EXPLOSIVES, ETC.

The exhibits assigned to this group comprised military and sporting arms, weapons, apparatus of hunting, explosives, etc., divided into eight classes, as follows:

1. CLASS 265.—Military small-arms, muskets, pistols, and magazine-guns, with their ammunition.
2. CLASS 266.—Light artillery, compound-guns, machine-guns, mitrailleuses, etc.
3. CLASS 267.—Heavy ordnance and its accessories.
4. CLASS 268.—Knives, swords, spears, and dirks.
5. CLASS 269.—Fire-arms used for sporting and hunting, also other implements for the same purpose.
6. CLASS 270.—Traps for game, birds, vermin, etc. (For apparatus of fishing, see Group V.)
7. CLASS 204.—Explosive and fulminating compounds, in small quantities only, and under special regulations; shown in the building only by empty cases and cartridges. Black powder of various grades and sizes. Nitro-glycerine, and the methods of using and exploding. Giant powder, dynamite, dualin, tri-nitro-glycerine.
8. CLASS 205.—Pyrotechnics, for display, signaling, missiles, etc.

Six Judges were charged with the examination of these and of other military articles displayed at the Exhibition, and with reporting upon the same, viz.:

General H. L. Abbot, U. S. Army, *Chairman.*

Major W. H. Noble, British Royal Artillery, *Secretary.*

Colonel S. C. Lyford, U. S. Army.

Captain L. F. Saldanha da Gama, Brazilian Navy.

Captain Commandant A. Lesne, Belgian Artillery.

Mr. George A. Hamilton, Minnesota.

In submitting a report on the work intrusted to them, the Judges of Group XVI. regret that it was not in their power to apply any practical tests to the various military and sporting arms, explosives, etc., that came under their notice. In the absence of such tests, they do not feel justified in discussing here the relative merits of the different articles which were exhibited in this group, but propose to confine their observations to a general description of some of the principal objects, and to a brief history of the progress made in small-arms, artillery, and explosives during the past century. For this purpose it has been thought desirable to divide the descriptive portion of the subject by nationalities, and to conclude by treating the historical portion in a general manner.

UNITED STATES.

The exhibit of the United States in Group XVI. was exceedingly full and interesting. The warlike material was chiefly displayed by the Government, but in the class of small-arms, both military and sporting, many private individuals offered fine collections. The Government exhibit was divided between the Engineer, Ordnance, Quartermaster, and Signal Bureaus of the War Department, and the Bureau of Ordnance of the Navy Department. A brief summary of the more interesting articles of each of these displays will be made in turn.

The Engineer Department of the Army exhibited, by models floating in a glass tank and by the actual matériel itself, General Abbot's system of defensive torpedoes adopted for obstructing the channels and harbors of the United States. Interesting models also illustrated the system of trials carried out at Willet's Point, New York, in experimentally developing the subject of submarine mining. The adopted bridge-equipage of the army was shown, together with beautifully executed models of both reserve- and advance-guard trains; also the photographic outfit used by the Engineer troops for copying maps in the field, and the siege and mining tools of the army. This Bureau also exhibited models of gun-carriages devised by officers of the Corps of Engineers, two of which are especially interesting: one, a depressing carriage made by General (then Major) De Russy in 1835, contains the Moncrieff principle which has recently excited so much attention in Europe; the other is the well-known depressing carriage of Major King, adapted to guns of large calibre. The details of the block-houses elaborated by Colonel Merrill, used by the United States in defending important bridges on long lines of railway, also shown by a model, are worthy of careful study.

The Ordnance Department of the Army had an exceedingly full and interesting exhibit. In the classes of heavy and field-artillery the following table furnishes details of the more important guns, but there were many experimental and superseded patterns which well indicated the past and present course of investigation in the United States:

DIMENSIONS.	20-INCH SMOOTH BORE.	THOMPSON 12-INCH BREECH-LOADING RIFLE.	WOODBRIDGE 10-INCH MUZZLE-LOADING RIFLE.	SUTCLIFF 9-INCH BREECH-LOADING RIFLE.	MANN 8.4-INCH BREECH-LOADING RIFLE.	U. S. 8-INCH CONVERTED MUZZLE-LOADING RIFLE.	13-INCH SEA-COAST MORTAR.	U. S. 4.5-INCH MUZZLE-LOADING RIFLE.	U. S. 3-INCH MUZZLE-LOADING RIFLE.	PARROT 3-INCH MUZZLE-LOADING RIFLE.
Total weight, pounds	115,100	84,280	30,300	44,800	20,000	16,160	17,120	3450	820	890
Length of bore, inches	243	192	155	148	144	117	35	120	65	70
Calibre, inches	20	12	10	9	8.4	8	13	4.5	3	3
Number of grooves	....	7	19	36	11	15	....	11	7	3
Feet for one turn	....	70	50	45	60	40	....	15	11	10
Projectile, pounds	1080	600	400	230	168	180	200	30	10	10
Charge, pounds	200	120	70	45	30	35	20	3.25	1	1
Powder, kind	Hex.	Hex.	Hex.	Hex.	Hex.	Hex.	....	....	....	....
Muzzle velocity, feet	1386		1350	1417	1406	1411	....	1280	1232	1232
Preponderance, pounds	0	0	100	0	....	....	....	....	....	....

The Laidley gun-lift, worked by hydraulic jacks acting upon levers, merits attention as a portable and effective means of dispensing with blocking in mounting and dismounting heavy guns. The collection of artillery projectiles and fuses, also, was especially full and interesting. In machine-guns the Gatling and Hotchkiss patterns, together with many now superseded, were exhibited. In military small-arms the display was peculiarly interesting, being arranged to mark the successive steps of progress since the ante-Revolutionary period. But perhaps the most attractive part of the ordnance exhibit consisted of the gun-making and metallic-cartridge machinery in actual operation. The precision and rapidity of this work is admirable, and well maintains the reputation long held by the United States in this branch. A good collection of instruments employed in testing ordnance was shown in a small laboratory, which was constructed upon a plan designed by Colonel Laidley expressly with a view to a possible explosion. The building consisted of an iron frame covered with boards arranged to yield readily to a force from within. An accident which occurred in 1875 demonstrated the merit of this plan. The instruments are excellent in construction, the chief novelties being Colonel Benton's thread-velocimeter and an improvement upon the Shultz chronoscope, whereby the troublesome mercury break circuit is avoided.

The Quartermaster Department of the Army exhibited, at work, a Warth machine, by which 500 uniform coats, or 1000 pairs of trousers, can be cut daily; also, a screwing-machine for soling shoes; also, a fine cloth-testing machine, devised by General Meigs. An admirable display of uniforms, harness, camp-equipage, and tools was also made. One of the wagons, still in running order, had nearly five years of active service during the late war, traveling over 4000 miles with the Army of the Potomac and with General Sherman. The veterinary exhibit of this department is worthy of special notice, as showing the system of shoeing in use by the army. It contained many specimens to illustrate the injuries and diseases of the horse.

The Signal Service Bureau made an interesting exhibit, especially of its field-telegraph train, consisting of one battery, four wire-, and four lance-wagons, capable of transporting fifty miles of portable telegraph line; also of its flags, heliographs, and other apparatus for communicating signals for an army in the field.

The Bureau of Ordnance of the Navy made a large and attractive display of material used by that branch of the service. In artillery- and machine-guns the collection was specially designed to give an idea of the successive stages of progress during the past century. The following table furnishes details respecting the larger guns:

DIMENSIONS.	15-INCH SMOOTH BORE.	11-INCH SMOOTH BORE.	9-INCH SMOOTH BORE.	8-INCH SMOOTH BORE.	8-INCH CONVERTED RIFLE.	100-PDR. PARROTT RIFLE.	60-PDR. PARROTT RIFLE.
Total weight, pounds.	42,000	15,700	9,000	6,500	17,275	9,700	5,400
Length of bore, inches	146	131	107	96	126	130	105
Calibre, inches..........	15	11	9	8	8	6.4	5.3
Number of grooves....	....	....	....	....	15	9	7
Feet for one turn	....	....	....	....	40	18	12
Projectile, pounds......	Shot, 440 Shell, 352	Shot, 166 Shell, 138	Shot, 90 Shell, 74	Shot, 64 Shell, 53	Shell, 180	Shell, 96	Shell, 55
Charge, pounds.........	100 35	15	10	7	20 35	10	6
Powder, kind............	Cannon.	Cannon.	Cannon.	Cannon.	Rifle.	Rifle.	Rifle.
Muzzle velocity, feet..	1560 1160	1,270	1,350	1,330	1270 1450	1,250	1,200

In projectiles, fuses, small-arms, and equipments generally the naval exhibition was extensive and interesting. The display of offensive torpedoes was especially worthy of notice, as it included specimens of all the varieties of that class of weapon now under trial. The Lay and Ericsson torpedoes, which remain under the control of the operator during their run; a fish torpedo of the Luppis-Whitehead type; the Harvey torpedo, a similar device, constructed at Goat Island; and the Barber torpedo; and, finally, the Spar topedo, as now supplied to our war vessels, were all shown. The small articles, fuses, key-boards, and Farmer's dynamo-electric-machine used for firing completed this interesting display.

Among the more conspicuous of the private exhibits of the United States in Group XVI. may be mentioned that of the South Boston

Iron Co., which maintained its high reputation by a fine display of field-guns and projectiles. Dr. R. J. Gatling showed several of his well-known machine-guns of different calibres, and, especially, a new five-barreled pattern, which contains several improvements, and is well worthy of notice. Among the small-arm exhibits, that of E. Remington & Sons was especially conspicuous from its size; and those of Colt's Fire Arms Manufacturing Co., Sharps Rifle Co., the Whitney Arms Co., Winchester Repeating Arms Co., Providence Tool Co., Smith & Wesson, F. Wesson, and others, well maintained the reputation of American small-arms. Among the novelties may be mentioned the new magazine-guns shown by the Evans Rifle Manufacturing Co., and by Colt's Patent Fire Arms Manufacturing Co.

GREAT BRITAIN.

It is much to be regretted that Great Britain did not attempt any display of its implements of war. The admirable workmanship and thorough efficiency of the ordnance manufactured in England, both in the Royal Arsenal and by private firms, are well known. The 80-ton gun now under trial at Woolwich is the largest piece of rifled ordnance in the world, and the Judges have reason to believe that still larger guns are in course of construction at Elswick by the firm of Sir William Armstrong & Co. The display, however, by Great Britain of sporting arms was both extensive and varied. All the leading manufacturers were represented, and the exhibits fully maintained the character of British sporting guns. Mr. James Purdey, of 314½ Oxford Street, London, showed some very fine specimens of his celebrated shot-guns and express-rifles, illustrative of his snap-action and double-lock. Mr. Alexander Henry, of 12 South St. Andrew Street, Edinburgh, exhibited some admirable specimens of breech-loading express-rifles for deer-stalking and for the destruction of all kinds of large and dangerous game. Messrs. Lang & Sons, of 22 Cockspur Street, Pall Mall, London, exhibited some very fine specimens of their well-known self-cocking double breech-loading sporting guns. Messrs. Lancaster, Rigby, Scott, and Webley were also well represented.

In the British Colonial department there was a general absence of military or sporting arms, but an interesting collection of aboriginal weapons was exhibited by New Zealand.

FRANCE.

In the French department no display whatever of artillery was made, and the exhibits were confined to a few sporting arms and a good display of cartridge-cases by the well-known house of Gevelot.

GERMANY.

The magnificent display by Herr Krupp, of Essen, of heavy and light artillery was unequaled in any former Exhibition. The exhibit consisted of the following articles:

1. 35½-centimetre gun, mounted on barbette carriage and chassis.
2. Long 24-centimetre gun, mounted on barbette carriage and chassis.
3. 8.7-centimetre field-gun, with carriage and limber.
4. Ditto, with carriage only, polished.
5. 7.5-centimetre field-gun, with carriage and limber.
6. 8-centimetre mountain-gun, with carriage, pole, and ammunition-boxes.
7. 6-centimetre mountain-gun, with carriage, pole, and ammunition-boxes, mounted on mules.
8. Saddles and harness for 6-centimetre mountain-guns.
9. A collection of projectiles.

The following table gives the weights and dimensions of the principal parts:

	35.5 CM.	24 CM.	8.7 CM.	7.5 CM.	8 CM.	6 CM.
Total weight, pounds	126,766	23,700	1,069	661	227	198
Length of bore, inches	270.2	177.6	73.9	70.7	33.3	34.6
Calibre, inches	14	9.45	3.42	2.95	3.15	2.36
Number of grooves	80	54	24	24	18	18
Weight of projectile, pounds	1,125	342	13.7	9.3	8.8	4.4
Weight of charge, pounds	275	84	3.3	2.2	0.9	0.4
Muzzle velocity, feet	1,591	1,542	1,558	1,496	952	919

RUSSIA.

The Russian Government exhibited an interesting and varied assortment of munitions of war, well selected to illustrate the excellent character of the work done in the arsenals.

The small-arms and metallic-cartridge display showed a perfection of workmanship which leaves nothing to be desired. The parts of the muskets made at different arsenals are interchangeable, and the gauges used in testing are marvels of mechanical accuracy. The greatest novelty was the fortress-rifle devised by Major-General Baron Hahn and adopted by the Russian War Office. It is 0.8 inch in calibre, is loaded at the breech, and fires steel or cast-iron bullets, lead-coated. The recoil is taken up partly by a projection which rests over a sand-bag on the parapet and partly by a movable spring-supported butt-plate. The charge is about an ounce, or one-fifth the weight of the bullet, which is designed to pierce the sap-roller or iron shield protecting the head of a sap. The swords of the army are also worthy of commendation.

In artillery, the army and navy both contributed specimens, of which the chief details are given in the following table:

DIMENSIONS.	Naval 9-in. Breech-Loading Rifle, Steel.	Naval 6-in. Breech-Loading Rifle, Steel.	Naval 4-pdr. Breech-Loading Rifle, Steel.	Army 4-pdr. New Model Breech-Loading Rifle, Bronze.	Army 3-pdr. Breech-Loading Mountain Rifle, Steel.	Army 8-in. Bronze Rifled Mortar.	Army 6-in. Bronze Rifled Mortar.	Experimental 4-pdr. Steel Rifle from Perm Works.
Total weight, pounds	33,376	8,960	784	1,097	224	8,220	3,600	1,318
Length of bore, inches	136	122	60	67	24	54	40	60
Calibre, inches	9	6	3.42	3.42	3	8	6	3.42
Number of grooves	32	24	12	8	12	30	24	12
Projectile, pounds	270	81	12	12	8.8	176	81	13.1
Charge, pounds	47	18	1.3	4	0.75	15.3	6.3	5.0
Powder, kind	Prism.	Prism.	....	Coarse.	Fine.	Prism.	Fine.	Coarse.
Muzzle velocity, feet	1,341	1,335	1,004	1,537	698	826	800	1,676

This ordnance is all breech-loading, a single cylindro-prismatic wedge and Broadwell ring being used for all but the naval 4-pounder gun, which has a French block. The experimental 4-pounder steel gun shown from the Perm Works is closed upon the Krupp system.

The greatest novelty in this ordnance exhibit was the carriage for the new model chill-cast and mandrel-hardened bronze 4-pounder gun. This carriage, devised by Colonel Engelhardt, is of iron, and is provided with a cork buffer for partially taking up the recoil. It has been severely tested, with good results, and will probably be adopted in the Russian service. The rifled mortars are also interesting. They were cast in a metallic mould under pressure, by the system of Colonel Lavroff. The larger one has been fired 300 times with 17 pounds of prismatic powder, giving a pressure of 1350 atmospheres, and 100 times with 17 pounds of artillery powder, giving a pressure of 2000 atmospheres. The grooves hardly show appreciable wear. The portable traveling-crane for moving ordnance stores exhibited by Mr. Wonlarlarsky is also worthy of special notice; as is also the fine exhibit of artillery harness. The Perm Works, beside the experimental 4-pounder steel gun, showed interesting models of a 20-inch smooth-bore gun, and of a 9-inch breech-loading hooped steel rifle gun, closed upon the French block system.

The Engineer Department displayed a very beautiful model of the

Russian ponton-train, after the Birago pattern; also numerous elaborate drawings of barrack structures, and of the siege of Sevastopol; also, a model of an iron shield as used at the fortress of Cronstadt; also, the siege and mining tools of the army.

SPAIN.

The Spanish War Office made a very attractive exhibit of war materials.

The magnificent models of fortresses and barracks, contributed by the Engineer Department, were objects of general as well as of professional interest; while the models of the ponton-train, and, especially, of the Birago trestles packed on the back of mules for mountain warfare, excited deserved notice.

In artillery, the details of the mountain-gun were especially interesting. It is of iron, 3.24 inches in calibre, rifled on the French system, and with the French breech-closing mechanism. The carriage is of iron. The pack-saddles for its transportation are peculiar in construction. The models of a 9.7-inch rifled sea-coast-gun, of the field-artillery-equipage, and of sling-carts of various patterns, were beautifully executed.

The exhibition of small-arms used in the Spanish service, and, especially, of the well-known Toledo sword-blades, attracted much attention. The aboriginal arms from the Philippine Islands were also shown.

SWEDEN.

The Swedish Government exhibit possessed much interest; and was supplemented by some specimens of chilled-iron shot, of admirable quality, from the private establishments of Carl Ekman and A. de Maré, and by a fine display of Damascus sword-blades from the Eskilstuna Iron Manufacturing Co.

The models of the military bridge-equipage devised by Captain V. Norman of the Swedish Engineers, and exhibited by the Government, possess novelty,—especially in the peculiar arrangement of the king-bolt of the wagon, by which the front axle may be traversed under the body without requiring an undue reduction in the size of the wheels or building up of the side rails. The self-acting brake is also worthy of notice. In small-arms, a fine exhibit, showing the details of manufacture of the Government rifle at the Royal Factory at Karl Gustafs Stad, was made.

In artillery, some admirable steel hoops for large rifles were displayed by the Motala Mechanical Works Co.; and specimen carriages of a field-artillery-train, complete, were shown by the Government.

The guns, of cast iron banded with steel, exhibit an endurance worthy of the reputation of the Swedish ores. The traces are made of double rope, to serve as drag-ropes in case the battery be crippled by the loss of its horses.

In closing our remarks upon the Swedish war exhibit, it may be well to refer to the admirable lay figures used to display the uniforms of the different corps. They were without a rival in the Exhibition, and in the crowd might easily be mistaken for living men.

BELGIUM.

The exhibition made by Belgium in this group consisted almost exclusively of small-arms, shown by private firms. The excellence and cheapness of the gun-barrels manufactured by the firms of Liége are well known, and have been fully acknowledged at all former Exhibitions. On this occasion, the duty of supporting their country in this national industry was undertaken mainly by the firms of Mairlot & Heuse, and Heuse, Lemoine, & Cie.

SWITZERLAND.

The Swiss exhibit under Group XVI. was confined to small-arms displayed by private parties; especially by the Swiss Industrial Company, which showed samples of the Vetterli and other breech-loading and magazine-guns.

HOLLAND.

