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ANNUAL REPORTS

OF THE

WAR DEPARTMENT

FOR THE

FISCAL YEAR ENDED JUNE 30, 1906.

VOLUME VI.

REPORT OF THE CHIEF OF ORDNANCE.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1906.

ARRANGEMENT OF THE ANNUAL REPORTS OF THE WAR DEPARTMENT FOR THE YEAR ENDED JUNE 30, 1906.

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Inspector-General.
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[a] Printed in Report of Chief of Engineers, Vol. V.
[b] Printed in Report of Chief of Ordnance, Vol. VI.

REPORT OF THE CHIEF OF ORDNANCE.

War Department,
Office of the Chief of Ordnance,
Washington, October 13, 1906.

Sir: I have the honor to submit the following report on the principal operations of the Ordnance Department during the past year, together with certain remarks as to its interests and necessities:

PERSONNEL.

By the act of June 25 last the personnel of the Ordnance Department was increased from 71 officers to 85, and at the same time it was enacted that details to the Department should be made from the Army at large, from the grade in which the vacancy exists or from the grade below; that details should be made on the recommendation of a board of ordnance officers after at least one examination, open to competition, and that the compulsory interval between details should be diminished from two years to one for officers detailed in grades below that of major, and abolished altogether for the other grades. In carrying out this act it is intended that an examination shall be a condition precedent to detail for the first time only in the Ordnance Department; for subsequent detail in the same grade an examination will not be required, nor will such examination be required for detail to a higher grade, if there shall have been sufficient service in the Department on the part of the candidate to enable an intelligent recommendation to be made by a board of officers; otherwise there will be a qualifying examination, which will include subjects appropriate for the grade to which the detail is under consideration, and not covered by the examination which the candidate already has past. At the time of my last annual report the number of officers in the Department was 59; it is now 65, but under the stimulus of the new law it is expected that the personnel will be recruited as rapidly as the consideration that too many officers should not go out at the same time by expiration of detail will render desirable. The next examination will be held in March.

The law is believed to embody a satisfactory method of recruiting and maintaining the personnel, and the efficiency of the Department can now be said to be in the hands of its members. Faithful and

efficient service has continued to be received from the officers, rendered especially laborious by reason of the deficiency of personnel, but this condition has been remedied by the law, of which the stimulating effect has been felt throughout the Department, and it is preferred to let personal merits be made apparent to the service through works which come to its intimate knowledge rather than by recital at the present time of the special services of officers.

FISCAL AFFAIRS.

The statement giving the receipts and expenditures of the Ordnance Department under general headings for the fiscal year of 1906 is herewith submitted in tabular form, so as to show the data under the various appropriations made for the service of this Department, including those made for experiments conducted under the direction of the Board of Ordnance and Fortification and for the purchase of submarine mines, the control of which rests with the Chief of Artillery.

The following tables show that on July 1, 1905, there was in the Treasury and in the possession of disbursing officers the sum of $14,646,306.19 pertaining to Ordnance Department appropriations:

Statement showing receipts, etc., of the appropriations under control of the Ordnance Department for the fiscal year ended June 30, 1906.

RECEIPTS.