The Netherlands exhibit was restricted to military small-arms and swords from the Government manufactory at Delft, and to a magnificent collection of East Indian weapons displayed by the Colonial department.

TURKEY.

The only weapons in the Turkish section consisted of a fine exhibit of rifles, accoutrements, and sabres made at the Imperial Arms Factory of Tophané; and some highly ornamented pistol-holsters and horse-equipments from private parties.

EGYPT.

The Government of Egypt displayed some interesting weapons, more particularly samples of the magnificent antique Damascus blades so celebrated in history, and some richly ornamented dromedary, horse, and donkey saddles and equipments. Also, some modern weapons used in desert warfare. The contributions from the National Museum of Cairo were especially attractive.

BRAZIL.

The exhibition of war material from Brazil was almost exclusively made by the Government, and showed a degree of mechanical skill and progress in that country not generally suspected.

A model of one of the 300-pounder Whitworth rifles now manufactured at the Rio Janeiro Arms Arsenal is beautifully made, and, with three smooth-bore mortars and three muzzle-loading field-guns rifled on the French system, gives a good idea of the ordnance of Brazil.

In small-arms, and in projectiles for cannon, a fine display was made; also in fuses and metallic cartridges manufactured at the Pyrotechnic Laboratory of Campinho.

TUNIS.

The display from Tunis was of great historical interest, consisting of antique guns and pistols, richly inlaid, and of magnificent Damascus swords, some of which probably date from the time of the Crusades. Gorgeously-embroidered horse- and mule-equipments added to the distinctive character of the exhibit.

JAPAN.

The exhibit from Japan under Group XVI. was made entirely by private parties, and consisted of swords, armor, bows and arrows, and other weapons in use before the nation opened her ports to foreigners. The display had much popular interest.

MILITARY SMALL-ARMS.

To trace in detail the development and perfection of military small-arms during the past one hundred years, in the various countries represented at this Exhibition, and, by means of descriptions and statistics, to give the successive steps of improvement that have led to present stages of efficiency in each, would, if skillfully and impartially done, afford a valuable record for the present as well as a valuable memorial for the use of succeeding World's Fairs, where the same progressive field of human ingenuity shall be again opened to investigation. The preparation of a memoir of so comprehensive a character could not, however, be undertaken and completed in the short space allotted to this Exhibition, as the success of any effort of this kind would depend upon the previous collection, in each of the countries, of authentic detailed information, with the view of putting the mass into shape for international dissemination. In the absence, therefore, of such general preparation at this Exhibition, only a cursory review of the history of military firearms in this country can be attempted.

The manufacture of military arms was carried on in the United States only to a very limited extent previous to the year 1795, gun-making, like all contemporaneous industries, being then in its infancy. Small-arms for the service of the troops were in those times principally of foreign manufacture. During the troublous period succeeding the Revolution, great anxiety was felt on the subject of properly maintaining the country in a condition of defense, and in 1794 Congress laid an embargo upon the exportation of any "cannon, muskets, pistols, bayonets, swords, cutlasses, musket-balls, lead, bombs, grenades, gunpowder, sulphur, or saltpetre," and encouraged the importation of all such materials by admitting them free of duty. These provisions were continued for several years, and in the mean time the initial steps were taken by the Government for the establishment of national armories at Springfield, Massachusetts, and Harper's Ferry, Virginia.

In 1795 the Secretary of War reported to Congress that the armorers engaged at the Government establishment at Springfield, Massachusetts, in repairing arms and preparing to manufacture the most essential parts of the musket, had made some specimens equal in quality to the manufactures of any country in the world. In order to foster the art, in the interest of national security, contracts with private arms manufacturers to the extent of seven thousand muskets were given out by the Government in that year. The muskets so manufactured were after the model of the French arms, which composed by far the greatest part of those in the national store-houses at the close of the Revolutionary War. The oldest pattern of the French musket then known was the one of 1746. Successive alterations and improvements were made to this model in 1754 and 1763; and, finally, in 1776 or 1777, the French Government decided on a model which stood its ground for a period of nearly forty years, saving only some trifling modifications introduced during the period of the French Revolution. This model of 1777, embodying the gradual improvements suggested by the experience of above a hundred years in the martial nation of France, was in those times considered to be exempt from every essential defect, and, doubtless, not to be susceptible of any decided improvement.

The muskets made at the national armories have, from the foundation of those institutions to the adoption of the present breech-loading rifle, been essentially of French model, with only such minor modifications as the progress of the arts and the experience of the service have demonstrated to be desirable. The arms furnished by the French Government to the United States during the war with Great Britain in 1812–14 were principally of the old model of 1763, commonly known by the name of the "Charleville" musket. This musket, indeed, served generally as a pattern in this country in the early manufactures of military arms.

In the interest of public policy, the National Government early took under its care the private arms manufacturers of the country, and, by advancing funds to them and letting of contracts for military arms, sought to build up these manufactories as places of reliance in case of national danger. It was deemed important, in order to secure the services of these manufacturers when they might be of the highest necessity, to continue in times of peace to furnish them employment. Many of the individuals of small property who engaged in these contracts were absolutely ruined thereby, and the difficulties were so much greater than had been apprehended that it proved in general a losing business to those concerned. Some of them, however, profited by the assistance rendered them, and, in the absence of workmen who had been regularly brought up to the trade of gun-making, original tools and modes of executing various parts of the work were contrived, adapted to the inexperience of the hands, and calculated to obviate the necessity of employing exclusively men who had been bred to the trade. Some of these inventions proved to be valuable improvements in the art, and were gradually disseminated and adopted into general use. In order to secure to the Government workshops the highest class of skilled workmen, an act was passed by Congress in 1800 prohibiting, under penalty of fine and imprisonment, the enticing away from the national armories or employment of any workmen under engagements at those places. To the same end, also, these workmen were exempted by the same act from all military and jury duty during their employment.

The want of competent skilled labor in the various industrial arts in this country gave rise, as above intimated, to great activity and progress in the adaptation of machinery to the performance of mechanical operations and processes. The toilsome labors of hand-production which, up to the beginning of the present century, had been the almost universal practice, began within the first quarter of the century to give way steadily to the more improved methods of manipulation by machinery. The mysteries which theretofore had surrounded many of the arts, and which required years of study and labor to acquire, began to be dispelled; the ingenuity of the intelligent artisan, aided by the wisdom of the scientist and experimentalist, began its inroads upon previous methods and processes, and in many instances what had theretofore constituted a complete "trade" eventually became broken up into numerous specialties, each complete in itself, but all subordinate to the general calling. This radical division of labor in what had constituted particular trades, gave enlarged scope to the inventor; and thenceforward the general improvement of any established art became dependent entirely upon the direct improvements in its separate subordinate branches. Under the laws for the encouragement and promotion of the useful arts, inventors acquired an absolute property in all inventions made by them, and hence all important improvements became at once matters of pecuniary value to the holders. A constant emulation was thereby engendered and sustained in every branch of mechanical labor.

The art of gun-making kept steady pace with the progress of the times. One of the earliest and most important sets of labor-saving machinery introduced in the national armories was the invention of Thomas Blanchard, of Millbury, Massachusetts. His lathe for turning irregular forms, which was adapted to the turning of gun-stocks, was invented and matured at his own shop in Millbury, and was first built and put in operation at the Harper's Ferry Armory in 1819, and subsequently at the Springfield Armory in the fall and winter of the same year.

Numerous other machines were devised and perfected by this inventor, who was thereafter employed to erect his machinery at the national armories; and on February 7, 1827, he formally relinquished to the United States, for a valuable consideration, all the rights, interests, and privileges which he had in any of the following machines then or theretofore in use at either of the armories: a machine for sawing off the stock to its proper length; one for facing the stock and sawing it lengthwise; one for turning the stock; one for boring the stock for the barrel; one for milling the bed for the breech of the barrel and the breech-pin; one for cutting the bed for the tang of the breech-plate; one for boring the holes for the breech-plate screws; one for gauging the barrel; one for fitting the tang of the breech-pin; one for forming the concave for the upper band; one for dressing the stock and between the bands; one for forming the bed for the interior of the lock; one for boring the holes for the sides and tang-pin; one for turning the barrel and the flats and ovals on the breech of the barrel. This array of machines shows to what extent labor-saving machinery had been introduced in the preparation of gun-stocks at the national armories at this early date.

About the year 1819 another ingenious inventor, John H. Hall, was employed to proceed to Harper's Ferry Armory to erect machinery for the manufacture of a breech-loading arm of his invention. The arm was invented in 1811, and the machinery for its construction was devised by him after he went to Harper's Ferry. The nature of this machinery can best be understood from the following extract from an official report made by the Colonel of Ordnance to the Secretary of War in January, 1827:

"It is but an act of justice to Mr. Hall, the inventor, to state that during the whole of this period he has devoted himself with the greatest zeal and assiduity to the perfecting of this arm, and of the means for fabricating it, and that in both he has been eminently successful; and to him is due the credit of effecting so great an improvement in firearms.

"The machinery used in the fabrication of these rifles has been constructed upon a new and improved plan, by which a very important improvement in the fabrication of firearms has been effected. By the use of this machinery each of the various separate parts, which when united form one arm, are constructed in that perfectly accurate and uniform manner that every one of the parts of one arm will fit exactly the corresponding parts of any other arm of similar model.

"This degree of perfection in the fabrication of small-arms has ever been considered an object of the highest importance in all national armories, and has been frequently attempted in the armories of Europe, but hitherto without success, and the attempt has been generally abandoned from the belief that the object was unattainable.

"The machinery constructed for and used in fabricating the Hall's rifles executes the work with such exactness that the component parts of one hundred rifles, made some years past, have been joined to other parts, made recently, without the least difficulty, all the parts fitting as exactly as if each had been separately adjusted to the particular rifle thus formed from the scattered members."

This great uniformity of parts was secured by the use of standard metal gauges for each component, whereby the utmost precision was attained through the medium of rigid inspections kept up during the progress of the work. The manufacture of Hall's breech-loading arms continued, under his supervision, at Harper's Ferry until 1844, when, he having died, and a growing sentiment having arisen among the authorities against the use of breech-loading arms, the manufacture entirely ceased. The total number made at Harper's Ferry, from 1820 to 1844, was about twenty-five thousand nine hundred. There were furnished by outside contractors in the same period about twenty-three thousand seven hundred additional. There were still nineteen thousand eight hundred of these arms on hand, in the arsenals and armories, in 1860.

Hall's arms, although the first breech-loading arms which received any considerable degree of Government patronage in the United States, never enjoyed an unqualified reputation for efficiency in the army. It is extremely doubtful if any considerable number of them were used in the war with Mexico.

The result accomplished by him in his machinery, however, was a matter of very great importance. A gradual reorganization of the machinery at the two national armories was begun as early as 1839, under the supervision of the master-armorers at those places, who were experienced practical mechanics, and by the year 1850 the manufactures at both places were characterized by entire interchangeability. These establishments had been conducted by civil superintendents from their foundation until the year 1842, when the control was transferred to the military supervision of the Ordnance Department of the army. The supervision of the Ordnance Department was superseded by civil superintendents in 1853, who were again supplanted in 1861 by the Ordnance Department, since which time the affairs at the national armories have been administered by that department.

The armory at Harper's Ferry was destroyed by Confederate troops in 1861, and has not since been rebuilt.

With the exception of Hall's arms, and a few Jenks' carbines, all military firearms (muskets, rifles, and carbines) made previous to 1840 were muzzle-loaders, and the ignition was by means of the old flint-lock. The first production of percussion arms at the armories was in 1844. Up to that date there had been manufactured at these two places from their institution an aggregate of seven hundred and fifty-eight thousand flint-lock muskets alone, besides rifles and pistols. Flint-locks were discarded in the manufactories after the year 1844, and subsequently large quantities of the flint-lock arms on hand were transformed to use the percussion principle.

In 1842 rifling of muskets was begun at the armories, and, in 1855, a model rifled musket was adopted and manufactured by the United States in large quantities, and became eventually the infantry arm of the great War of the Rebellion, 1861–1865.

A general distrust of breech-loading arms of all classes, in the then state of the art, was entertained by the military authorities from a period anterior to the dissolution of the Hall's factory in 1844, and continued down to the period of the War of the Rebellion. A board of ordnance officers having under consideration the subject of Colt's and Jenks' carbines in 1846,—these arms having been brought to the attention of the War Department in 1838 and 1839, and trials in the field having in the mean time been made with them,—reported as follows:

"After duly considering the subject, the Board have the honor to report that there have been innumerable trials made of arms loading at the breech. The principal advantages of these kinds of arms are a greater and more exact range with less recoil. This results from their being fired with a ball which fits exactly, or slug, which allows the charge to be reduced. It is necessary to add that, when the mechanism is well contrived, they may be handled with ease and quickness,—an advantage of some importance, but often greatly exaggerated. Unfortunately, these advantages appear difficult to obtain with sufficient solidity, simplicity, and durability.

"The first trials of these arms were anterior to the flint-lock. The application of this principle has been made in various ways, but the almost innumerable varieties may be classed under three heads:

"1st. Those with an opening on the top of the barrel.

"2d. Those with an opening at the rear end of the barrel.

"3d. Those in which the chamber is raised or moved from the line of the barrel, so as to allow the introduction of the charge.

"The same general objections have been found to exist to all these methods, viz.: Want of solidity of the parts most exposed to the action of the charge, the liability of the movable parts to become unserviceable by their getting fast from rust or dirt deposited at each discharge, and the escape of the gas through the joints or junctions of the different parts. The defects inherent to this method of loading have been such that, notwithstanding the repeated trials made with it for centuries and the many ingenious and well-executed contrivances offered of late years, of which those of Hall, Colt, and Jenks, in this country, deserve mention, this method has not been adopted for arming troops in any country, except partially in this, nor has it been brought into general use for other purposes. In France there are a great variety deposited in the Musée d'Artillerie, among others the Amusette of Maréchal Saxe, the principle of which is very similar to the one now under discussion. The authority of Maréchal Saxe in all that related to war caused the fabrication of a number of these arms. The dragoons of his regiment were armed with a carbine on the same principle, and the marine received a great number in their arsenals. Experiments on a large scale were unfavorable, and their use was abandoned.

"In 1831 a 'fusil de rampart' (wall-piece), loading at the breech, was adopted in France, but when tried more extensively it was found not to answer, and has also been abandoned. Trials made of late years to adapt a carbine of this kind for the cavalry have not proved favorable. Such being the facts, this Board, charged with the duty of prescribing the kind and quality of arms to be provided for our troops, must be thoroughly satisfied that an arm loading at the breech is free from the defects which have heretofore prevented their general use before they can recommend to the War Department to go to the expense of making so great a change in our arms."

In November, 1850, an Ordnance Board, having six varieties of breech-loading arms under trial at Washington, D. C., recommended Sharps rifle for trial with the troops, and some carbines of this pattern were purchased and placed in the hands of mounted men for the purpose; but in July, 1854, the matter being again before an Ordnance Board, they declined to propose any further action on the subject until a decisive report should be received as to the result of the trials in service.

By the act approved August 5, 1854, making appropriations for the support of the army for the year ending 30th June, 1855, the sum of ninety thousand dollars was appropriated "for the purchase of the best breech-loading rifles, in the opinion of the Secretary of War, for the use of the United States army: provided the Secretary of War, after a fair, practical test thereof, shall deem the purchase advisable and proper."

Inventors and manufacturers were therefore invited by advertisement, in September, 1854, to send in specimens of such arms; and, in December, 1854, trials took place at Washington, D. C., resulting in the recommendation by the Board that Sharps and Symmes' arms, presented, be subjected to trial in the hands of troops, and that such trial arms be adapted to the service of cavalry. To these were added the arms presented by Mr. Greene. The arming of infantry troops with any of the systems of breech-loading rifles then extant was not favored by the War Department authorities during this period, and very little of the appropriation for the "purchase of breech-loading rifles" was spent during the term of the then Secretary of War.

Indeed, the military authorities had, in 1855, decided upon adopting, for use in the infantry branch of service, the muzzle-loading percussion-arm, widely known as the Springfield rifled musket of 1855, using elongated expanding ball-cartridges of calibre 58, and the manufacture of these arms in great quantities was immediately begun by the Government. The sentiment of the then Secretary of War on the subject of breech-loaders for infantry service may be gathered from the following extract from a speech of his in the Senate, made after he had retired from the secretaryship.

"The infantryman," says he, "who has space enough and is in proper position to load his piece at the muzzle, I think, is better served with a muzzle-loading piece than a breech-loading piece. When breech-loading was first introduced the great defect in arms was the difficulty of putting down the ball so as to obtain all the force of the powder to propel it. It was necessary it should be rammed home with great force. Then breech-loading had its value in rapidity of fire, or, at any rate, in putting the ball in, if intended to have rapid firing, so that it should be tight in passing out. All that has been superseded by the introduction of the expanding-ball, which is put in loose in the muzzle, rammed home without delay, expanded by the powder the moment it is ignited, and passes out of the piece tight. There is, therefore, no advantage to the footman in loading a piece at the breech. . . . I object to any alteration upon any new plan of breech-loading of those arms which we have and which we know to be good."

The majority of all the inventions in breech-loading arms put forward previous to 1857 were found to be objectionable after continuous firing, there being no means of preventing the accumulation of residuum in the joints, or of overcoming the liability to failure from the rusting of the joint under exposure. A single particle of rust or residuum in the joint, during the service of the gun, opened a way to the wearing action of the gas, producing permanent injury to the piece. Much uncertainty of fire was also experienced in the various methods of priming of that day. In many specimens, the small vent-holes afforded favorable depositories for residuum, rust, or moisture,—which operate with equal effect to render the arm for the time being ineffectual or useless. The difficulties of the breech-loading problem were not fully overcome until the invention of self-primed expanding metallic cartridges. Hitherto, efforts to produce a perfect gas check were mainly confined to the gun itself, independent of the cartridge,—the loose ammunition, or paper or linen cartridges of the period, not affording any assistance to that end; but the introduction of the metallic cartridge-case, of copper or other expansible metal, as a means of closing the joint by lateral expansion under the force of the explosion, and the renewal of these cases at each discharge, effected a complete revolution in the production of breech-loading arms,—giving rise to a great many varieties of weapons owing their excellence, if not their origin, to the merits of this peculiar ammunition, and in time superseding altogether the other methods of rendering arms breech-loading.

The earliest varieties of metallic cartridges, as constructed in the United States, had for their primary object the closure of the breech-joint. Some were provided with a flange at the base to facilitate ready withdrawal from the gun after discharge, and all relied upon the old method of ignition by percussion-caps through the medium of the fire-duct as in the old arms; but the generation of ignition at or within the base of the cartridge-case itself was soon hit upon as avoiding in a great measure the contingencies of failure, and the cartridge became the subject of improvement in that respect also.

The advocates of breech-loading arms found much more liberal encouragement in the action of the succeeding Secretary of War, whose term began in 1857. Experiments were almost immediately inaugurated by his direction, at the Government workshops, to test the merits of the more promising systems of breech-loaders presented to his notice; and in 1858 he was active in urging before Congress that an appropriation should be made for the purchase of breech-loading carbines for the cavalry service, and also for the alteration of old arms then in the arsenals so as to make them breech-loading arms for the use of infantry soldiers. It was this last proposition which was so strongly opposed by his immediate predecessor, who was then a Senator in Congress, and from one of whose speeches the above quotation has been made. The appropriations were, however, finally granted; and, from 1858 to 1861, continuous experiments were in progress at the national armories, and before Boards of officers, in the examination and trial of breech-loading arms. These experiments, and the hope of ultimately gaining the exclusive monopoly of Government patronage, had the effect of stimulating the ingenuity of inventors in the production of arms; and although these measures of the Secretary of War were not during his term crowned with entire success, his faith in the value of breech-loading arms as a military armament was in no wise diminished. In his annual report of 1859 he says, "Under the appropriation heretofore made by Congress to encourage experiments in breech-loading arms, very important results have been arrived at. The ingenuity and invention displayed upon the subject are truly surprising, and it is risking little to say that the arm has been nearly, if not entirely, perfected by several of these plans. These arms commend themselves very strongly for their great range and accuracy of fire at long distances, for the rapidity with which they can be fired, and their exemption from injury by exposure to long-continued rains. With the best breech-loading arm one skillful man would be equal to two, probably three, armed with the ordinary muzzle-loading gun. True policy requires that steps should be taken to introduce those arms gradually into our service, and to this end preparations ought to be made for their manufacture in the public arsenals."

And in his annual report for 1860 he says, "Very frequent and numerous experiments have been made, under my direction, of breech-loading arms; and inventions for this purpose are wonderfully numerous. Many have been rejected, but some plans for breech-loading have been approved, after very numerous experiments, and are now conceded by all who are familiar with them, and capable of judging, to be by far the most efficient arm ever put into the hands of intelligent men. Immediately steps ought to be taken to arm all our light troops with the most improved of these arms.

"I hold it to be an inhuman economy which sends a soldier into the field, where his life is constantly in danger, without furnishing him with the best (not the most expensive) arms that are or can be made. It is no answer to say that our troops cannot be taught to use with skill this character of arm as well as another. It is the practice and drill that make the soldier expert in the use of his arm, and whilst he may attain to great skill with a good weapon, he certainly never can do so with an indifferent one.

"I think it may be fairly asserted now that the highest efficiency of a body of men with firearms can only be secured by putting in their hands the best breech-loading arm. The long habit of using muzzle-loading arms will resist what seems to be so great an innovation, and ignorance may condemn; but as certainly as the percussion-cap has superseded the flint and steel, so surely will the breech-loading gun drive out of use those that load at the muzzle. For cavalry the revolver and breech-loader will supersede the sabre."

The following list shows the purchases made by the Government of breech-loading arms during the nine years preceding the war, being the period when inventive ingenuity in that direction began first to be spurred by Congressional legislation. It was during this period that the foundation was laid for the armament of the cavalry with the improved breech-loading arms, which rendered that branch of service so efficient during the late War of the Rebellion:

1852.—200 Sharps carbines.

1854.—200 Greene's carbines.

1855.—400 Sharps, 200 Symmes', and 170 Merrill's carbines.

1856.—200 Burnside's and 10 Schroeder's carbines.

1857.—400 Colt's rifles, 200 Sharps, 100 Greene's, and 50 Joslyns' carbines; and 400 Maynard's and 1400 Sharps rifles.

1858.—3040 Sharps and 691 Burnside's carbines; and 20 Colt's rifles.

1859.—2500 Sharps, 100 Merrill's, and 64 Colt's carbines; and 100 Merrill muskets, 100 Merrill rifles, and 288 Colt's rifles.

1860.—1000 Joslyns' and 300 Smith's carbines.

Besides these, the Government purchased the right to make or alter from old arms the following at the Government workshops, viz.:

1858.—Right to alter 2000 muskets or rifles according to plan of George W. Morse; right to alter same number of muskets and rifles on plan of W. Mont Storm.

1860.—Right to manufacture 3000 carbines, and metallic cartridge-cases for same, on patents of George W. Morse.

The manufacture of the standard muzzle-loading rifled musket of the model of 1855 was steadily in progress at the national armories at the breaking out of the War of the Rebellion in 1861; and the productive energy of the remaining establishment (the Harper's Ferry Armory having been destroyed in the first months of the war) was taxed to its utmost to supply this standard rifled musket to meet the increasing wants of the service. In the face of open hostilities and the extraordinary demands resulting therefrom, there was left no time for continuing experiments with unperfected systems of breech-loading for infantry service, nor to contrive and construct new and untried machinery for the production of arms of that character. These experiments were, therefore, discontinued by the Government; but they were industriously pursued by private enterprise during the whole period of the war, resulting in the production of many ingenious weapons, which were largely patronized by the Government for use in the cavalry service. The demand for the regulation muzzle-loading arms made by the Government for the infantry service became so great shortly after the war opened that private contractors had to be called in to duplicate the machinery and aid in the enormous production imperatively needed. The success attained by the use of breech-loaders in the cavalry service, however, had engendered a very strong sentiment by the close of the year 1863 in favor of the introduction of breech-loaders among the infantry regiments. It was not until the fall of 1864, however, that the Government was in a condition to initiate measures looking to a change of its manufactures. The most economical plan then deemed expedient (as previously considered in 1858) was the alteration of the stock of muzzle-loaders then on hand to breech-loading arms. In October, 1864, the Chief of Ordnance of the army reported to Congress, through the Secretary of War, as follows:

"The use of breech-loading arms in our service has, with few exceptions, been confined to mounted troops. As far as our limited experience goes, it indicates the advisability of extending this armament to our infantry also; and this experience is corroborated by that of several foreign nations, into the military service of which the breech-loader has been or is about to be introduced as the exclusive firearm for both cavalry and infantry. It is, therefore, intended to make this change of manufacture at our national armories as soon as the best model for a breech-loading arm can be established by full and thorough tests and trials, and the requisite modifications of the present machinery for fabricating that model can be made.

"The alteration of our present muzzle-loading arms is also a very desirable measure, both on account of economy and improvement in the character of these arms. It is thought that they can be altered at a moderate cost, and in a short time, to very efficient breech-loading arms. The details for effecting both these measures will receive the early attention of this Bureau."

A Board of officers was convened at Springfield Armory, in January, 1865, to "examine, test, and recommend for adoption a suitable breech-loader for muskets and carbines, and a repeater or magazine-carbine." Experiments had been in progress at the armory by the master-armorer since the fall of 1864 in perfecting a system of altering the muzzle-loading arms on hand, in accordance with a plan that had been suggested by an employee of the armory during the progress of the experiments at that post in 1858. The Board examined and tested a considerable number of specimens of breech-loading arms, and, in April, 1865, recommended the adoption of the "Peabody" rifle, and expressed the opinion that Spencer's magazine-carbine combined more advantages than any other magazine arm presented. The recommendation of the Peabody rifle was not adopted by the War Department, and the manufacture of the Joslyn breech-loading rifle was undertaken at the armory, about three thousand of them being made in 1865; but reports from the field being very unfavorable to this arm its manufacture was discontinued, and measures were taken in July of that year for the alteration of five thousand arms in accordance with the plan that had been the subject of experiment by the master-armorer. One hundred stands of these arms were issued to troops by the end of March, 1866, and a Board of officers having in the mean time been assembled at Washington, D. C., on the subject of altering old arms to breech-loaders, specimens of these arms were laid before them. The Board examined and tested a considerable number of specimens of arms, and selecting preliminarily the Berdan, Remington, Richardson, and master-armorer's plans, they finally agreed upon the Berdan plan as the best.

The War Department, however, selected the Berdan, Yates, Remington, Roberts, and master-armorer's plan for competitive trial in service, but this recommendation was never carried out. In July of that year orders were given for the immediate conversion of twenty-five thousand muzzle-loaders to breech-loaders, and the master-armorer's plan (called Allin plan) was adopted for these arms. Orders were at the same time given for the manufacture of metallic centre-primed cartridges for these arms at the Frankford Arsenal, Philadelphia, Pennsylvania.

The preparation of metallic ammunition suitable for these military arms involved the institution of extensive experiments at the Springfield Armory and at Frankford. Not only were the proper form of construction of the cartridge-case itself and the proper method of priming to be selected, but the proper machinery also had to be selected and adapted to the production, in large quantities, of the adopted cartridge. The manufacture of metallic cartridges was a known branch of industry in the United States at the time, the production of ammunition of this character having been undertaken by private enterprise anterior to the war of the Rebellion; indeed, much of it had been used in that war. Large manufactories were in operation in Massachusetts and Connecticut as early as 1863. Ammunition of this class, however, had up to this time been principally of the kind known as rim-primed. It was desirable that the cartridge for military arms should be centre-primed, if one suitable and equally sure of fire could be selected. An original cartridge was devised at the Springfield Armory; but one involving principles of construction that had already been suggested by various inventors was experimented upon and finally adopted for manufacture at the Frankford Arsenal. The machinery for these latter productions had also been, in a great measure, previously suggested by inventors, and through the skill of the practical workmen at the Frankford Arsenal, superintended and controlled by the officer in charge of the post, this machinery was perfected and supplemented so as to increase the production by each set of machines from a small number a day, in the beginning, to more than ten thousand a day when all the improvements were effected.

The manufacture at the Springfield Armory of the newly-adopted breech-loaders progressed as rapidly as the preparations there made and the state of the public funds would admit; and successive improvements in the details of the breech arrangement, and in the reduction of the calibre of the arm, were made at that post up to March, 1870, when a Board of officers convened at St. Louis, Missouri, was directed by the War Department to "examine and report on the best small-arms and accoutrements for the use of the army of the United States." This Board tested a considerable number of arms, including the Remington, Peabody, Roberts, Berdan, Colt, Baxter, Triplett &

Scott, Sharps, Ward-Burton, Martini, Morgenstern, and Conroy breech-loading rifles, and the Remington, Roberts, Sharps, Spencer, and Conroy breech-loading carbines, in competition with the adopted Springfield breech-loading rifles and carbines; and selected the Remington, Springfield, and Sharps as the three principal systems of breech-loading which commended themselves most strongly to the judgment of the Board. One thousand rifles of each of the models, and 1000 Ward-Burton rifles, together with 200 carbines of each kind, were put into the hands of troops for comparative trial under all the vicissitudes of actual field service. In 1873, a Board of officers was convened at Springfield Armory, under authority of an act of Congress, for the purpose of recommending for adoption "a breech-loading system for muskets and carbines." This system was, in the language of the act, to be, when so adopted, "the only one to be used by the Ordnance Department in the manufacture of muskets and carbines for the military service." The following is a list of the arms received and examined by the Board:

LIST OF ARMS.

No.	1.	Wooden model	Edwin Sleeper.
"	2.	Muskets and carbines, calibre .50 (four samples)	General B. S. Roberts.
"	3.	Carbine	W. T. Scott.
"	4.	Magazine-carbine	W. R. Evans.
"	5.	Musket, calibre .50 (two samples) . . .	Sharps Rifle Company.
"	6.	Wooden model	F. W. Worrell.
"	7.	Muskets and carbine (three samples) . .	Peabody Rifle Company.
"	10.	Musket, calibre .50 (four samples) . . .	E. Whitney.
"	14.	Musket, calibre .42	J. D. Greene.
"	15.	Carbine, calibre .42	William Morgenstern.
"	16.	Musket (two samples)	Frederick Wohlgemuth.
"	18.	Musket, calibre .50	John Broughton.
"	19.	Muskets (eight samples)	E. Remington & Sons.
"	24.	Musket, calibre .50	W. H. Elliot.
"	25.	Musket, calibre .50	A. T. Freeman.
"	26.	Musket and carbine, calibre .50 (two samples) .	Ward-Burton.
"	30.	Musket, calibre .50	B. M. Spencer.
"	32.	Musket, calibre .50	W. S. Smoot.
"	33.	Musket, calibre .50	Oscar Snell.
"	34.	Musket, calibre .42	S. F. Van Choate.
"	35.	Musket, calibre .52	W. H. Robertson.
"	36.	Musket, calibre .50	Captain J. M. Whittemore.
"	37.	Musket, calibre .50	John L. Kirk.
"	38.	Musket, calibre .50	Smith & Chamberlain.
"	40.	Musket, calibre .50	B. F. Joslyn.
"	42.	Musket, calibre .50	Updegraff.
"	43.	Musket, calibre .50 (two samples) . . .	Remington-Ryder.
"	44.	Musket, calibre .50	James F. Thomas.
"	45.	Muskets (two samples)	John Broughton.
"	46.	Musket, calibre .42	Westley Richards.

No. 47.	Musket, calibre .50	Schofield-Remington.
" 48.	Muskets and carbines (six samples)	Springfield.
" 49.	Wooden model	Alfred Beals.
" 50.	Musket, calibre .50 (two samples)	I. M. Milbank.
" 52.	Magazine-musket, calibre .44	Stetson.
" 53.	Muskets (three samples)	James Lee.
" 55.	Wooden model	G. R. Remington.
" 56.	Revolving carbine	Helm.
" 57.	Musket, calibre .42	Berdan-Russian.
" 58.	Magazine musket and carbine (two samples)	Ward-Burton.
" 59.	Musket, calibre .50	A. T. Freeman.
" 60.	Musket, calibre .58	Mont-Storm.
" 62.	Musket, calibre .50	Oscar Snell.
" 63.	Musket, calibre .50	Peabody.
" 65.	Musket, calibre .50	Earnest.
" 66.	Musket, calibre .50	Springfield-Stillman.
" 68.	Musket, calibre .50	Springfield-Allin.
" 74.	Wooden model	J. B. Rumsey.
" 76.	Musket, calibre .50	A. T. Freeman.
" 77.	Carbine, calibre .50	E. Whitney.
" 78.	Repeating musket, calibre .45	Winchester.
" 80.	Carbine, calibre .50	W. H. Elliot.
" 82.	Locking rifle, calibre .50	Remington.
" 83.	Musket, calibre .50	Merrill.
" 84.	Musket, calibre .50	William Conroy.
" 85.	Navy rifle, calibre .50	Remington.
" 87.	Magazine-musket, calibre .42	William Gardner.

The following foreign arms were also examined by the Board, from which it will be seen that, so far as the facilities in the way of ammunition would permit, all the principal domestic and foreign systems of modern date were examined and tried:

Chassepot,	Needle-gun,	Needle-gun (improved),
Needle-carbine,	Mauser,	Werndl,
Werder,	Vetterlin,	Martini-Henry.

After the most thorough and exhaustive trials with all the foregoing arms, extending over a period of eight months, and the examination of a great number of reports on the comparative trials then going on in the field, the Board was unanimous in recommending the Springfield breech-loading system for exclusive adoption in the rifles and carbines of the United States military service, and it has been so adopted and used since that time. A classification of breech-loading arms, as made by the recorder of that Board, is herein inserted as of interest in connection with the subject of that class of firearms.

Breech-loading small-arms have (1st) a *fixed chamber*, or (2d) a *movable chamber*, as in the Burnside, Hall, SLEEPER, and WORRELL arms. The movable chamber is now obsolete. The following table shows the divisions of breech-loading weapons having a *fixed chamber:*

A CLASSIFICATION OF BREECH-LOADING SMALL-ARMS *founded on the motions of the principal part by which the breech is opened and closed.*

- 1st, a *movable barrel*, which is—
  - 1st, sliding .... GARDNER'S REPEATER.
  - 2d, sliding and rotating .... Gallagher.
  - 3d, rotating about an axis.
    - 1st, parallel to axis of barrel .... All revolvers like Colt's; SCOTT; HELM.
    - 2d, at 90° to axis of barrel, and—
      - 1st, vertical, in plane of axis of barrel .... PRUSSIAN NEEDLE-CARBINE.
      - 2d, horizontal, beneath barrel .... Maynard; WOHLGEMUTH.
- 2d, a *movable breech-block*, which is—
  - 1st, sliding...
    - 1st, in line of axis of barrel by ....
      - 1st, direct action, *i.e.*, *bolt-guns*, having
        - 1st, concealed locks .... PRUSSIAN NEEDLE-GUN; DREYSE'S IMPROVED NEEDLE-GUN; CHASSEPOT; WARD-BURTON; MAUSER; VETTERLIN; GREENE, No. 14; MILBANK, No. 51; LEE, No. 53.
        - 2d, outside locks VAN CHOATE; JOSLYN-TOMES; MERRILL, No. 83.
      - 2d, indirect action, *i.e.*, moved by levers, from
        - 1st, above .... Morse, No. 1; Merrill; BARNEKOV-GREENE.
        - 2d, below .... WINCHESTER; STETSON; BURGESS; A. C. BEALS, No. 49; RUMSEY.
    - 2d, at 90° to axis of barrel, and—
      - 1st, vertically .... SHARPS.
      - 2d, horizontally .... A French gun, name forgotten.
  - 2d, sliding and rotating .... Ballard.
  - 3d, rotating about an axis.
    - 1st, parallel to axis of barrel, and—
      - 1st, above it ....
      - 2d, below it .... WERNDL.
      - 3d, beside it, to the—
        - 1st, right .... Snider; Warner; SNELL.
        - 2d, left .... Joslyn; EARNEST.
    - 2d, at 90° to axis of barrel, and—
      - 1st, vertical, lying
        - 1st, in plane of axis of barrel .... FREEMAN.
        - 2d, out of plane of axis of barrel, and in— (*All are to the right.*)
          - 1st, front .... MILBANK, No. 50; BROUGHTON, No. 45.
          - 2d, rear ....
      - 2d, horizontal, lying—
        - 1st, above axis of barrel, and in—
          - 1st, front .... SPRINGFIELD; BERDAN-RUSSIAN; MORGANSTERN; BROUGHTON, No. 79.
          - 2d, rear moved from ....
            - 1st, above .... ROBERTS; ELLIOT; WERDER; SMOOT; LEE, No. 54; LEE, No. 61.
            - 2d, below .... PEABODY; MARTINI; WESTLEY-RICHARDS; CONROY.
        - 2d, in plane of axis of barrel, and in—
          - 1st, front .... Beal.
          - 2d, middle .... Allen & Wheelock.
          - 3d, rear .... Morse, No. 2; Symmes.
        - 3d, below axis of barrel, and in—
          - 1st, front, moved from—
            - 1st, above (*by a thumb-piece*). REMINGTON; REMINGTON-LOCKING, including THOMAS; REMINGTON-RYDER; WHITNEY, Nos. 10 and 13; DEXTER; WHITTEMORE; MUIR-MONT-STORM, No. 60; UPDEGRAFF.
            - 2d, below (*by a lever*). SPENCER; BROUGHTON, No. 18; ROBERTSON; Starr's; EVANS; KIRK; G. R. REMINGTON.
          - 2d, rear ....

The names in small capitals are those of types submitted to the Board.

N.B.—This list is an abstract of a much more extended one, embracing over one hundred names, from which only prominent examples have been selected, when the docket of the Board failed to present a suitable type for the illustration of the principle involved.

The several varieties of metallic cartridges now in use have been classified as follows:

1st. Those in which the shells are made of continuous metal, combined with a suitable primed anvil, but not reinforced in the head.

2d. Those in which the shells are made of continuous metal, and of combinations of pieces of metal, combined with a primer, with and without a separate anvil, and are also reinforced in the head.