Appropriations.	Amount in the Treasury to credit of ordnance appropriations on July 30, 1905.	Amount deposited in the Treasury on account of the Ordnance Department, but not credited to ordnance appropriations, on July 1, 1905.	Amount in the United States depositaries to credit of disbursing officers under ordnance appropriations on July 1, 1905.	Amount of appropriations made for the fiscal year ended June 30, 1906, including the amount of those contained in the act making appropriations for fortifications and other works of defense, etc., approved June 25, 1906, under control of the Ordnance Department.	Amount refunded during the fiscal year ended June 30, 1906, to ordnance appropriations by Treasury settlements on account of transfers of property to the various bureaus and Executive Departments, to the organized militia, etc.	Amount received during the fiscal year ended June 30, 1906, from sales of ordnance and ordnance stores, from collections from troops on account of loss or damage to ordnance stores, from Chicago, Rock Island and Pacific R. R. Co., on account of maintenance of Rock Island Bridge, proceeds arising from tests made by the Government testing machine at Watertown Arsenal, and from other sources not before mentioned.	Total.
Ordnance service, 1906				$300,000.00			$300,000.00
Ordnance stores—ammunition, 1906				1,250,000.00			1,250,000.00
Ordnance stores and supplies, 1906				1,254,922.00		$86.75	1,255,008.75
Replacing ordnance and ordnance stores, 1905 and 1906	$619,683.45	$13,920.96	$31,356.96		$264,466.32	883.34	930,311.03
Replacing ordnance and ordnance stores, 1906 and 1907					631,490.15	58,493.76	689,983.91
Manufacture of arms, 1905–1906	1,429,875.74		196,136.95		388.83		1,626,401.52
Manufacture of arms, 1906–1907				1,700,000.00	110.50		1,700,110.50
Ordnance material (proceeds of sales)			14,459.63	75,000.00			89,459.63
Field artillery for organized militia, 1904 and 1905	248,062.66		90,833.42				338,896.08
Field artillery for organized militia, 1905 and 1906	495,943.43		4,403.56				500,346.99
New arms and equipments for organized militia	52,308.19		28,559.89				80,868.08
Converting muzzle-loading guns for saluting purposes, 1906				16,000.00			16,000.00
National trophy and medals for rifle contests, 1906				4,000.00			4,000.00
Repairs of arsenals, 1906				125,000.00			125,000.00
Board of Ordnance and Fortification	268,632.27		8,989.68	5,000.00	821.76		283,443.71

Statement showing receipts, etc., of the appropriations under control of the Ordnance Department for the fiscal year ended June 30, 1906—Continued.

RECEIPTS—Continued.

Appropriations.	Amount in the Treasury to credit of ordnance appropriations on July 30, 1905.	Amount deposited in the Treasury on account of the Ordnance Department, but not credited to ordnance appropriations, on July 1, 1905.	Amount in the United States depositaries to credit of disbursing officers under ordnance appropriations on July 1, 1905.	Amount of appropriations made for the fiscal year ended June 30, 1906, including the amount of those contained in the act making appropriations for fortifications and other works of defense, etc., approved June 25, 1906, under control of the Ordnance Department.	Amount refunded during the fiscal year ended June 30, 1906, to ordnance appropriations by Treasury settlements on account of transfers of property to the various bureaus and Executive Departments, to the organized militia, etc.	Amount received during the fiscal year ended June 30, 1906, from sales of ordnance and ordnance stores, from collections from troops on account of loss or damage to ordnance stores, from Chicago, Rock Island and Pacific R. R. Co., on account of maintenance of Rock Island Bridge, proceeds arising from tests made by the Government testing machine at Watertown Arsenal, and from other sources not before mentioned.	Total.
Submarine mines	$317,340.02		$9,147.29	$300,000.00	$554.03	$28.00	$627,069.34
Armament of fortifications	7,624,726.14	$6,475.44	600,559.61	2,072,000.00	100,101.75	685.48	10,404,548.42
Fortifications in insular possessions	605,659.41		11,886.60	537,000.00			1,154,546.01
Torpedoes for harbor defense	2,007.92		11,953.07				13,960.99
Augusta Arsenal, Augusta, Ga				50,000.00			50,000.00
Proving ground, Sandy Hook, N. J	149,264.95		23,172.68	86,943.00		394.00	259,774.63
Frankford Arsenal, Philadelphia, Pa	16,500.00		18,253.30	25,500.00			60,253.30
San Antonio Arsenal, San Antonio, Tex	16,000.00						16,000.00
Powder depot, Dover, N. J	107,485.00		24,479.15	46,000.00		1.00	177,965.15
Rock Island Bridge, 1906				12,500.00		1,234.03	14,224.03
Rock Island Arsenal, Rock Island, Ill	12,500.00		16,096.67	17,500.00			46,096.67
Rock Island power plant				12,500.00		19.00	12,519.00
Springfield Arsenal, Springfield, Mass			4,678.05	10,000.00			14,678.05
Watertown Arsenal, Watertown, Mass	8,500.00		21,833.99	20,500.00			50,833.99
Testing machine, 1906				15,000.00	105.63	1,087.11	16,192.74
Rock Island Arsenal, 1903 and 1904	2,480.00						2,480.00
Watervliet Arsenal, West Troy, N. Y	14,000.00		13,244.84	25,000.00			52,244.84
Isham shell and Tuttle thorite	100,000.00						100,000.00
Ordnance service, 1904	756.98						756.98
Ordnance stores—ammunition, 1904	553.09						553.09
Ordnance stores—manufacture, etc., 1904	4,450.26						4,450.26
Ordnance stores—equipments, 1904	25,730.16				10.22		25,740.38