3d. Those in which the body of the case is of continuous metal, and have a solid or other suitable attached head, properly primed.

4th. Those made with a solid head of metal, continuous with the case, and suitably primed.

It is generally conceded that the metallic cartridge of which the bodies are of continuous metal are superior to the wrapped-metal cartridge for military purposes, the latter not being so well adapted to stand the shock of transportation and the incidents attendant upon their carriage upon the person of the soldier.

Immediately after the production of metallic ammunition had begun at Frankford Arsenal in 1866, daily firings were instituted at that post in order to keep the quality of the work up to its highest standard. There gradually grew out of these firings a regular and systematic course of experiments having for its object the improvement of the ammunition in its several features, having respect both to the raw constituent materials and to the actual performance of the ammunition in its completed state. These experiments were of the most prolonged and painstaking description, involving the use of numerous specially-contrived appliances, and of the most highly-improved electro-magnetic and inductive instruments adapted to ballistic research. From the results attained in these experiments, and subsidiary results with rifles of various calibres at Springfield Armory in 1872, a Board of officers was enabled in that year to determine, within limits almost approximating mathematical certainty, the proper calibre, length, weight, rifling, and form of chamber of the gun, and the quality and quantity of the powder, the size, weight, and form of bullet, size and form of metallic cartridge-case, and quantity and quality of lubricant, that would secure in the greatest degree the following qualities, viz.:

1. Accuracy in all winds.
2. Cleanliness, or sustained accuracy.
3. Flatness of trajectory.
4. Penetration at long ranges.
5. Moderate recoil.
6. Lightness of arm.
7. Lightness of ammunition.

The results of the labors of this Board were made use of by the

Board which selected the breech-loading system for the arms of the military service.

Having thus sketched in a cursory way the history of the military arms of the United States for the service of infantry soldiers, a word may be added on the subject of pistols and revolvers. Thus far, in treating of firearms, the standard Government arms have been taken as the highest types of such manufactures, the adoption of such arms being in all cases made only after such experiments, competitive and otherwise, on the proving-ground and in actual service in the field, as the resources of Government alone can afford. The development of the pistol has been more the work of private parties.

The earlier pistols used in our service were a class of single-barrel flint-lock arms, worn in holsters attached to the pommel of the saddle. These in time gave way to percussion arms, still single-barreled, and still worn in the holster on the saddle. The invention of the Colt revolving pistol, in 1836, was the first giving any promise of success as a military weapon of this class. Its performances during the Mexican War, in 1847, were far from satisfactory, but by a series of improvements it was brought, by the year 1857, to a pretty high degree of efficiency. It performed a conspicuous part in the War of the Rebellion, where it was very generally used in the cavalry service. Many other revolvers, in principle like the Colt, were put forward during this war. In 1867 the Colt was transformed to use metallic cartridges, and is now one of the adopted arms of the cavalry service. The Smith & Wesson revolver, using metallic cartridges, has also been and is now very considerably used in the cavalry service.

The private enterprise engaged in the production of small-arms has in our day risen to very great proportions. For a detailed description of the most important of the large number of American inventions in breech-loading arms, and the manufactories of the same up to the year 1872, attention is invited to the volume of the report of the United States Commission to the Paris Exposition of 1867, entitled *American Breech-loading Firearms.* The information embodied in this volume regarding this growing industry cannot fail to be of interest to professional men as well as to the general reader. For the details of the experiments made by the Government in breech-loading arms and metallic ammunition, attention is invited to the professional papers and published reports of the Ordnance Department of the army.

SPORTING ARMS.

In few departments of industry has greater progress been made, during the last one hundred years, than is exhibited in the production of sporting firearms, every part of which, from the heel-plate to the muzzle, has been changed, modified, and improved, until, with the present propelling agent, it is believed to be nearly perfect.

The progress in the future will perhaps be in the propelling force. Although gunpowder now holds the first place, the constant experiments with other chemical compounds may eventually produce an agent which, giving greater power, will attain better results, and, superseding gunpowder, will no doubt require a further modification of the gun.

The barrel is the most important part of the gun, and the improvement in its manufacture has been very great. The most celebrated barrels of the last century were those forged by Nicolas Biz and Juan Belez, in Madrid. These were made by forging into a homogeneous mass iron nails from horseshoes, drawing the bloom into strips of proper length, width, and thickness, and welding longitudinally. The fine quality of the iron originally employed in the manufacture of the nails, and the repeated hammering of the small pieces at the forge, in addition to the wear when under the horse's hoof, resulted in the production of an iron of great density and elasticity; and although the fibre was parallel to the axis, the barrels possessed great and enduring strength.

Damascus iron, composed of alternate plates of iron and steel, although not a modern compound, is now generally used for the best barrels. The plates being welded and forged into a bloom, are drawn into rods under the tilt-hammer or between rolls; each rod is then twisted on itself, and three rods with the twist running in different directions are welded together and brought to a proper thickness for the barrel. These strips or ribbons are then wound around a mandrel, welded, and hammer-hardened, and the rough barrel is the result. The process of twisting, rolling, and welding can be carried to a great extent; and if the operations are carefully performed the iron will be improved and the beauty of the figure increased, as shown on the surface when browned. This same figure extends through the whole mass, and will show its beautiful lines wherever the browning preparation is applied. Barrels of great strength, hardness, elasticity, and beauty are produced by welding scraps of mild steel into a bloom, hammering and rolling; and although the repeated heats dissipate most of the carbon, yet the result is a metal of wonderful density.

The progress in barrel-making has resulted in combining in the highest degree strength, lightness, elasticity, hardness, and durability.

The next great improvement, and one which revolutionized the whole system of ignition, was the invention of the percussion principle, in 1807, by Forcyth, of Scotland; and although the percussion-cap was not introduced until about 1820, yet this invention contained the germ of all subsequent advances. The advantages gained over the flint-lock system were the certain and instantaneous fire, and the saving in power by closing the orifice through which ignition was produced. The interior parts of the lock remain the same; and the main- and sear-springs, tumbler, and swivel perform the same functions as in the flint-lock. The last improvement consists in lengthening the top of the mainspring and extending it towards the tumbler; the crank of the tumbler is lengthened beyond the swivel, and projects over the top part of the mainspring. At half-cock the crank of the tumbler rests upon the top of the mainspring, and keeps the hammers from coming in contact with the strikers. This arrangement retains the hammers at half-cock after every discharge, and, by allowing the striking-pins to be withdrawn within the face of the breech, removes all danger of premature discharge while in the act of loading and closing the gun. This improvement is now adopted by all first-class makers, and may be considered a decided success. For simplicity of construction and perfect adaptability to an end the modern gun-lock is a beautiful mechanism.

The breech-loading action, although in principle dating back to a former century, is in its present perfect form the result of the labor and skill of the last thirty years; and its success is due to the production of a cartridge which in itself is a perfect gas check. Introduced into England from France in 1856, the invention of M. Lefaucheux has been modified, improved, and perfected by the skill and genius of many mechanical minds; and although every conceivable mode of fastening securely the barrels to the breech-block has been tried, and a great variety are now in use, yet but one end is to be obtained, and that is the most perfect locking at the moment of discharge between parts necessarily separated. The double bolt under the barrels, combined with the extended top-rib loop-fastening, seems to combine all the requisite strength. The cartridge is the essential part of the breech-loading system.

Within a few years the American system of choke-boring has been revived in England with the most satisfactory results, when not carried to the extreme. The modified choke, as produced by Henry, of Edinburgh, and others, gives an equal and uniform distribution of the shot, and increases the penetration without sensibly increasing the recoil for the same charge of powder. This system has the advantage of durability, and must supersede the extreme choke, as exhibited in the last "field" trial, being better adapted to all classes of sportsmen than the other. This invention, being certain and constant, dispenses with wire cartridges and concentrators, the irregularity of which was a constant source of disappointment and annoyance. The minor parts of the gun have also been greatly improved. The stock is made more symmetrical, and its strength is increased by the selection of the firmest wood. Horn is substituted for iron in covering the butt, thereby exposing less surface to the action of rust. The tail-piece is attached by a spring, working instantly, securely, and pleasantly, and dispenses with the old socket and loop. The shooting powers have been largely increased, and the perfected breech-loader of to-day is as powerful and effective at sixty yards as the muzzle-loader of thirty years ago was at forty yards.

It is not positively known at what time and by whom the germ of the rifle was invented, but it is certain that, as early as 1498, grooved guns existed at Leipzig; the crowning act of the invention, however, was the introduction, by Augustin Kutler, of the rose-grooved rifle with a spiral form in 1520, and to him belongs the honor of producing a weapon more potent for the purpose of attack and defense than any previous invention, and one which reduces the flight of the projectile to the individual skill of the marksman. The spiral grooves of the rifle give the bullet a rotary motion, in proportion to the force applied and the pitch of the twist. The revolution of the projectile on its own axis keeps that axis in a line parallel to the axis of the bore of the gun, varied only by the power of gravitation and the resistance of the air. Since Kutler's day, the ingenuity and skill of thousands of artisans and many scientific minds have been devoted to the improvement and perfection of the rifle, and the names of Armstrong, Whitworth, Lancaster, Purdey, and Henry stand pre-eminent in the list; but there is hardly a form adopted in the last one hundred years which has not previously been tried with more or less satisfactory results, and the great advance is to be attributed to the perfection of machinery which cuts the spiral grooves with mathematical accuracy, and to science which produces such homogeneous metal for the barrels, rather than to any new principle.

The modern express-rifle is constructed on a principle by which great accuracy and power are obtained; good targets are made up to fourteen hundred yards, and heavy rifles with explosive shells are used with certain effect upon large game. Henry's rifling is the system generally adopted for these weapons. It consists of seven grooves and one turn of twist in twenty-two inches. It is evident that this great increase of twist must require a corresponding increase of propelling force to overcome the enormous friction, consequently the charge of powder is enlarged to four drachms, materially extending the range. The application of the breech-loading system to the rifle has produced the most satisfactory results. The projectile has no longer to be forced from the muzzle to the breech, but is now inserted in the chamber, and can be made the full size of the bore. The passage from the chamber into the tube causes the operation of rifling to take place immediately and perfectly.

FIELD-ARTILLERY.

The field-artillery used during the American War of Independence, of 1776, consisted mainly of bronze smooth-bore 12-pounders, 6-pounders, and 3-pounders, and fairly represented the field-guns of that period. The present organization, on the battery system, was then unknown, and the artillery of an army consisted of a train, which usually included field- and siege-guns. The former were nominally divided into brigades or regiments, but the guns, for fighting purposes, were distributed among the infantry battalions, and were horsed by hired cattle driven by civic conductors temporarily employed for the purpose. This miserable organization was general in all armies until 1792–93, when horse-artillery was introduced into the French and English services; but battalion guns were retained in the latter service as late as 1802, and in 1799 the two 6-pounders of an infantry brigade were each drawn by three horses in single draught, conducted by a man on foot with a wagoner's whip.

Considerable progress was made in the organization and equipment of field-artillery during the latter part of the eighteenth and early part of the nineteenth centuries, and in the wars of Napoleon field-artillery became a special and powerful arm, possessed of great mobility, and capable, when skillfully handled, of deciding the fate of battles.

Still, although several important improvements were made in the smooth-bore equipment during the long peace which preceded the Crimean War, little was done during the first half of the present century towards introducing a rifled arm.*

* The following note, extracted from the *English Text-Book of the Construction and Manufacture of Rifled Ordnance* (Major F. S. Stoney, R.A., and Captain C. Jones, R.A.), gives a list of the principal inventors of rifled cannon previous to the year 1850:

In the Arsenal of St. Petersburg there is a gun two and three-quarter inches in diameter and sixty-two inches in length of bore, which was rifled in nine grooves in 1615.

Rifled muskets throwing spherical projectiles had long been in use, but it was not until 1846 that the first military small-arm using an elongated projectile was introduced by the French. The adoption of this muzzle-loading rifled musket was followed in 1848 by the appearance of the celebrated Prussian needle-gun; and, within a few years, the armies of the world were equipped with rifled small-arms firing elongated projectiles.

The difficulties in the way of perfecting ammunition and constructing guns were very much greater in the case of ordnance than in that of small-arms; and, although several desultory experiments in this direction had been made, the question of rifled ordnance first assumed a practical shape about the year 1855. Three years later, the first rifled gun, a field muzzle-loader, was introduced by the French; and was followed immediately by the adoption in England of the celebrated Armstrong breech-loading gun. The latter was abandoned in 1870 in favor of a muzzle-loading gun.

It is not in the scope of this paper to discuss in detail the various changes which have been made from time to time in the artillery services of the world since the introduction of rifled arms, but the following tables will show the field armament of the principal nations before the Franco-German War of 1870:

In 1661 the Prussians experimented at Berlin with a gun rifled with thirteen shallow grooves.

In 1696 the elliptical bore was known, and had been tried in various parts of Germany.

In 1745, the date at which Robins was experimenting in England, the Swiss already possessed small rifled pieces.

In 1746 Munich had a rifled breech-loader made, and T. Senner was engaged in rifling various guns.

In 1774 experiments with elongated projectiles, fired from a 6-pounder smooth-bore gun, were carried out at Woolwich by the "Military Society."

In 1776 Dr. Pollock proposed elongated shot for smooth-bored guns.

In 1790 Mr. Wiggin made designs of a rifled gun and belted projectiles.

In 1816–19 M. Pouchara, a distinguished French artillery officer, was making experiments with an old gun rifled with thirteen grooves.

In 1821 Lieutenant Croly, of the British army, proposed breech-loading cannon and lead-coated projectiles.

In 1823–32 Lieutenant Norton, of the English service, proposed explosive shells and a rifled gun.

In 1826 experiments were made with cylindro-conical percussion-shells, designed by Lieutenant-Colonel Miller, of the English Rifle Brigade.

In 1833 M. Montigny, of Brussels, invented a breech-loading rifled piece.

In 1842 Colonel Trenille de Beaulieu first presented to the French Government his plan for rifling muzzle-loading guns, with a few large grooves for studded projectiles, which was afterwards adopted in a modified form by the French service.

In 1845 Major Cavalli, a Sardinian officer, invented a breech-loading gun rifled with two grooves for a ribbed shot; guns on his system were used at the siege of Gaeta in 1860.

In 1846 the Swedish Baron Wahrendorf proposed the system of using lead-coated pro jectiles with shallow-grooved breech-loaders.

FIELD ARTILLERY IN 1869.

PARTICULARS.	AMERICAN.	ENGLISH.		FRENCH.		PRUSSIAN.		AUSTRIAN.		RUSSIAN.	
	LIGHT.	LIGHT.	HEAVY.	LIGHT.	HEAVY.	LIGHT.	HEAVY.	LIGHT.	HEAVY.	LIGHT.	HEAVY.
Calibre, inches......	3	3	3	3.41	4.78	3.1	3.6	3.2	3.98	3.42	4.8
Length of bore, inches...............	65	52.5	61.4	55.1	71.4	70.6	70.2	47.7	57.8	51.4	74.4
System of loading.	M. L.	B. L.	B. L.	M. L.	M. L.	B. L.	B. L.	M. L.	M. L.	M. L.	M. L.
Number of grooves	7	38	38	6	6	12	18	6	8	6	6
Total weight of gun, cwts...........	7.32	6	8.5	6.5	15.9	5.8	8.5	5.2	9.8	5.9	15.9
Weight of projectile, pounds.........	9.5	9	11.75	9	28.3	9.6	15.2	8.0	14.5	10	28.3
Weight of charge, pounds..............	1.25	1.13	1.5	1.21	3.16	1.1	1.32	1.16	2.03	1.35	3.16
Muzzle velocity, feet....................	1200	1060	1170	1066	1006	1150	1070	1093	1125	1050	1006

In 1870 England abandoned the breech-loading system and introduced muzzle-loading field-guns, while Russia, on the contrary, to a large extent abandoned muzzle-loading guns and introduced breech-loaders. But little has been done in England since 1870 to develop the power of field-artillery, as measured by the weight and velocity of the projectile thrown; but extensive experiments have taken place both in France and Germany, and both these nations have introduced a new armament for their field-artillery. Austria has also abandoned muzzle-loading guns, and bronze breech-loaders are now being gradually introduced in the Austrian service. The French experiments subsequent to the war were made both at Calais and Bourges; and, at the latter place, the new muzzle-loading 9-pounder English gun was tried in competition with others. The Bourges Committee summed up its conclusions in 1873 as follows:

"In spite of a few imperfections, the English matériel taken as a whole constitutes a system of artillery of the first class. The Woolwich gun, with steel tube and wrought-iron coils, produces results which are not inferior to those of any other field-gun actually in any service in Europe. It is, however, probable that these results may be surpassed. This is the end which we must pursue in the search for a field-gun, and it is indispensable to attain it in case we adopt breech-loading; this system of loading presenting as it does practical disadvantages, should, to be adopted, afford in compensation a very marked superiority over the best muzzle-loading gun."

It appears, therefore, that the French Commission fully recognized the advantages of a muzzle-loading system for field-artillery, although they ultimately adopted a breech-loading gun.

Notwithstanding the high reputation which the Prussian field-guns obtained during the war of 1870–71, there were many German artillery officers who were dissatisfied with their power; and the experiments which were carried out in England in 1872, in which the German 9-pounder breech-loader was tried in competition with the English 9-pounder muzzle-loader, strengthened this feeling. The German artillery was unanimous in favor of breech-loading; but it was thought that the field-guns which took part in the war were deficient in power, and that the breech-loading system was capable of much greater development. The Berlin Artillery Committee accordingly directed their attention to the defects in the existing guns, and with the assistance of Herr Krupp they appear to have produced an excellent field-artillery equipment. The guns are said to be of great accuracy and power, and, judging from the specimens exhibited by Herr Krupp at Philadelphia, the whole equipment appears to be of a most serviceable description.

The following table gives the dimensions of the guns now in use by European field-artillery:

FIELD-ARTILLERY OF 1876.

PARTICULARS.	ENGLAND.		FRANCE.	ITALY.	PRUSSIA.		RUSSIA.	
	LIGHT.	HEAVY.			LIGHT.	HEAVY.	LIGHT.*	HEAVY.
Calibre, inches	3	3.6	3.35	2.95	3.09	3.56	3.42	4.2
Length of bore, inches	63.5	68.4	74.1	62.6	74.2	73.4	60.7	57.2
Number of grooves	3	3	14	12	24	24	12	16
Weight of projectile, pounds	9	16	16	8.2	11	16	12.6	24
Weight of charge, pounds	1.75	3	2.65	1.21	2.76	3.31	1.5	3.25
Muzzle velocity, feet	1380	1355	1312	1312	1522	1460	1004	1000
Total weight of gun, cwts	6	12	12.02	6.02	7.68	8.86	6	12.6
Total weight of carriage, cwts	11.2	12.8	7.39	7.36	9.5	10.25	8.61	....
Number of rounds carried with gun and limber	40	28	32	46	39	33	18	12
Total weight behind team, including gun, carriage, and limber packed, cwts	32	41	37	24.6	35	37.7	24.4	....
System of loading	M. L.	M. L.	B. L.	B. L.	B. L.	B. L.	B. L.	B. L.

Rifled mountain-guns have now been generally introduced into European armies. A complete description of the equipment of each country is beyond the limits of this paper, but the following table gives the principal dimensions and weights of the pieces now in use:

* A new bronze breech-loading rifled gun has been approved, and is in process of introduction into the Russian service. The charge will be about four pounds, giving a muzzle velocity of 1530 feet.

PARTICULARS.	ENGLISH.	AUSTRIAN.	FRENCH.	ITALIAN.	RUSSIAN.	SPANISH.
	7-PDR.	3-PDR.	4-PDR.	8-CM.	3-PDR.	8-CM.
Calibre, inches	3	2.92	3.4	3.4	3	3.4
Length of bore, inches	36	35.8	31.7	35.8	24	31.6
Number of grooves	3	6	6	6	12	6
Total weight of gun, cwts	1.78	1.71	1.97	1.97	2	1.97
Material of gun	Steel.	Bronze.	Bronze.	Bronze.	Steel.	Bronze.
System of loading	M. L.	M. L.	M. L.	M. L.	B. L.	M. L.
Weight of projectile, pounds	7.3	6.2	8.8	6.5	8.8	8.9
Weight of charge, ounces	12	7.4	10.6	10.6	12	12.3
Muzzle velocity, feet	955	794	771	879	698	....

A highly interesting and valuable series of field-artillery experiments was carried out in the autumn of 1875, at Okehampton, in England. The object of these trials was to ascertain the effect of artillery fire under circumstances as regards ground, etc., that would represent, as far as possible, the conditions of actual war. For this purpose two batteries of Royal artillery were encamped for about a month on Dartmoor, in Devonshire. These batteries, day by day, drew their ammunition from a field-magazine, and manœuvred over all sorts of ground, coming into action in various positions and at different distances, the sites of the objects fired at being also varied so as to obtain as closely as possible a representation of the effects of fire under all circumstances that might occur on service. The objects consisted of wooden dummies representing infantry soldiers, and wooden targets to represent cavalry. The batteries depended for their knowledge of distance on observation alone, using for the purpose Nolan's range finder. The results of these important trials may be summarized as follows:

1. Both time- and percussion-shells are indispensable to the efficiency of field-artillery. The destructive effect of a good time Shrapnel against troops in any loose formation, and presumably in motion, is greater than that of a percussion-shell burst on graze. Against column formations, when the range is known, both projectiles appear to be equally efficient. The time-shell has the advantage when firing at batteries or troops retired behind the crest of a hill. When firing at objects in motion, the effect of time Shrapnel depends greatly on the accuracy with which the varying distances are estimated, upon the care and judgment in boring or setting the fuse to correspond with these conditions, and upon the facilities for observing the value of each shell as regards height and distance of the point of bursting from the object. On the other hand, the extreme simplicity of good percussion-shells and the valuable aid they offer in readily picking

up and varying the range are advantages that cannot be over-estimated, and render a projectile of this nature especially valuable for use in the excitement and heat of action. The chief disadvantage in the employment of percussion-shells arises from the uncertainty due to the nature and formation of the ground on which the shell may graze, and the possibility of its proper action being seriously interfered with or altogether nullified.

2. Bodies of troops cannot with impunity remain stationary, or even move deliberately, in front of rifled guns at any distance under four thousand yards, if the ground be all open, provided the artillery be so posted that they can see for that distance and the atmosphere be clear. Villages or depots of stores would be unsafe at longer ranges.

3. Under favorable circumstances of weather and of open ground, such as it may fairly be assumed an attacking force would have to traverse, it would be impossible without great loss to maintain column formation under the fire of rifled artillery at any distance under four thousand yards. Under these circumstances of weather and ground a well-sustained and concentrated fire of rifled field-artillery would prove most formidable to the advance of troops in any formation. Even against skirmishers well-served time Shrapnel could be used with considerable effect at ranges under two thousand yards.

4. A strong battery of rifled field-artillery can take care of itself, provided its flanks are protected and the ground in its front is moderately open.

5. It is most important that every field-artillery battery should possess the means of ascertaining distances. The instruments used for this purpose should be accurate, simple, and portable. It should, however, be borne in mind that no amount of simplicity or portability will compensate for inaccuracy. An instrument that will not find the range correctly is only in the way. But the possession of a trustworthy means of ascertaining distances should never be allowed to interfere with the practice of judging distance by eye. There will be many occasions where range-finders cannot practically be used at all, and the true method of teaching gunners to lay guns is to constantly and carefully practice them in the art so as to fix it indelibly upon their minds. There can be little doubt that field-artillery has a great future before it, and that when skillfully handled it will produce surprising results. To all appearance it has now arrived at perfection so far as regards power and mobility; but it is possible that within a few years steam may play a part in field-artillery, and that we shall live to see far heavier and more powerful guns than the present pieces brought into the field by traction-engines.

SIEGE-ARTILLERY.

The experience derived from the Franco-German War of 1870, and from recent experiments both in Germany and England, will doubtless result in considerable modifications being made in the rules as now laid down for the conduct of sieges. The marvelous accuracy of modern artillery will render the use of the embrasure a practical impossibility, except under peculiar circumstances of position and distance; and the production of a simple and strong siege-carriage, from which direct fire can be obtained with the minimum exposure of gun and detachment, is recognized to be a great desideratum. Of late years much attention has been given to the subject of rifled siege-artillery, particularly rifled mortars, and the following table gives the weights and dimensions of various pieces now in use.

TABLE GIVING THE WEIGHTS AND DIMENSIONS OF SIEGE-ARTILLERY, 1875.

NOTE.—The following abbreviations are used: S. and W. I. = steel and wrought iron. S. = steel. B. = bronze. C. I. = cast iron.

NATIONS.	Calibre, Inches.	Length of Bore, Inches.	Number of Grooves.	Weight of Shell Filled, Pounds.	Bursting Charge, Pounds.	Total Weight of Gun, Cwts.	Service Charge, Pounds.	Material of Gun.	System of Loading.	Muzzle Velocity, Feet.
UNITED STATES.										
100-pounder Parrot	6.4	130	9	101	5.5	86.6	10	C. & W. I.	M. L.	1250
30-pounder Parrot	4.2	120	5	29	1.5	37.5	3.2	C. & W. I.	M. L.	1293
4½-inch gun	4.5	120	11	25.5	1.5	30.8	3.2	C. I.	M. L.	1303
ENGLAND.										
64-pounder	6.3	97.5	3	64.6	7	64.5	10	S. & W. I.	M. L.	1375
40-pounder	4.7	85.5	3	38	2.6	35	7	S. & W. I.	M. L.	1336
8-inch howitzer	8	48	4	180	13	46	10	S. & W. I.	M. L.	790
FRANCE.										
24-pounder	6	79.2	6	52.9	2.2	40.4	5.5	B.	M. L.	955
12-pounder	4.8	78.9	6	25.3	1.1	17.1	2.6	B.	M. L.	1040
GERMANY.										
15-centimetre long	5.9	119.6	37	61.7	4.2	59	13.2	S.	B. L.	1542
15-centimetre short	5.9	73.9	24	61.1	4.4	29 5	3.3	S.	B. L.	830
12-pounder	4.7	75.3	18	32	1.1	17.1	2 3	B.	B. L.	978
21-centimetre gun	8.2	114.5	30	174	10.5	76	14.3	S.	B. L.	984
21-centimetre mortar	8.2	....	30	174	10.5	34.8	4.4	B.	B. L.	545
RUSSIA.										
24-pounder	6	113.9	24	64.2	2.6	42	6.3	S.	B. L.	......
12-pounder	4.8	84	18	32	1.2	18.5	3.1	B.	B. L.	1006
8-inch gun	8	113.5	30	176	6.1	102.2	17.2	S.	B. L.	1050
8-inch mortar	8	54.2	30	176	14	78.2	15.3	B.	B. L.	826
ITALY.										
16-centimetre	6.5	107	6	65.2	2.6	60.5	7	C. I.	M. L.	1092
12-centimetre	4.8	76.4	6	24.6	1.1	14.4	2.6	B.	M. L.	1117
22-centimetre howitzer	8.8	78.3	6	154.3	7.7	55.5	7.7	B.	M. L.	732
AUSTRIA.										
24-pounder	5.9	87.1	30	60.8	2.2	30	3.4	C. I.	B. L.	804
12-pounder	4.7	98.3	24	30	1.2	29.3	2.4	C. I.	B. L.	570
8-inch mortar	8.2	60.1	30	193	8.9	98.8	11.1	C. I.	B. L.	718

HEAVY ORDNANCE.

At the termination of the memorable siege of Gibraltar, about ninety-six years ago, the serviceable and mounted armament of the fortress consisted of the following natures of cast-iron smooth-bored ordnance,—which represented the heavy artillery of the period:

Guns: 32-pounders, 24-pounders, 18-pounders, and 12-pounders.
Mortars: 13-inch, 10-inch, and 8-inch.
Land-service howitzers: 10-inch and 8-inch.

At the great siege of Sebastopol, fifty-eight years afterwards, the artillery used on both sides, with the exception of a few Lancaster rifled guns employed by the British, were cast-iron smooth-bored pieces somewhat similar in general character to the guns used at Gibraltar. Thus, over half a century had passed without any marked improvement in the power of ordnance. This stagnation, however, must not be attributed to ignorance of the theory of gunnery, but to the want of suitable materials and proper machinery for the manufacture of larger and more powerful guns. Moreover, this period was not altogether one of inaction. General Paixhan, in 1822, pointed out the advantages of horizontal shell fire, the development of which ultimately led to the introduction of ironclads. General Rodman also—one of the pioneers of "Armed Science"—introduced the celebrated cast-iron smooth-bored ordnance which bears his name, and thus placed the United States for some time at the head of the nations of the world in the matter of powerful ordnance. It must, however, be admitted that the first practical step that led to the vast development which has of late years taken place in heavy ordnance was the substitution of the elongated for the spherical projectile.

Many attempts were made to rifle existing cast-iron smooth-bore guns by grooving the bore, and apparently strengthening the piece by superimposed iron breech-rings; but all those attempts were mainly due to a tendency to utilize the stock on hand,—and the trials in this direction showed that cast-iron guns thus rifled could not be depended upon when using high charges. Still, good results have been obtained by lining cast-iron guns with tubes of coiled wrought iron or steel, as proposed by Sir William Palliser and Captain Parsons, and recent improvements in gunpowder may render these systems applicable to very heavy guns.

The great progress, however, which took place in the manufacture of cast steel, and the introduction of the steam-hammer, enabled the artillerist to forge the monster weapons of the present day, and to produce trustworthy guns of vast size and power. This great development in the power of attack has advanced *pari passu* with a comparative increase in power of defense. The introduction of horizontal shell fire led to the use of armor on the sides of ships of war; and the memorable trial of the "Warrior" target in England, in 1862, showed that the defense had succeeded in producing a vessel that was proof against the most powerful rifled or smooth-bored guns then in Europe. This triumph, however, was but short lived. Within a few months, Sir Joseph Whitworth produced steel shells which perforated the "Warrior" target with ease; and, since that date, the question of guns *versus* armor has been one of an oscillating character, according as thicker plates or more powerful guns have, from time to time, been produced. The "Warrior" with 4½-inch plates was followed by other vessels protected successively with 6-inch, 7-inch, 8-inch, 9-inch, 10-inch, 12-inch, and 14-inch plates: other vessels with from 20- to 24-inch armor are now in course of construction. The 7-inch (150-pounder) rifled gun which perforated the "Warrior," was followed by rifled guns of 8-inch (180-pounder), 9-inch (250-pounder), 10-inch (400-pounder), 11-inch (500-pounder), 12-inch (700-pounder), and 12½-inch (800-pounder). A 14-inch rifled gun (1150-pounder) has been successfully constructed by Herr Krupp; and a 16-inch rifled gun (1700-pounder), manufactured in the Royal gun-factory, is now under trial at Woolwich. Seventeen-inch guns (1900-pounders) are in course of construction at Elswick by Sir William Armstrong & Co.* It is, moreover, apparent that this battle between the attack and defense has assumed the character of a gigantic international duel.

The problem demands, and receives, the most careful consideration of the scientific artillerist and the mechanical engineer, while some of the greatest achievements of the forge-master are required in attempting its solution. All the mystery which may have previously existed in matters of gunnery has now been cleared away; and the general principles upon which trustworthy guns can be constructed are perfectly well known and understood. It is, therefore, only in details that we may expect differences in the future construction of trustworthy ordnance. The precise pattern adopted by each country may—as Mr. Stuart Rendel very justly says—be "the result of compromise, and of a nice adjustment of the balance of advantage and disadvantage, as viewed by the respective ordnance authorities, and as well from a political and economical as from a technical point of view." But, however the details of metal, rifling, and method of

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* One of these guns has been finished and is now under trial.

loading may differ, the main conditions upon which the power of the guns depends—namely, velocity, penetration, and accuracy—must be secured. At present the most prominent methods of constructing heavy ordnance in Europe are three in number: the English, the French, and the German.

In the English, or Woolwich muzzle-loading system, the gun is built up of a strong, solid-ended steel tube, surrounded by several double or triple wrought-iron coils. It is claimed that this method of construction produces the safest, cheapest, and simplest system of heavy ordnance. The guns are said to be the most powerful of their class, and to possess the great merit of non-liability to burst explosively,—the failure of a gun being preceded by timely warnings to the gun detachments.

The French breech-loading system of construction (modèle 1871) consists of a cast-iron tube, reinforced from the breech about one-third of its length by a steel tube, and strengthened over the breech, as far as the trunnions, by superimposed rings of puddled steel. Thus the breech of the gun, where the strength is required, is fortified by an inner steel tube and outer steel rings, and the chase is simple cast-iron, unstrengthened.

The German or Krupp breech-loading method of construction has been very fully detailed in the report on the Vienna Exhibition. It consists of a steel tube surrounded by superimposed steel rings.

It would be impossible without a practical competitive trial to form an opinion as to the relative merit of these three systems, or to decide which country has the best armor-piercing gun. It is only possible to produce figures, drawn from the most trustworthy sources at our command, and arranged in the most convenient form.

The comparative merit of armor-piercing guns is deduced on paper from the weights of the projectiles which they throw, and the velocity with which these projectiles strike the object at which they are directed. The blow thus struck is proportional to what in scientific language is termed the "energy" of the projectile at impact. The numerical value of this quantity is found by multiplying the weight of the projectile in pounds by the square of the velocity on impact in feet, and dividing the product by twice the force of gravity in feet,—or

$$E = \frac{Wv^2}{2g} \quad \text{..................................} \quad (1)$$

As a matter of convenience it is usual to express the result in foot tons, and as there are 2240 pounds in a ton, equation (1) becomes

$$E_{,} = \frac{Wv^2}{4480g} \quad \text{..................................} \quad (2)$$

Here $E_{\prime}$ equals the total energy of the projectile, on impact, in foot tons; W equals the weight of the projectile, in pounds; and v equals the velocity of the projectile, upon impact, in feet. The facility with which the projectile will perforate an armored structure depends upon its diameter as well as upon its energy; but scientific artillerists are not agreed upon the expression which most faithfully represents the comparative powers of different diameters. As an illustration, however, we shall select the English expression, which assumes that the resistance offered by armor varies as the calibre. It is usual to express this rule by introducing into the formula the shot's circumference in inches, and to call the result of the computation the "energy per inch of the shot's circumference."

Thus, if $E_{\prime}$ be the total energy and $E_{\prime\prime}$ the energy per inch of the shot's circumference:

$$E_{\prime\prime} = \frac{E_{\prime}}{\pi D} = \frac{Wv^2}{4480\, g\, \pi D} \quad \text{..........................} \quad (3)$$

where D is the diameter of the projectile in inches.

The following table gives the principal dimensions and weights of English, French, and German armor-piercing guns, and a comparison of their relative merit as indicated by equation (2):

THE ENGLISH, FRENCH, AND GERMAN SYSTEMS OF HEAVY ORDNANCE, 1876.

PARTICULARS.	ENGLISH.			FRENCH.			GERMAN.		
	12.5-IN.	11-IN.	10-IN.	12.5-IN.	11-IN.	9.5-IN.	11-IN.	10-IN.	9-IN.
GUN.									
Calibre, inches	12.5	11	10	12.6	10.8	9.5	11.02	10.24	9.27
Length of bore, inches	198	145	145.5	204.1	163.7	162.6	207.1	194.5	177.6
Total weight, tons	38	25	18	34.5	21.7	13.8	27.07	21.65	15.26
COMMON SHELL.									
Weight empty, pounds	668	501.25	374	593.5	303.8	211.25	381	330.7	247
Diameter, inches	12.42	10.92	9.92	12.66	10.89	9.55	11.16	10.37	9.38
Length, inches	36.2	34.2	32.5	34.1	24.02	21	....	....	....
Bursting charge, pounds	43.8	28.75	27.1	38.1	13.67	9.25	23.48	19.8	15
Total weight filled, pounds*	726.5	530	401.1	631.6	317.5	220.5	404.5	350.5	262
BATTERING PROJECTILE.									
Diameter, inches	12.42	10.92	9.92	12.66	10.89	9.55	11.16	10.37	9.38
Length, inches	33	28.3	26.3	....	24.4	21	27.56	25.6	23.2
Total weight, pounds	815	535	400	760.5	476.4	317.6	517	414.5	306.4
BATTERING CHARGE.									
Weight, pounds	130	85	70	136.7	88.2	61.7	88.18	70.55	52.9
Muzzle velocity, feet	1,425	1315	1364	1312	1378	1427	1394	1385	1312
Total energy at muzzle, foot tons	11,160	6415	5160	9080	6270	4480	6970	5515	3660

The greatest amount of work realized in any gun to date (August 5, 1876) resulted in firing the 80-ton Woolwich gun, bored to 16

* Experiments are in progress with a common shell 815 pounds in weight and 37.5 inches long.

inches, with a charge of 350 pounds of 1.5-inch cubical powder and a projectile 1703 pounds in weight. In this case the muzzle velocity was 1505 feet, the muzzle energy 26,740 foot tons, and the mean pressure in the powder-chamber 20.4 tons on the square inch.

The question between muzzle-loading and breech-loading for heavy guns is a most complicated one, and can only be decided by balancing the advantages of one system against the other, according to the nature of the service for which the gun is required. The system of breech-loading now in use for heavy guns may be divided into two classes:

1. Those in which the breech is closed by means of a wedge or stopper introduced through an opening in the side of the gun, as in the Krupp system.