Ordnance stores—preservation, 1904	240.43						240.43
Ordnance stores—repairs, 1904	1,146.98						1,146.98
Repairs of arsenals, 1904	948.99						948.99
Artillery targets, 1904	116.07						116.07
Ammunition for morning and evening gun, 1904	188.43						188.43
Manufacture of arms, 1903–1904	12.71						12.71
National trophy and prizes for Army and militia, 1904	43.00			756.00			799.00
Testing machine, 1904	22.54						22.54
Ordnance service, 1905	3,472.03	771.70	44,890.05		1.37		49,135.15
Ordnance stores—ammunition, 1905	341,831.78	3.50	83,073.28			.29	424,908.85
Ordnance stores and supplies, 1905	10,856.93	1,925.00	129,463.05		106.12	6.67	142,357.77
Replacing ordnance and ordnance stores, 1904 and 1905	114,193.15		36,812.36		6.14		151,011.65
Manufacture of arms, 1904–1905	219,981.20	10.00	248,136.30		11.00		468,138.50
Artillery targets, 1905	934.61		15,281.42				16,216.03
Ammunition for morning and evening gun, 1905	6,742.45	100.00	102.75				6,945.20
Converting muzzle-loading guns for saluting purposes, 1905	4,616.41		20.80				4,637.21
Repairs of arsenals, 1905	1,273.00		13,116.78			5.30	14,395.08
National trophy and medals for rifle contests, 1905	196.00						196.00
Testing machine, 1905			2,237.20				2,237.20
Rock Island Bridge, 1905			191.02			1,295.84	1,486.86
Manila Ordnance Depot			15,340.90				15,340.90
Emery loading apparatus			8,434.42				8,434.42
National defense (war)	77,884.14						77,884.14
Medals of honor for distinguished services	12,000.00						12,000.00
Ordnance stores—equipments (certified claims)				273.74			273.74
Ordnance service (certified claims)				23.83			23.83
Sale of ordnance material						132,826.00	132,826.00
Miscellaneous receipts						8,489.46	8,489.46
Army powder factory				165,000.00			165,000.00
Total	12,919,160.52	23,206.60	1,727,145.67	8,126,418.57	998,173.82	206,026.03	24,000,131.21

Statement showing the expenditures, etc., of the appropriations under control of the Ordnance Department for the fiscal year ended June 30, 1906.

EXPENDITURES, ETC.