2. Those in which the closing is effected by a screw, withdrawn from the breech at every round, as in the French system.

For heavy rifled guns the points of greatest importance are strength, endurance, power, accuracy, and simplicity and safety in working. The practical question to be decided is whether these conditions can best be realized, as a whole, by inserting the charge at the breech or at the muzzle. It must be admitted that a solid-ended steel tube in the strongest part of the gun will afford greater longitudinal strength than the breech-loading arrangement in either of the above systems; but, in reply to this, it is asserted that the longitudinal strength given by the breech-loading construction is sufficient for all practical purposes, as shown by the fact that well-constructed breech-loading guns do not give way at the breech. As regards endurance a superiority is claimed for the breech-loader on the score of the vent—the most perishable part of the gun—passing through the breech-wedge or screw instead of through the body of the piece. The breech-wedge can be renewed at pleasure. It is also urged that in a *systême forcé* in which lead-coated or copper-banded projectiles are employed there is less chance of erosion in the bore. These claims are met by an admission that the power of renewing at pleasure that part of the gun in which the vent is situated constitutes an advantage for breech-loading; but it is pointed out that the use of a "gas check" or expanding base-ring effectually closes the windage in the muzzle-loading guns, and thus places them on a par with breech-loaders as regards erosion of the bore.

With respect to power and accuracy, it is urged that both are increased by having a long bore, and that the breech-loading gun may be made of any desired length without practical inconvenience; whereas the length of the muzzle-loader must depend on the position in which it is mounted. In reply to this argument the advocates of muzzle-loaders admit the advantage with respect to guns mounted in fortifications and on the broadside of vessels, but do not accept it in the case of turret-vessels armed with two guns in each turret. It is urged that the dimensions of turrets are governed by the space required for the guns' crews to work, or the space which must be left between the gun-slides and the interior of the turret; with guns of similar calibre this space would, it is said, be the same whether the guns were breech-loaders or muzzle-loaders. Simplicity and safety in working includes ease of loading, exposure of the men while loading, treatment of recoil, and the possibility of the gun being rendered unserviceable while in action.

The advocates of breech-loading urge that the labor and difficulty of bringing up a heavy projectile to the muzzle, and of placing it in the bore where the space is most confined and the men have least room to work, is considerably mitigated in the service of a breech-loader. Moreover, muzzle-loading guns necessitate long sponges and rammers, and the manipulation of such long staves is attended with much difficulty and loss of time. These difficulties also naturally increase with the length of bore and weight of projectile, so that every advance in the size of guns favors the breech-loading system. In consideration, therefore, of the reduced distance over which the charge has to be carried, and the facility afforded in ramming it home, a greater rapidity of fire is claimed for breech-loaders.

It is urged that with muzzle-loaders the men are much exposed to the fire of the enemy's guns and rifles, and that their *morale* may be destroyed by the casualties caused by sharpshooters or Shrapnel shell. In the service of the muzzle-loader from six to eight men are grouped together for some considerable time in the most exposed position—*i.e.*, at the opening of the port or embrasure—whilst sponging and loading the gun. With breech-loaders the same men are at a distance from the port, and are covered to a great extent by the gun and carriage. It is said that recoil can be more easily and simply treated in breech-loaders, as the muzzle-loaders require a nice adjustment of the compression to insure sufficient recoil for loading; and, in case the recoil should not be sufficient, running-back tackle must be used, thus causing delay. It is further urged that injury to the gun whilst loading is reduced to a minimum in breech-loaders. In the hurry of action, and difficulty of handling the long, unwieldy rammer of a muzzle-loader, the projectile may not be sent home on the cartridge,—a circumstance which would not only be attended by loss of accuracy, but might lead to fatal injury being inflicted on the gun through the premature bursting or breaking up of the projectile.

The condition of the bore of the breech-loader can be ascertained at any moment, and it is sure to be kept free from dirt and rust, which, in muzzle-loaders, are difficult to detect and are detrimental to the gun. Lastly, the breech-loader, assuming the safety of the breech-action, is perfectly exempt from those distressing accidents which from time to time occur from the premature explosion of the cartridge.

In reply to these arguments* the advocates of muzzle-loaders admit that the actual manual labor expended in loading a heavy muzzle-loading gun is probably greater than in a breech-loader of the same calibre, and that this increases with the size of the gun, but they point out that, as a matter of fact, no real difficulty is experienced in loading heavy muzzle-loading guns up to the 12-inch, and that the introduction of machinery will supersede manual labor in guns of the heaviest nature. It is as easy, if not easier, to apply machinery for this purpose to a muzzle-loader as to a breech-loader.

It should, moreover, be borne in mind that the time saved in the breech-loader by the reduced distance over which the charge must be carried, and the facility afforded in ramming it home, will be counterbalanced by the time lost in opening and closing the breech and inserting and withdrawing the bridge. Indeed, there is no clear proof that, with the heavy rifled guns now actually used by European powers, breech-loaders have any advantage in rapidity of fire over muzzle-loaders.†

With respect to the exposure of the detachments while loading muzzle-loaders, it is pointed out that the assumption cannot be admitted as regards guns mounted in armor-clad vessels, because the ports are always fitted with iron rifle-proof lids having a small circular

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* Many of the following arguments are condensed from an excellent paper on the subject by a distinguished British naval officer.

† The following facts are interesting as instances of the rapidity of fire of heavy muzzle-loading rifled guns. The English ironclads "Monarch" (turret) and "Hercules" (broadside), when steaming at the rate of between four and five miles an hour, opened fire at a rock distant about one thousand yards, using battering charges and Palliser projectiles.

The "Monarch" in five minutes fired twelve rounds from the four 12-inch guns, and struck the rock seven times. The "Hercules" in five minutes fired seventeen rounds from her four 10-inch guns, and struck the rock eleven times. In June, 1876, some practice was carried out at Shoeburyness, in England, to test the rapidity of fire and accuracy of the 12.5-inch rifled gun, of thirty-eight tons, firing 800-pound projectiles with 130-pound charges. The gun was directed successively at three targets, at the respective distances of one thousand, one thousand five hundred, and two thousand yards, each target being taken in turn, so as to vary the direction and training of the guns for each round. The average time of firing was two minutes and twenty seconds per round, and the practice was excellent, all the targets being completely shot away.

hole in the centre through which the handles of the sponge and rammer are worked, and these port-lids are lowered whilst the guns are being loaded under rifle or Shrapnel fire. The same system could probably be applied to the embrasures or shields of casemated works.

No practical difficulty is said to be found in controlling the recoil of muzzle-loading guns, and with a little practice the compression can be adjusted so as to allow the gun, on recoil, to assume the proper position for loading without using the running-in gear at all; but in the event of the gun not having recoiled sufficiently, owing to too great compression having been given, a very few turns of the running-in winches places it immediately in the required position. The possibility of injury being caused to the gun by careless loading in the muzzle-loader is counterbalanced by the possibility of careless manipulation of the breech-closing apparatus of the breech-loader. But, in order to insure the projectile being rammed close to the cartridge, a plain and distinct mark is placed on the staff of each rammer in such a position that when the mark is in line with the muzzle of the gun it is certain that the projectile is close home on the cartridge. There is no case on record of the premature explosion of a cartridge while firing shotted charges in a heavy muzzle-loading rifle gun, and the practice of using saluting charges in such guns, although attended with very little risk, should be discouraged as much as possible.

Lastly, the advocates of muzzle-loading lay considerable stress on the simple character of the weapon. It is urged that in actual warfare we require an article with the *minimum* chances of going out of order. There is always a chance that the breech-closing arrangement may give trouble just at the most critical moment, whereas comparatively nothing can go wrong in a muzzle-loader. The foregoing are the main arguments on the question of breech- *versus* muzzle-loading for armor-piercing guns.

To give an opinion one way or the other is not within the scope of this paper; indeed, the duty of the "expert" lies in placing the arguments impartially side by side, so that in discussing the question the true advantages and disadvantages may be clearly recognized. The subject can then be dealt with, not as a question of sentiment, but as a matter of fact.

The subject of gunpowder will be treated under the head of Explosives; but as the development of modern ordnance has, in great measure, depended upon the invention of large-grained gunpowder by General Rodman and the subsequent improvements in manufacture, it will not be out of place to give a brief *résumé* here of the general conclusion which may be drawn from recent experimental research in this direction.

1. It has always been a matter of difficulty to distinguish a "blow" from a "pressure." A blow is said to be a pressure suddenly applied; but as there must always be variation in the suddenness of application, we cannot easily define the point where the pressure ends and the blow begins.

It has long been assumed that the effect produced by the explosion of a charge of gunpowder within the bore of a gun partakes of the character of a blow, but recent experiments appear to indicate that this is not the case. In the investigations carried out at Woolwich in 1869–76, the pressure was directly recorded by means of an instrument on the Rodman principle. The apparatus, termed the "Crusher-Gauge," is screwed into the body of the gun, and admits of the explosion acting directly on the base of a small steel piston, which, in its turn, acts upon a small cylinder of pure copper. The latter, on the explosion of the charge, is compressed by the piston, and the amount of compression is a measure of the pressure exerted. It has been found that successive applications of pressure produced by again and again using the same copper cylinder with similar charges, produce no further compression over that due to the first charge than might be accounted for by variation in the pressure of similar charges.

For example, in a 10-inch gun the effect of firing a 400-pound projectile with a 70-pound charge of pebble-powder was to reduce the length of the copper cylinder, say from 0.5 inch to 0.25 inch; but this cylinder was not perceptibly reduced in length lower than 0.25 inch, by subjecting it to the action of several other discharges of 70-pound charges and 400-pound shot. A similar copper cylinder was then placed under a falling weight and made to receive a blow which reduced its length from 0.5 inch to 0.25 inch. It was then subjected to several successive blows given by the weight falling again and again from the same height. The result was that it was battered into a form somewhat resembling a cent. It is evident, therefore, that the pressure produced by slow-burning powder is not dynamical, or similar to that due to a weight falling from a height.

The following table gives the results of an experiment in which the same cylinders were subjected several times to the action of heavy charges fired from a 12½-inch rifled gun of thirty-eight tons. In some cases the form was unchanged after the second round.

PRESSURES INDICATED BY THE CRUSHER-GAUGE IN THE 12.5-INCH RIFLED M. L. GUN.

Charge 130 pounds of 1.5 inch cubical powder. Projectile 800 pounds.

No. of Round.	Muzzle Velocity.	Pressure in Tons per Square Inch at Various Points from end of Bore.						Remarks.
		0	12 inches.	24 inches.	36 inches.	48 inches.	60 inches.	
1	1401	22.3	21.4	20.3	20.1	14.1	12.0	New copper cylinder.
2	1417	22.7	22.8	20 4	21.1	14.9	12.1	Same coppers as used in round 1.
3	1408	22.7	22.9	20.5	21.3	16.1	12.3	Same coppers as used in rounds 1 and 2.
4	1424	22.7	22.9	22.4	23.6	17.1	12.7	Same coppers as used in rounds 1, 2, and 3.

These experiments corroborate those made previously on the same subject by General Rodman.

2. The use of unsuitable descriptions of powder, or even of excessive charges of slow-burning powder, may give rise to oscillations of pressure termed "wave action," which act violently on local points in the powder-chamber without contributing to the useful effect of the charge.

3. If powder be burned uniformly in the gun without indication of wave action, the pressure will increase with the increase of charge,—at first very rapidly, but after twenty tons on the square inch has been exceeded, then very slowly.

4. With a suitable charge for the gun, the pressure in the powder-chamber increases slowly but steadily with the increase in weight of the projectile up to a certain point: beyond this point no material increase of pressure can be obtained by increasing the weight of the projectile.

5. As already stated, the greatest amount of work heretofore realized in any gun resulted in firing the 80-ton Woolwich rifled muzzle-loading gun with a charge of 350 pounds and a projectile 1703 pounds in weight. In this case the muzzle velocity was 1505 feet, total muzzle energy 26,740 foot tons, and mean pressure in the powder-chamber 20.4 tons on the square inch.

The Krupp 14-inch breech-loading rifled gun has realized a muzzle energy of 21,300 foot tons in firing a charge of 297.6 pounds, and shot of 1146.4 pounds, the pressure being 25.9 tons on the square inch.

6. Experiment has shown that the pressure produced by the explosion of large charges can be varied and controlled by mechanical alterations in the form and density of the gunpowder used. It has also been proved that hydraulic power can be easily applied to the service of the heaviest guns. We may, therefore, conclude that the size of heavy rifled ordnance will go on steadily increasing, and will only be limited by practical requirements.

MACHINE-GUNS.

The machine-gun, although of comparatively recent date as a weapon of practical use in military operations, cannot be regarded as a new invention, or even as a novel idea in the science of mechanism. At no period in the history of firearms did the genius of invention rest content with the completion and successful trial of any single weapon; for no sooner was such success assured than mechanical ingenuity seized upon the idea, and endeavored by all manner of strange devices to increase and multiply the destructive effect of the newly-discovered power. This constant effort to combine in one weapon the force of many kept pace with and adapted to its own use the discovery of each new principle in the development of firearms; so that the history of machine-guns may be said to have commenced with the crude match-locks of olden times, and to have continued uninterruptedly to the perfection of the modern breech-loader.

Machine-guns, under the names of *ribaudequins orgues*, organ- or tube-guns, were known in the early days of artillery,—a gun composed of four breech-loading tubes of small calibre placed on a two-wheeled cart having been used in Flanders as early as 1347. Mention is also made of a machine, used in Italy in the fourteenth century, which consisted of a carriage having one hundred and forty-four small bombards ranged upon it, in rows of twelve each, so that thirty-six balls could be fired at once. Four-tubed guns were also used by the Scotch during the civil war in 1644.

All of these guns were of a clumsy construction, uncertain in range, and so slow in delivering their fire that they were regarded as of very little value; and although much improved during the sixteenth and seventeenth centuries, they were gradually superseded by the introduction of field-artillery, which until that time had not been in actual use, owing to the difficulty of constructing carriages strong enough to resist the recoil of the guns and at the same time possessed of the lightness and mobility requisite for a field-piece.

Little more is heard of machine-guns during the two centuries following, until the Crimean War woke up the spirit of destructive invention. Among the hundreds of warlike implements which immediately appeared were several varieties of compound guns mounted on frames and wheels, and loaded and fired by various complex devices.

None of these inventions, however, were considered suitable for active service; but as they undoubtedly possessed some of the essential features of a perfect machine-gun, the interest in them was not allowed to subside. The War of the Rebellion in America following soon after, aroused all the inventive genius of the New World, gave additional impetus to European attempts, and in a few years brought machine-guns so near perfection that their successful use in active service during the Franco-Prussian War demonstrated the fact that the difficulties which had so long prevented their adoption had finally been overcome, and that a new weapon had taken its place in modern warfare. The history of these arms in the United States, beginning with an 11-barreled breech-loading gun introduced during the War of 1812, and ending with the Gatling gun of world-wide reputation, shows a continuous series of attempts to solve the difficult problem of combining magnitude of effect with simplicity of mechanism. The records of the Ordnance Bureau of the War Department alone contain descriptions of no less than twenty-five different designs of machine-guns, and these probably form but a small portion of the number actually invented. They include almost every possible method of arranging the barrels, and in the operations of loading and firing call into use all the means of effecting that purpose which from time to time have been introduced into the manufacture of small-arms. They were used for the first time, though to a very limited extent, during the Rebellion,—a Requa rifle-battery used at the siege of Charleston being almost the only instance on record. Other varieties, such as the Union or "Coffee-mill" gun, the Rapheal repeating-gun, the Kellogg gun, and the Vandenburg volley-gun, were brought into notice from time to time and were tested by the Government, but none were found suitable for active service. All of these machine-guns had the same objectionable features that had prevented the adoption of their numerous predecessors, viz., complexity of mechanism, want of mobility necessary in field-artillery, and damaging recoil from the simultaneous explosion of so many distinct charges of powder.

The Gatling gun, invented in 1862 and subsequently much improved, was a long step in advance of all the machine-guns that had preceded it, and possessed to a great extent that simplicity and lightness so much needed in an arm of this kind. It was not until January, 1865, however, that its merits were brought to the knowledge of the War Department, and extensive and elaborate trials were inaugurated, which finally resulted in its adoption into the military service of the United States. The early history of the Gatling, like that of all breech-loaders, is clouded by defects and failures arising from the want of the essential feature of this system, viz., an effectual gas check; this was at length furnished by the adoption of a metallic cartridge for all breech-loading arms,—so that, after all, it owes a great part of its success to the perfection of late attained in the manufacture of this ammunition.

EXPLOSIVE AND FULMINATING COMPOUNDS.

During the past century a great advance has been made in knowledge respecting the nature of explosive agents, and many new varieties have been added to the list available for use in peace and in war. Indeed, one hundred years ago gunpowder was exclusively employed, while to-day it is often superseded by more powerful and economical agents then quite unknown. Although, from obvious reasons, this class could only be represented by imitations at the Centennial Exhibition, the subject is one of so much importance that a few words respecting the explosives now in common use will not be out of place.

The effects of an explosion are due to the sudden evolution of a great volume of highly-heated gas in a confined space. Detonation implies that this physical change occurs instantaneously, giving rise to a violent blow rather than to a sustained pressure. The essential constituents of most explosives are carbon, oxygen, and nitrogen; and the gaseous products consist mainly of carbonic acid gas and free nitrogen, but other elements are often present and enter into the chemical reactions.

Modern explosive agents may be divided into two great classes, mechanical mixtures and chemical compounds. To the former belong the nitrates and chlorates, and to the latter gun-cotton, nitroglycerine and its compounds, the picrates, and the various fulminates, each of which will be briefly considered in turn.

The Nitrates.—Gunpowder is the best-known type of this class. It is a mechanical mixture of potassium nitrate, carbon, and sulphur, the proportions by the atomic theory being about 74.5, 13.5, and 12.0 respectively. For the military service the proportions usually differ but slightly from these figures; for sporting purposes the potassium nitrate is often increased, and for blasting purposes decreased. The general characteristics of gunpowder and the usual process of manufacture are too well known to require notice here; but a very recent modification in the latter, invented and introduced in Russia by Colonel Wierner three years ago, merits attention,—especially as samples of the powder thus made have been submitted to the Judges of Group XVI.

The new process consists, essentially, in replacing the wetting, compressing, and drying processes by dry hot pressure between steam-heated plates. The temperature should be about 248 Fah. A pressure of 30 atmospheres gives a density from 1.66 to 1.70, and of

130 atmospheres from 1.86 to 1.90. The powder should remain under pressure for ten minutes. It is claimed that by this change the needful machinery and the cost of production are largely reduced; that the powder is rendered less absorbent; that the operation is less dangerous, because from the great saving of time less bulk is operated upon at once; and, lastly, that greater uniformity in density is secured. After soaking samples of the powder shown at this Exhibition for ten days in pure water the plates did not break up, while powder of excellent quality made in the usual way, treated in like manner, soon became thoroughly disintegrated. The process can be used as well for blasting powder made from sodium nitrate as for the higher grades made from potassium nitrate.

Although gunpowder has been in general use for more than five hundred years, the modern system of experimental research has led to great advances in knowledge respecting it during the past century. The investigations of Count Rumford, communicated to the Royal Society in 1797, furnished data respecting the pressure developed by its explosion, which have continued to be regarded as the best standard until very recently (1875), when the elaborate results obtained by Captain Andrew Noble and Mr. Abel were published. In 1825, Chevreul drew attention to the difference in decomposition caused by variations in the conditions under which gunpowder may be exploded. General Piobert made many valuable experiments between the years 1831 and 1836, which were fully elaborated in his standard work published in 1859. In 1841, Colonel Rumford, U. S. A., devised a system of measuring the pressure exerted in different parts of the bore of a cannon, which has done much to improve the construction of modern ordnance. In 1856, General Rodman, U. S. A., invented better apparatus for observing these pressures, and by its aid discovered the important and normal changes which may be caused in the ratio between the pressure exerted upon the gun and the velocity communicated to the projectile by judiciously varying the size and composition of the grains. These studies led him to invent mammoth and perforated cake powder, which have been adopted, with certain modifications, by the British Government under the names of pellet and pebble powder, and by the Russians under the name of prismatic powder. Without these inventions the immense guns now adopted in all military services could never have been introduced. The general principle upon which these improvements are based is the fact that gunpowder does not detonate, but burns; and that the rate of burning may be varied by changing the size and form of the grains, and by regulating their density and hardness and the mechanical condition of their exterior. For instance, the powders employed in the experiments in progress with the 80-ton gun in England consist of grains of a cubical form varying from one to two inches on the edge.

Space forbids even an enumeration of the works upon gunpowder which have appeared during the past twenty years; but the following summary of some of the more important conclusions announced by Noble and Abel will give a sufficient idea of the present state of knowledge upon the subject.

When gunpowder is fired in a space entirely confined, one gramme occupying one cubic centimetre, the products consist of about fifty-seven per cent. by weight of matter, which ultimately assumes a solid form, and forty-three per cent. of permanent gases,—of both of which chemical analyses are given by the writers. At the instant of explosion these fluid and gaseous products are approximately of the same specific gravity. The tension is about 6400 atmospheres, or about forty-two tons per square inch, if the powder entirely fills the space in which it is fired. The temperature of explosion is about 4000° Fah., and about 705 gramme units of heat are developed by the decomposition of one gramme of the kind of powder tested.

When gunpowder is fired in the bore of a gun the proportions of the solid and gaseous products are the same as the above. The work on the projectile is effected by the elastic force due to the permanent gases. The reduction of temperature due to the expansion of the permanent gases is in a great measure compensated by the heat stored up in the liquid residue. The total theoretical work of gunpowder, indefinitely expanded, is about 486 foot tons per pound of powder. For many other important details and formulæ, reference should be made to the original paper which appeared in the *Philosophical Transactions of the Royal Society*, 1875.

The cost of potassium nitrate has occasioned many experiments to be made with a view to replacing it by other nitrates, especially with that of sodium; but the deliquescent character of that salt is so objectionable that, although it is largely employed in making blasting powder, it is little used for the other varieties. By substituting uncarbonized peat in place of part of the carbon, Mr. Oliver has lately succeeded in making a powder which, when well rammed, is claimed to give a high initial velocity with less recoil and smoke than ordinary grades of cheap powder. Kellow's powder was prepared several years ago from potassium nitrate, spent tan, and a little sulphur; and a similar blasting powder, under the name of pudrolythe, has recently appeared in England. The latter is said from its slow rate of burning to have great lifting force in quarrying.

The Chlorates.—Potassium chlorate gives up its oxygen much more readily than potassium nitrate, and when mixed with carbon in various forms makes a powder which explodes more sharply than gunpowder, and, indeed, resembles the chemical compounds in the suddenness and violence of its action. It was introduced and considerably used in blasting in this country a few years ago, but its extreme sensitiveness to friction led to many accidents, and it is now practically superseded by the nitro-glycerine mixtures. The principal forms were known as Horsley's powder, Oriental Safety compound, White gunpowder, and Erhardt's powder; composed, respectively, by mixing potassium chlorate with nut-galls, crude gamboge, potassium ferrocyanide, and tannin. If sulphur be used in combination with the oxidizing agent an extremely dangerous mixture is formed, which, however, finds a special use as a priming for explosive bullets.

By using potassium chlorate as an absorbent for combustible liquids many of the objections to this class are removed, for the two portions may be kept separate, and only united as desired for use. Moreover, the incorporation, which with the carbon in a solid form is very dangerous, is rendered safe. A mixture of potassium chlorate and petroleum belongs to this type; but a very powerful detonator, like a disk of gun-cotton, is needful to effect explosion.

Gun-cotton.—The history of gun-cotton is peculiarly interesting, and well illustrates the advantage of thorough experimental investigation in dealing with explosives. The germ of the discovery dates from 1832, when Braconnet ascertained that by dissolving starch in nitric acid and adding water a white explosive solid was precipitated, to which the name xyloidin was given. Shortly after pyroxylin was discovered by Pelouse in treating paper and cotton or linen cloth with nitric acid. Gun-cotton was first made by Schönbein in 1846, and at once attracted general notice as a possible substitute for gunpowder in the military service. Commissioners were appointed by several governments to investigate its properties; but in every country except Austria adverse reports were made, based on its supposed liability to spontaneous explosion, its violent and irregular action, and its corroding residua. Baron von Lenk of the Austrian commission alone continued the study, and made an elaborate series of experiments, which promised so well that, in 1853, he constructed a 12-pounder field-battery which was temporarily introduced into the Austrian service. His improvements consisted in more thoroughly purifying the ingredients, in devoting special attention to removing all traces of acid from the finished product, in rinsing it in a hot solution of potassium silicate to retard combustion, and in regulating the density by weaving it into cloth, or twisting it into ropes, to secure uniformity of action. This Austrian success led the British War Office to renew experiments; and, beginning his investigations in 1863, Mr. Abel has succeeded in so greatly improving the manufacture that gun-cotton is now recognized as the safest known explosive. Although not suited for use in artillery, it has been adopted by many nations for the torpedo service, and is very largely used for blasting purposes. Abel's principal improvements consist in thoroughly pulping the gun-cotton after its treatment with the mixed acids and moulding it into disks which are strongly compressed by applying pressure ranging from four to six tons per square inch. He employs ordinary cotton-waste, instead of the expensive long staple variety adopted by Lenk; and his pulping process effectually removes all free acid, which could not certainly be done in the Austrian method of manufacture. The recent discovery that even wet gun-cotton can be detonated by exploding a dry disk in contact with it, while it is absolutely safe against ordinary accidents, has largely added to the value of this new explosive. If frozen, however, it recovers its liability to detonation. It is reported that works will soon be established in the United States, under the Abel patent, with a view to introducing gun-cotton into general use here.

The chemical formula of gun-cotton is $C_6H_7N_3O_{11}$. Ignited (in the form of disks) in small quantities and unconfined it burns with a strong blaze. Fired by a detonating fuse, or raised to a temperature of about 350° Fah. in a stout case, it explodes with great violence. Very recently attempts have been made to furnish the slightly deficient supply of oxygen by soaking in a solution of potassium nitrate or chlorate, and experiments in this direction, as well as the manufacture in a granulated form, mark the latest stages of progress.

In practice, the detonation of all modern explosives is usually effected by the use of small initial charges of fulminates, and some very surprising facts have recently been established which go far to induce a belief that synchronism in vibration is an important element. Thus, compressed gun-cotton may be detonated by five grains of fulminating mercury, but requires fifty grains of chloride of nitrogen, and fails with one hundred grains of iodide of nitrogen, and even with one hundred and twenty-four grains of nitro-glycerine itself, which develops far more heat and mechanical force. On the other hand, a small initial charge of gun-cotton readily detonates nitro-glycerine. Fulminating mercury is usually adopted in practice for this use, to which it appears to be especially suited.

Mr. Abel has recently determined the velocity of detonation, transmitted from disk to disk of dry gun-cotton in contact, to be about seventeen thousand feet per second, while if the disks are saturated with water it is decidedly higher,—say twenty thousand feet.

Nitro-glycerine.—This explosive was discovered in 1847 by Ascagne Sobrero, but was first introduced into general use in blasting by Alfred Nobel in 1864. Since that date it has been largely employed in Europe and this country. It is the most powerful agent now known; but, uncombined with absorbents, it is justly considered as dangerous in manipulation and as unfit for long storage on account of liability to spontaneous decomposition, or even detonation, unless extreme care has been observed in its manufacture.

It is made by slowly introducing pure glycerine into a mixture of strong nitric and sulphuric acids, especial attention being paid to preventing a rise of temperature. There are believed to be three nitro-glycerines, mono-, di-, and tri-; and the chemical formula of the latter, which should be as exclusively produced as possible, is $C_3H_5N_3O_9$. Above 40° Fah. it is an oily liquid having a specific gravity of 1.6, odorless, and of a sweet taste. It is poisonous; and, if placed in contact with the skin, even in small quantities, before the system has become accustomed to its action, it produces violent headache. Below 40° Fah. it congeals into a white crystalline solid, which is nearly or quite unexplosive, and which may be handled or transported with safety. It may readily be thawed by introducing the can into warm water, which restores its full explosive power. These characteristics are those of tri-nitro-glycerine. Important discrepancies reported in its properties are believed to be caused by various admixtures of the lower nitro-glycerines.

Nitro-glycerine, ignited in small quantities by a flame and unconfined, burns with difficulty like an ordinary oil. At 423° Fah. it deflagrates violently. If ignited confined, or if subjected to the explosion of fifteen grains of fulminating mercury, it detonates with tremendous force. Fully exploded, it gives off no injurious gases,—an important advantage in tunnel blasting.

The accidents which attended the use of nitro-glycerine in its liquid form led Alfred Nobel to experiments with absorbents; and, in 1866–67, he invented and introduced the explosive known as dynamite or giant powder. This consists of seventy-five per cent. of nitro-glycerine and twenty-five per cent. of an inert silicious earth. The best variety of the latter is that known as kieselguhr, found in Hanover, but many others have been employed. Nitro-glycerine in this form possesses great advantages. It is less liable to accidental detonation from shocks and to spontaneous combustion than in the liquid state; it is more convenient to handle; frozen in the state of loose powder, it does not lose the property of exploding from the action of the usual fuse (fifteen grains of fulminating mercury), while, if compressed into cartridges, it becomes as inexplosive as nitro-glycerine itself; saturated with water, it retains its detonating power, but requires a larger initial explosion to develop it; ignited in small quantities by a flame, and unconfined, it burns quietly.

As already stated, many other absorbents beside kieselguhr have been used. They belong to two distinct classes,—those which in themselves are explosive, and those which are inert. To the former belong gun-cotton, the product being glyoxiline, saw-dust treated with nitric and sulphuric acids, the product being dualin, some modification of the elements of gunpowder, the product being variously known as lithofracteur, rendrock, vulcan powder, dynamite No. 2, giant powder No. 2, etc. Among the inert absorbents may be named Boghead coal-ashes, mica scales, artificially deposited silica, etc.

While it will generally be admitted that the detonating force of these compounds is derived solely from the nitro-glycerine contained in them, the percentage of which varies greatly owing to differences in their power of absorption, it is far from true that their economic value as explosives can be thus compared. The element of time, which determines whether a blow or a push is delivered, is of primary importance, and should practically determine which compound should be selected. In flint-rock no explosive can compete in force with liquid nitro-glycerine; but for common earth, gunpowder is far more effective. Between these limits most of the nitro-glycerine compounds named above may find a use.

The Picrates.—Picric acid was discovered in 1788 by Haussman, when treating indigo with concentrated nitric acid; but it is now often derived from other substances, especially from carbolic acid. It is used in commerce as a dye, being of a brilliant yellow color and unexplosive. Its salts are numerous, and are more or less explosive; the potassium and ammonium salts, often in connection with potassium nitrate or chlorate, are those usually employed for that purpose. Potassium picrate possesses great explosive energy, but is dangerous to handle from its liability to explode by friction. Designolle's powder, a mixture of potassium picrate and nitrate, sometimes with a little charcoal added, was formerly considerably used in France, but has ceased to be manufactured since the occurrence of a destructive accident.

Brugiere powder, a mixture of ammonium picrate and potassium nitrate, is widely different in its properties, being safe against friction, and slower in action. Abel has recently proposed to use it in shells, under the name picric powder, and Hill is experimenting with it as a possible substitute for gunpowder in spar torpedoes.

The Fulminates.—The salts of fulminic acid are easily exploded, and some of them are dangerously sensitive to friction, electricity, etc. They are never used in large quantities, not only because of the great danger of handling them, but also because the volume of gas given off is small, thus limiting the range of effect. Fulminating mercury ($C_2HgN_2O_2$) is the only one of them which at the present time has much practical value; it is largely used in fuses, percussion-caps, primers, etc. When wet it is unexplosive, and for security it should always be kept and handled in that state.

REPORTS ON AWARDS.

GROUP XVI.

1. Smith & Wesson, Springfield, Mass., U. S.

SMITH & WESSON REVOLVING PISTOLS.

Report.—Commended for its capacity as a military arm. The ejection of all the discharged shells simultaneously, the workmanship and materials used in its manufacture, its interchangeability, and the simplicity of its action, render it a desirable weapon for defense or offense.

2. Merwin, Hulbert, & Co., New York, N. Y., U. S.

POCKET REVOLVERS.

Report.—Commended for general excellence of workmanship and beauty of finish.

3. Bayet Brothers, Liège, Belgium.

REVOLVER, SELF-ACTING COCK.

Report.—Commended for its remarkable self-acting extractor that allows the cartridges to be extracted successively, only using the right hand, which is an advantage for cavalry; and also for the simplicity and solidity of the mechanism.

4. Colt's Patent Fire Arms Manufacturing Co., Hartford, Conn., U. S.

COLT'S REVOLVER.

Report.—A military weapon extracting the discharged shells singly; combining strength and simplicity of action; not liable to get out of order; readily taken apart and easily cleaned; having entire interchangeability of parts, with a high order of finish. Commended for durability and actual service in the hands of a soldier, and for the perfection to which the manufacture of pocket pistols has been brought, and the low price at which a good arm can be produced.

5. Clark & Sneider, Baltimore, Md., U. S.

BREECH-LOADING SPORTING GUNS.

Report.—Commended for good material and workmanship, improved compensating action, and improved rebounding locks.

6. E. Remington & Sons, Ilion, N. Y., U. S.

BREECH-LOADING SPORTING GUNS AND TARGET RIFLES.

Report.—Commended as good and serviceable, and at low prices.

7. Chas. Parker, Meriden, Conn., U. S.

BREECH-LOADING SPORTING GUNS.

Report.—Commended for good materials and workmanship, as shown in low-priced guns.

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8. J. Stevens & Co., Chicopee Falls, Mass., U. S.

BREECH-LOADING SPORTING GUNS.

Report.—Commended as good and strong, and at very low prices.

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9. P. Webley & Son, Birmingham, England.

SWINBURN'S BREECH-LOADING MUSKET.

Report.—Commended as a good breech-loading musket, regarding the solidity of the mechanism and the disposition of the different pieces.

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10. John Krider, Philadelphia, Pa., U. S.

BREECH-LOADING SPORTING GUNS.

Report.—Commended for good materials, workmanship, and low prices.

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11. Alexander Henry, Edinburgh, Scotland.

BREECH-LOADING RIFLE.

Report.—Commended for the perfection and simplicity of its mechanism; and the highly efficient character of the rifling, charge, and bullet, known under the name of the "Henry system."

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12. P. Webley & Son, Birmingham, England.

BREECH-LOADING SPORTING ARMS.

Report.—Commended for good materials and workmanship in guns at low prices.

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13. Moraes Ancora, Rio de Janeiro, Brazil.

BREECH-LOADING RIFLE.

Report.—An excellent breech-loading rifle, both by the workmanship and remarkable simpiicity and solidity of the mechanism, and also by the efficiency of the system of extraction, and by the ingenious disposition of a piece of wood over the barrel to isolate the heat.

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14. Dumoulin Lambinon, Liége, Belgium.

BREECH-LOADING SPORTING GUNS.

Report.—Commended for fine materials and workmanship at very low prices.

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15. Lebeau & Co., Liége, Belgium.

BREECH-LOADING SPORTING GUNS.

Report.—Commended for excellent materials and workmanship at very low prices.

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16. John Rigby & Co., Dublin, Ireland.

SPORTING GUNS AND RIFLES.

Report.—Commended for perfection of materials and workmanship; very superior long-range rifle.

17. Charles Lancaster, London, England.

BREECH-LOADING SPORTING GUNS.

Report.—Commended for fine materials and unsurpassed workmanship, and especially for his "cast-off" stock for a person who has lost the right eye.

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18. Wm. Wurfflein, Philadelphia, Pa., U. S.

PARLOR RIFLES AND TARGETS.

Report.—Commended as good, cheap, and very ingenious.

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19. George Gibbs, Bristol, England.

METFORD PATENT SPORTING RIFLE.

Report.—Commended for excellence and finish in the manufacture of the Metford patent rifle.

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20. William Soper, Reading, England.

LONG-RANGE SPORTING RIFLES.

Report.—Workmanship and materials good; absolute safety of action; easily and rapidly manipulated.

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21. The Imperial Russian Rifle Manufactory at Toola, Russia.

RIFLES.

Report.—Commended for perfection of workmanship in the articles exhibited, particularly in the mechanism of machine-made infantry rifles, and the admirable system of gauging employed.

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22. The Rifle Manufactory at Sestroretsky, near St. Petersburg, Russia.

RIFLES.

Report.—Commended for excellence of manufacture of the Cossack muskets, and admirable system of gauging.

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23. Alexander Henry, Edinburgh, Scotland.

SPORTING GUNS AND RIFLES.

Report.—Commended for very best materials and workmanship, combined with moderate prices; also for his system of rifling.

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24. W. & C. Scott & Son, Premier Gun Works, Birmingham, England.

SPORTING GUNS.

Report.—Commended for materials and workmanship in their medium and best qualities, their "triplex action," and their "compensating lump."

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25. Alfred Lancaster, London, England.

SPORTING GUNS.

Report.—Commended for finest materials and perfect workmanship.

26. James Purdey, London, England.

SPORTING GUNS AND EXPRESS RIFLES.

Report.—Commended as perfect in materials and workmanship, strong and well-proved actions.

27. Evans Rifle Manufacturing Co., Mechanic Falls, Me., U. S.

EVANS MAGAZINE GUN.

Report.—Commended for novelty in the feeding arrangement and general substantial construction.

28. J. Lang & Sons, London, England.

SPORTING GUNS AND RIFLES.

Report.—Commended for simplicity, strength, and thorough workmanship of their self-cocking gun.

29. Providence Tool Co., Providence, R. I., U. S.

LONG-RANGE SPORTING RIFLE.

Report.—A long-range rifle of good materials and workmanship.

30. Providence Tool Co., Providence, R. I., U. S.

PEABODY-MARTINI RIFLE.

Report.—A military arm combining strength, simplicity, high quality of workmanship, ease of manipulation, with accuracy and rapidity of fire, using a central fire metallic cartridge, and ejecting the discharged shell unfailingly.

31. Baron Hahn, St. Petersburg, Russia.

FORTRESS MUSKET OF LARGE CALIBRE.

Report.—Commended for good manufacture and novelty of design.

32. E. Remington & Sons, Ilion, N. Y., U. S.

MILITARY FIRE-ARMS AND AMMUNITION.

Report.—Commended for general excellence of workmanship, as shown in the manufacture of military arms and ammunition.

33. Thomas W. Sparks, Philadelphia, Pa., U. S.

DROP AND MOULD SHOT.

Report.—Commended for uniformity and general good finish of the pellets.