Appropriations.	Amount disbursed by disbursing officers from ordnance appropriations during the fiscal year ended June 30, 1906.	Amount paid and transferred by Treasury settlements during the fiscal year ended June 30, 1906, from ordnance appropriations on account of property from other bureaus and Executive Departments to the Ordnance Department, and of payment to contractors for certain purchases, etc.	Amount deposited in the Treasury during the fiscal year ended June 30, 1906, and credited to ordnance material (proceeds of sales).	Amount covered into the Treasury under miscellaneous receipts on account of proceeds of sales Government property during the fiscal year ended June 30, 1906.	Amount covered into surplus fund of the Treasury on June 30, 1906.	Amount in United States depositaries to credit of disbursing officers under ordnance appropriations on June 30, 1906.	Amount deposited in the Treasury on account of Ordnance Department, but not credited to ordnance appropriations on June 30, 1906.	Amount in Treasury to credit of ordnance appropriations on June 30, 1906.	Total.
Ordnance service, 1906	$266,584.76	$1,557.49				$29,093.48	$708.22	$2,056.05	$300,000.00
Ordnance stores—ammunition, 1906	1,041,737.77	78.76				122,967.06	132.00	85,084.41	1,250,000.00
Ordnance stores and supplies, 1906	999,763.95					146,825.50	1,790.80	106,628.50	1,255,008.75
Replacing ordnance and ordnance stores, 1905 and 1906	727,997.72	993.14				81,890.71	2,110.03	117,319.43	930,311.03
Replacing ordnance and ordnance stores, 1906 and 1907	152,238.13	1,205.33				63,661.63	9,794.10	463,084.72	689,983.91
Manufacture of arms, 1905–1906	1,444,130.08					67,330.44		114,941.00	1,626,401.52
Manufacture of arms, 1906–1907	283,478.92					163,730.21		1,252,901.37	1,700,110.50
Ordnance material (proceeds of sales)	81,690.67				$5,956.86	507.06	1,305.04		89,459.63
Field artillery for organized militia, 1904 and 1905	158,769.93					7,308.84		172,817.31	338,896.08
Field artillery for organized militia, 1905 and 1906	297,253.30					33,221.54	21.10	169,851.05	500,346.99
New arms and equipments for organized militia	55,361.71	215.47				6,326.04	1.20	18,963.66	80,868.08
Converting muzzle-loading guns for saluting purposes, 1906	15,654.42					3.08		342.50	16,000.00

National trophy and medals for rifle contests, 1906	2,730.82					249.95		1,019.23	4,000.00
Repairs of arsenals, 1906	103,577.35					20,414.45	451.74	556.46	125,000.00
Board of Ordnance and Fortification	29,843.70	45,538.88				8,965.40		199,095.73	283,443.71
Submarine mines	40,825.04	1,080.00				6,919.55		578,244.75	627,069.34
Armament of fortifications	3,761,140.67	18,413.26			1,619.36	379,209.45	1,478.69	6,242,686,99	10,404,548.42
Fortifications in insular possessions	137,529.77					58,760.03		958,256.21	1,154,546.01
Torpedoes for harbor defense	2,305.97					11,655.02			13,960.99
Augusta Arsenal, Augusta, Ga								50,000.00	50,000.00
Proving Ground, Sandy Hook, N. J	117,665.43				394.00	14,737.89		126,977.31	259,774.63
Frankford Arsenal, Philadelphia, Pa	54,795.28					5,458.02			60,253.30
San Antonio Arsenal, San Antonio, Tex								16,000.00	16,000.00
Powder Depot, Dover, N. J	152,895.79					2,213.38	11,284.09	11,571.89	177,965.15
Rock Island Bridge, 1906	14,167.33					56.70			14,224.03
Rock Island Arsenal, Rock Island, Ill	43,287.27					2,809.40			46,096.67
Rock Island power plant, 1906	10,971.04					1,547.96			12,519.00
Springfield Arsenal, Springfield, Mass	12,931.64					1,746.41			14,678.05
Watertown Arsenal, Watertown, Mass	27,503.71				330.28			23,000.00	50,833.99
Testing machine, 1906	12,277.41					3,809.70		105.63	16,192.74
Rock Island Arsenal, 1903 and 1904	300.00				2,180.00				2,480.00
Watervliet Arsenal, West Troy, N. Y	20,359.73					11,885.11		20,000.00	52,244.84
Isham shell and Tuttle thorite								100,000.00	100,000.00
Ordnance service, 1904	38.10	170.62			548.26				756.98
Ordnance stores—ammunition, 1904		8.60			544.49				553.09
Ordnance stores—manufacture, etc., 1904		33.29			4,416.97				4,450.26
Ordnance stores—equipments, 1904	24,482.41	107.49			1,150.48				25,740.38
Ordnance stores—preservation, 1904					240.43				240.43
Ordnance stores—repairs, 1904		77.70			1,069.28				1,146.98
Repairs of arsenals, 1904					948.99				948.99
Artillery targets, 1904					116.07				116.07
Ammunition for morning and evening gun, 1904.					188.43				188.43
Manufacture of arms, 1903–1904					12.71				12.71
National trophy and prizes for Army and Militia, 1904					43.00			756.00	799.00
Testing machine, 1904					22.54				22.54
Ordnance service, 1905	47,414.41	346.20						1,374.54	49,135.15
Ordnance stores—ammunition, 1905	424,897.51							11.34	424,908.85
Ordnance stores and supplies, 1905	133,428.10	163.20				4.17		8,762.30	142,357.77
Replacing ordnance and ordnance stores, 1904 and 1905	150,137.76	873.89							151,011.65
Manufacture of arms, 1904–1905	350,944.50	35.80				17,468.26		99,689.94	468,138.50
Artillery targets, 1905	10,651.92							5,564.11	16,216.03
Ammunition for morning and evening gun, 1905	6,851.55							93.65	6,945.20
Converting muzzle-loading guns for saluting purposes, 1905	3,173.70							1,463.51	4,637.21
Repairs of arsenals, 1905	12,678.78	1,000.38						715.92	14,395.08
National trophy and medals for rifle contests, 1905	188.00							8.00	196.00
Testing machine, 1905	1,490.97							746.23	2,237.20
Rock Island Bridge, 1905	1,486.86								1,486.86

Statement showing the expenditures, etc., of the appropriations under control of the Ordnance Department for the fiscal year ended June 30, 1906.—Cont'd.

EXPENDITURES, ETC.—Continued.

Appropriations.	Amount disbursed by disbursing officers from ordnance appropriations during the fiscal year ended June 30, 1906.	Amount paid and transferred by Treasury settlements during the fiscal year ended June 30, 1906, from ordnance appropriations on account of property from other bureaus and Executive Departments to the Ordnance Department, and of payment to contractors for certain purchases, etc.	Amount deposited in the Treasury during the fiscal year ended June 30, 1906, and credited to ordnance material (proceeds of sales).	Amount covered into the Treasury under miscellaneous receipts on account of proceeds of sales Government property during the fiscal year ended June 30, 1906.	Amount covered into surplus fu d of the Treasury on June 30, 1906.	Amount in United States depositaries to credit of disbursing officers under ordnance appropriations on June 30, 1906.	Amount deposited in the Treasury on account of Ordnance Department, but not credited to ordnance appropriations on June 30, 1906.	Amount in Treasury to credit of ordnance appropriations on June 30, 1906.	Total.
Manila Ordnance Depot	$15,241.16					$99.74			$15,340.90
Emery loading apparatus	8,434.42								8,434.42
National defense (war)	44,328.56							$33,555.58	77,884.14
Medals of honor for distinguished services		$12,000.00							12,000.00
Ordnance stores—equipments (certified claims)		273.74							273.74
Ordnance service (certified claims)		23.83							23.83
Sale of ordnance material			$132,826.00						132,826.00
Miscellaneous receipts				$8,489.46					8,489.46
Army powder factory								165,000.00	165,000.00
Total	11,305,638.02	84,197.07	132,826.00	8,489.46	19,782.15	1,270,876.18	29,077.01	11,149,245.32	24,000,131.21

The total amount of the appropriations for the fiscal year 1906, including those contained in the act making appropriations for fortifications and other works of defense, approved June 25, 1906, amounted to $7,961,418.57. The total amount with which the appropriations were credited in accordance with authority of law from sales, transfers, etc., was $1,204,199.85. The total of the payments made by disbursing officers and by Treasury settlements during the year amounted to $11,389,835.09. The total sales of condemned stores during the year amounted to $141,315.46, all of which was credited on the books of the Treasury Department to "Ordnance Material (Proceeds of Sales)." The total amount to the credit of disbursing officers on June 30, 1906, was $1,270,876.18 and the total amount in the Treasury on the same date amounted to $10,984,245.32.

FUNDS ON HAND AT THE BEGINNING AND CLOSE OF THE FISCAL YEAR.

The principal amounts on hand at the beginning of the year pertained to the following appropriations:

Manufacture of arms, 1905–6	$1,626,012.69
Field artillery for organized militia, 1905–6	500,346.99
Board of Ordnance and Fortification	276,800.19
Armament of fortifications	8,231,760.75
Fortifications in insular possessions	617,546.01

The status of these appropriations at the close of the fiscal year will be seen by reference to the tabular statement, and will be discussed later under the above heading.