34. Merchants' Shot Tower Co., Henry D. Harvey, President, Baltimore, Md., U. S.

DROP AND MOULD SHOT.

Report.—Commended for uniformity and general good finish of the pellets.

35. Eley Brothers, London, England.

WADDING, SHELLS, AND PERCUSSION CAPS.

Report.—Commended as perfect in materials and workmanship.

36. C. J. Stoddard, Washington, D. C., U. S.

CARTRIDGE-LOADING IMPLEMENT.

Report.—A compact and convenient article, well suited for the object intended.

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37. The St. Petersburg Cartridge Manufactory, Russia.

Report.—Commended for excellence of workmanship in articles exhibited, particularly in the admirable gauges employed.

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38. Winchester Repeating Arms Co., New Haven, Conn., U. S.

METALLIC CARTRIDGES FOR SMALL ARMS.

Report.—Commended for the perfection of the metallic ammunition for military purposes.

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39. United States Cartridge Co., Lowell, Mass., U. S.

MILITARY CARTRIDGES.

Report.—A re-loading, solid head metallic cartridge, containing great strength and non-liability to rupture. Commended for its adaptability to re-loading, ease of extraction, and certainty of fire; waterproof; especially adapted for use in a machine gun, where a defective head or failure to extract might prove of serious consequence.

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40. Union Metallic Cartridge Co., Bridgeport, Conn., U. S.

METALLIC CARTRIDGES FOR MILITARY PURPOSES, AND ESPECIALLY THE BERDAN PATENT CENTRAL FIRE CARTRIDGE.

Report.—Commended for the system of constructing the cavity in the head of the shell, the anvil in the same on which the primer is exploded being formed from the same metal from which the shell is drawn, the conical form of the anvil assisting the effect of the blow of the firing-pin when striking the cap to ignite the fulminate; the primer perfectly waterproof, and formed complete from one piece of metal, avoiding all danger from additional pieces dropping out and causing miss-fires; the whole forming a perfect and complete system for exploding centre-fire cartridges, and for rendering them completely impervious to temperature and water, and adapting them to ready reloading after firing.

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41. Ch. Fusnot & Co., Cureghem, near Brussels, Belgium.

CARTRIDGES FOR MILITARY SMALL ARMS.

Report.—Commended for the perfection of the workmanship and of the material, and also for the price and large amount of the production.

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42. Gevelot, Paris, France.

CARTRIDGES AND CAPS.

Report.—Commended for the variety exhibited and the excellence of manufacture.

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43. South Boston Iron Co., Boston, Mass., U. S.

THREE AND ONE-HALF INCH CONDENSED BRONZE CANNON, AND TWENTY-FOUR PDR. BRONZE HOWITZER.

Report.—Commended for improved method of manufacturing bronze ordnance under the Dean patent of 1869, the merit consisting in mechanically compressing the metal outward from the bore, by forcing through it mandrels of successively increasing size until a permanent enlargement of about one-eighth of an inch has been effected, thus increasing the density, tenacity, and elasticity of the metal; also for good chill casting.

5

44. Richard J. Gatling, Hartford, Conn., U. S.

THE GATLING GUN.

Report.—Eminently entitled to recognition, not only as one of the best machine guns in existence, but also as the first really serviceable weapon of its class. A new five-barrel gun is exhibited, showing improvements over the usual pattern in respect to simplicity; the automatic spreading of the shot; the feeding arrangement; an adjustment for adapting the gun to receive metallic cartridges having rims of varying thickness; diminished weight; increased facility in extracting the locks; and, generally, in separating the gun for cleaning, etc.

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45. The St. Petersburg Arsenal, Russia.

Report.—Commended for excellence of workmanship in the articles exhibited, particularly in the new pattern 3.42 inch bronze breech-loading rifled gun, and in the harness for the mountain gun.

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46. The Government of Brazil.—The Rio Janeiro Army Arsenal.

Report.—An interesting exhibit of artillery and small arms used in the Brazilian service.

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47. Fried. Krupp, Essen, Germany.

HEAVY ORDNANCE AND LIGHT ARTILLERY.

Report.—Commended for perfection of workmanship and finish. The exhibit made by Mr. Krupp is one of the finest displays of ordnance in the Exhibition, and reflects great credit on the exhibitor.

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48. South Boston Iron Co., Boston, Mass., U. S.

BUTLER PROJECTILES AND FIFTEEN-INCH CLUSTER SHOT.

Report.—Commended for excellence of manufacture and accuracy of finish.

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49. M. Carl Ekman, Finspong, Sweden.

CHILLED PROJECTILES FOR HEAVY RIFLED GUNS.

Report.—Commended for excellence of quality.

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50. A. De Maré, Ankarsrum, Sweden.

CHILLED PROJECTILES FOR HEAVY RIFLED GUNS.

Report.—Commended for excellence of quality.

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51. The Perm Gun Foundry, Russia.

TRUNNION BARRELS AND STEEL GUNS.

Report.—Commended for excellence of manufacture of large trunnion bands, and of an experimental four-pounder steel gun, and for interesting models of twenty-inch and nine-inch guns.

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52. The Ministry of the Navy.—The Obookhof Steel Foundry, near St. Petersburg, Russia.

HEAVY BREECH-LOADING ORDNANCE.

Report.—Fine samples of heavy breech-loading ordnance, the largest being a nine-inch gun.

53. **Ordnance Department, St. Petersburg, Russia.**

Report.—Commended for excellence of workmanship in articles exhibited; particularly an iron carriage for six-inch mortar on the system of Major General Semenof, and a field iron carriage with cork buffer on the system of Colonel Engelhardt, of the Russian artillery.

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54. **Motala Machine Co., Motala, Sweden.**

PARTS OF STEEL GUNS.

Report.—Commended for excellence of workmanship and finish.

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55. **Paul Koorikof, St. Petersburg, Russia.**

HARNESS FOR FIELD ARTILLERY.

Report.—Commended for excellent workmanship and novelty of manufacture.

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56. **Vonlarlarsky, St. Petersburg, Russia.**

PORTABLE TRAVELING CRANE FOR ARTILLERY USE.

Report.—Commended for efficiency, economy of labor, and simplicity of application.

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57. **Zlatoust Armory, Government of Orenburg, Russia.**

STEEL SWORDS.

Report.—Commended for excellence.

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58. **William H. Horstmann & Sons, Philadelphia, Pa., U. S.**

SWORDS.

Report.—Commended for elegance of finish and fabrication.

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59. **Eskilstuna Iron Co., Sweden.**

SWORDS.

Report.—Commended for first-class workmanship and material.

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60. **Ames Manufacturing Co., Chicopee, Mass., U. S.**

SWORDS AND SCABBARDS.

Report.—Commended for elegance and variety of finish.

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61. **Laffiteau & Rieger, Paris, France.**

SPORTING ARMS.

Report.—Commended for elegance of finish and manufacture.

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62. **Sharp's Rifle Co., Bridgeport, Conn., U. S.**

BREECH-LOADING HUNTING RIFLE.

Report.—Commended as simple, strong, and good.

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63. **Westley Richards & Co., Birmingham, England.**

HAMMERLESS BREECH-LOADING SPORTING GUN.

Report.—Commended for excellence of workmanship and novelty of design.

64. Winchester Repeating Arms Co., New Haven, Conn., U. S.

MAGAZINE SPORTING RIFLE.

Report.—The best magazine rifle for sporting purposes yet produced.

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65. Frank Wesson, Worcester, Mass., U. S.

BREECH-LOADING SPORTING AND POCKET TARGET RIFLES.

Report.—Commended for good materials and workmanship and low prices.

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66. Laflin & Rand Powder Co., New York City, N. Y., U. S.

FRICTIONAL ELECTRIC BLASTING MACHINE AND FUSES.

Report.—A very superior frictional blasting apparatus, combining electrical power, mechanical strength, portability, and general adaptation to rough blasting. Its peculiar merits are—1st, the condenser, of which the plates are well insulated, and protected against moisture by being imbedded in soft ebonite and then vulcanized; 2d, the thorough manner in which damp air is excluded from the generator by clamped casings of vulcanized rubber and a crank stuffing-box; 3d, the convenient arrangement for firing by a simple reversal of the crank; 4th, facility in opening, thus rendering occasional cleaning, re-amalgamation, etc., possible by blasters of ordinary intelligence. Also serviceable fuses for use with the above.

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67. Laflin & Rand Powder Co., New York City, N. Y., U. S.

MAGNETO-ELECTRIC BLASTING MACHINE AND FUSES.

Report.—It is a compact and serviceable blasting apparatus, acting upon the dynamo-magneto-electric principle. When a sufficiently strong magnetic field has been generated by a Siemens armature working on short circuit through its electro-magnet, the current is shunted to the external circuit containing the fuses, thus utilizing, for the needed instant, both the normal current and the extra current induced by breaking the magnet circuit. The peculiar excellence of this machine lies in the manner in which the change of circuit is effected. Instead of the usual external key, an ingenious automatic trigger is introduced, to be worked by the increase in magnetic power of the magnet. This trigger is adjustable by a spring, so that it may be set to require the whole or only a small part of the available current, thus adapting the machine for convenient use, whether many or only a single fuse be employed. The apparatus is admirably suited for use where high insulation in the lead wires cannot readily be secured. Also serviceable platinum wire fuses for use with above.

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68. Toy, Bickford, & Co., Simsbury, Conn., U. S.

SAFETY FUSE FOR BLASTING.

Report.—Commended for variety and excellence of manufacture.

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69. Colonel Winner, St. Petersburg, Russia.

GUNPOWDER.

Report.—Commended for novelty in the manufacture of gunpowder cakes.

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70. Bickford, Smith, & Co., Tuckingmill, Cornwall, England.

SAFETY FUSES FOR BLASTING OPERATIONS.

Report.—Commended for maintaining the good qualities of a valuable agent in mining industry, which was originally introduced by the exhibitors.

71. Government of Brazil.—The Pyrotechnical Laboratory of Campinho.

FUSES AND AMMUNITION.

Report.—A fine display of fuses and small-arm ammunition.

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72. The Okhta Powder Mills, near St. Petersburg, Russia.

GUNPOWDER.

Report.—Commended for excellent quality of gunpowder manufactured at this establishment.

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73. Pigou, Wilks, & Laurence, London, England.

GUNPOWDER OF VARIOUS DESCRIPTIONS.

Report.—All the gunpowders manufactured by this firm are of excellent quality.

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74. V. T. Unge, Stockholm, Sweden.

DISTANCE WATCH FOR MILITARY USE.

Report.—Commended for portability, ingenuity, and simplicity of design.

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75. L. Mairlot & P. Heuse, Fraipont, near Liége, Belgium.

DAMASCUS GUN BARRELS.

Report.—Commended for fine materials and workmanship; very low prices.

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76. E. Heuse, Lemoine, & Co., Nessonvaux, near Liége, Belgium.

DAMASCUS GUN BARRELS.

Report.—Commended for fine materials and workmanship; very low prices.

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77. Kniaze Mikhailovsky Steel Works, Government of Orenburg, Russia.

GUN BARRELS.

Report.—Commended for excellence.

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78. Government of Tunis.

WEAPONS AND EQUIPMENTS.

Report.—A highly interesting display of antique arms, including pistols, guns, swords, and daggers; also splendid embroidered saddles and horse furniture.

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79. Government of Egypt.

WEAPONS AND EQUIPMENTS.

Report.—Commended for a fine display of weapons and richly-ornamented dromedary, horse, and donkey saddles, and equipments; more particularly for the articles exhibited from the National Museum of Cairo.

80. The Spanish Ministry of War.

Report.—For a complete exhibit from the different branches of the army :

A. *The Spanish Military Engineer Department.*

Report.—Commended for an interesting exhibit from the Museum of Engineers at Madrid; particularly for the beautiful models of fortifications and barracks, and for the models showing the manner of transporting a trestle bridge on mules.

B. *The Museum of Artillery at Madrid.*

Report.—A fine display, comprising particularly models of guns and sling carts.

C. *The Manufactory at Toledo.*

Report.—The excellence of the celebrated sword blades.

D. *The National Bronze Foundry at Seville.*

Report.—For the excellent quality of field and mountain guns.

E. *The National Manufactory at Trubia.*

Report.—For the excellence of the iron and steel plates.

F. *The National Fire-Arms Manufactory at Oviedo.*

Report.—For the merit of arms, with samples to show the different stages in their construction.

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81. Government of India.

ARMS.

Report.—An interesting collection of arms, selected from the India Museum.

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82. Government of the Netherlands.

WEAPONS.

Report.—Commended for the exhibit of weapons from the royal small-arm factory at Delft, and for the magnificent collection of East Indian weapons from the royal cabinet of curiosities at The Hague, and from the Royal Palace Het Loo.

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83. Colony of New Zealand.

WEAPONS AND CLOTHING.

Report.—An interesting collection of aboriginal (Maori) weapons and clothing, made for the commissioners of New Zealand by Mr. R. W. Woon, R.M.

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84. The Artillery Department of the Royal War Office of Sweden.

Report.—Commended for excellence of manufacture and the interesting character of the articles exhibited.

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85. The Investment Department of the Royal War Office of Sweden.

Report.—Commended for excellence of manufacture and the interesting character of the articles exhibited.

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86. Dinaburg Arsenal, Russia.

Report.—Beautifully constructed and interesting models of the pontoon equipage now used by the Russian army.

87. **The Engineer Department of the Ministry of War, Russia.—The Main Department of Engineers.**

Report.—Commended for a large and fine collection of drawings illustrative of barrack structures and permanent fortifications; for the model of a gun-shield as used in the fortress of Cronstadt; and for intrenching tools.

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88. **The Chief Intendency of War, Russia.**

Report.—A fine exhibit of military uniforms, knapsacks, and equipments generally, and of military wagons.

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89. **E. J. DuPont de Nemours & Co., Wilmington, Del., U. S.**

GUNPOWDER.

Report.—Commended for a handsome exhibit of samples representing various granulations of gunpowder, and for fine specimens of refined saltpetre.

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90. **Whitney Arms Co., Whitneyville, Conn., U. S.**

SPORTING RIFLES ON WHITNEY SYSTEM.

Report.—A strong, safe rifle, of good workmanship and materials.

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91. **United States War Department, The Ordnance Bureau, Washington, D. C., U. S.**

Report.—Commended for an exceedingly interesting exhibit, covering heavy and light artillery and machine guns, now in service and under experiment, as well as many samples of historical types; for an extensive collection of projectiles for rifled and smooth bore cannon, and of fuses for the same; for a large and instructive collection of military small arms, new and old; for excellent samples of military equipments generally, and especially for machinery actually at work, showing the method of making metallic ammunition and the more important parts of the adopted Springfield rifle; also for a fine exhibit of instruments used in testing ordnance and gunpowder; also for the excellent character and quality of the articles manufactured by the Ordnance Department.

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92. **United States Navy Department, Bureau of Ordnance, Washington, D. C., U. S.**

Report.—Commended for an extensive and interesting exhibit of the ordnance, projectiles, and small arms, and especially for the offensive torpedoes used in the naval service of the United States.

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93. **United States War Department, Engineers' Bureau, Washington, D. C., U. S.**

Report.—Commended for a handsome exhibit, covering the defensive torpedo system, the bridge equipage, the field photographic outfit, and siege and mining tools adopted by the United States; also for a beautifully finished model showing every detail of the bridge equipage and of its transportation; also for some interesting models of depressing gun carriages, notably one invented by Brigadier-General De Russy in 1835, involving the fundamental principle of the Moncrieff system, and one devised by Major King for guns of large calibre; also for a highly interesting model showing the details of the block-houses successfully used during the late war to enable a few men to defend important railway bridges against cavalry raiding parties.

94. United States War Department, The Signal Service, U. S. Army, Washington, D. C., U. S.

Report.—Commended for a fine exhibit of the field outfit of this bureau, and especially for the field telegraph train.

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95. United States War Department, The Quartermaster's Bureau, Washington, D. C., U. S.

Report.—Commended for an interesting exhibit of the articles supplied and tools employed by this department, and especially for the large collection of specimens designed to illustrate the veterinary service and horseshoeing of the army.

29

SIGNING JUDGES OF GROUP XVI.

The numbers annexed to the names of the Judges indicate the reports written by them respectively.

HENRY L. ABBOT, 21, 22, 27, 33, 34, 36, 37, 42, 43, 44, 45, 46, 51, 52, 53, 57, 58, 60, 61, 66, 67, 68, 71, 72, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 91, 92, 93, 94, 95.

W. H. NOBLE, 19, 31, 47, 48, 49, 50, 54, 55, 56, 59, 63, 69, 70, 73, 74.

S. C. LYFORD, 1, 2, 4, 30, 32, 38, 39, 40.

GEO. A. HAMILTON, 5, 6, 7, 8, 10, 12, 14, 15, 16, 17, 18, 20, 23, 24, 25, 26, 28, 29, 35, 62, 64, 65, 75, 76, 90.

L. F. DE SALDANHA DA GAMA, 3, 9, 11, 41.

ALPHONSE LESNE, 13.

SUPPLEMENT TO GROUP XVI.

REPORTS
OF
JUDGES ON APPEALS.

JUDGES.

JOHN FRITZ, Bethlehem, Pa.
EDWARD CONLEY, Cincinnati, Ohio.
CHARLES STAPLES, JR., Portland, Me.
BENJ. F. BRITTON, New York City.
H. H. SMITH, Philadelphia, Pa.
COLEMAN SELLERS, Philadelphia, Pa.
JAMES L. CLAGHORN, Philadelphia, Pa.
HENRY K. OLIVER, Salem, Mass.
M. WILKINS, Harrisburg, Oregon.
S. F. BAIRD, Washington, D. C.

1. Manuel Antonio Da Silva & Sons, Lisbon, Portugal.

LEAD SHOT.

Report.—An extensive exhibit of lead shot, from large to small sizes, of good quality.

2. Firmin & Sons, London, England.

DRESS AND SERVICE SWORDS.

Report.—Commended for excellence in fabrication and finish.

3. Capt. Edward Podmore Clark, Bath, England.

MILITARY MODEL FOR ILLUSTRATING AND TEACHING DRILL MOVEMENTS.

Report.—Commended for novelty, ingenuity, and fitness for the purpose intended.

4. Tatham & Bros., New York, N. Y., U. S.

DROP AND PRESSED LEAD SHOT.

Report.—Commended for exact uniformity in size, truly spherical form, high degree of finish, and general excellence.

5. American Arms Company, Boston, Mass., U. S.

BREECH-LOADING SPORTING GUNS AND GUN LOCKS.

Report.—Commended for great strength, simplicity, and durability; non-liability of getting loose or shaky from constant service; the positive action of the extractor; the ease and rapidity with which the barrels may be detached; construction on the interchangeable system; excellence in fabrication; the cheapest guns as strong and durable as the higher priced ones; and for very low prices. A separate exhibit of gun locks are admirable specimens of workmanship, their details interchangeable.

SIGNING JUDGES OF SUPPLEMENT TO GROUP XVI.

The figures annexed to the names of the Judges indicate the reports written by them respectively.

CHARLES STAPLES, JR., 1, 2, 4, 5.
HENRY K. OLIVER, 3.