The principal amounts on hand at the close of the fiscal year pertained to the following appropriations:

Ordnance stores—ammunition	$208,183.47
Replacing ordnance and ordnance stores, 1906 and 1907	536,540.45
Manufacture of arms, 1905–1906	1,416,631.58
Armament of fortifications	6,623,375.13
Fortifications in insular possessions	1,017,016.24
Field artillery for organized militia, 1905–1906	203,072.59

The above amounts under the appropriations "Armament of fortifications" and "Fortifications in insular possessions" include the sums of $2,072,000 and $537,000, which had been appropriated at the last session of Congress under these appropriations, respectively. Under the law these appropriations are available on the approval of the act making them and until used.

The balances under the fund "Replacing ordnance and ordnance stores, 1906 and 1907," and the appropriation "Manufacture of arms, 1906–1907," are available for the fiscal year 1907.

Of the above amounts reported on hand at the close of the fiscal year the greater portion, in nearly every case, has been allotted to meet outstanding obligations. The available balances under the

above-named appropriations at the close of the fiscal year are as follows:

Ordnance stores—ammunition	$512.99
Replacing ordnance and ordnance stores, 1906 and 1907	42,015.70
Manufacture of arms, 1906–1907	4.27
Armament of fortifications	3,016,819.14
Fortifications in insular possessions	597,681.95

It will be seen, therefore, in case of the above-named appropriations, that they were largely obligated at the close of the fiscal year, except in case of the appropriations which had been made and increased at the preceding session of Congress.

TRANSFERS AND SALES OF ORDNANCE STORES.

The value of ordnance stores transferred to the executive departments is refunded to ordnance appropriations by Treasury settlements, and the funds received become available upon receipt and remain so during that and the following fiscal year for replacing the stores so transferred. The total value of the stores thus transferred amounted to $998,173.82. Of this amount $219,089.97 were on account of transfers to the Navy Department, $63,580.98 on account of transfers to the Marine Corps, $14,893.16 on account of transfers to other executive departments, and $700,809.91 on account of transfers to the organized militia. In conducting experiments for the Board of Ordnance and Fortification the value of the ordnance stores which were used in them amounted to $31,290.41, which was transferred from the appropriations for the Board to the ordnance appropriations proper.

The total amount of sales made to the organized militia, to the Philippine government, to officers of the Army, to American designers engaged in the development of military inventions, etc., amounted to $206,026.03, all of which was refunded to ordnance appropriations.

The total of the transfers and sales amounted to $1,204,199.85, which is 15⅛ per cent of the total amount appropriated for the use of this Department in arming, equipping, and supplying of the Regular Army.

PAYMENTS.

The total amount of payments made by disbursing officers amounted to $11,305,638.02 and by Treasury settlements to $84,197.07, a total of $11,389,835.09. As the appropriations proper for the year amounted to $7,961,418.57, it will be seen that by reason of the procurement of ordnance and ordnance stores to replace articles transferred or sold to other departments, etc., the disbursements were about 43 per cent in excess of the appropriations.

The amounts of disbursements made at the principal arsenals and in the Ordnance Office during the fiscal year are as follows:

Frankford Arsenal	$1,866,855.92
Rock Island Arsenal	2,331,637.30
Sandy Hook Proving Ground	180,784.16
Springfield Armory	1,742,628.66
United States Powder Depot	204,559.63
Watervliet Arsenal	484,490.39
Watertown Arsenal	589,987.94
Ordnance Office	3,413,744.27

AMOUNTS COVERED INTO THE SURPLUS FUND.

The principal amounts covered into the surplus fund of the Treasury were $4,416.97 for ordnance stores—manufacture, 1904; $1,619.36 for armament of fortifications; $2,180 for Rock Island Arsenal, 1904; $1,150.48 for ordnance stores—equipments, 1904; and $1,069.28 for ordnance stores—repairs, 1904.

COMPARISON OF THE FISCAL STATEMENT WITH THAT OF THE PRECEDING YEAR.

Comparing the fiscal statement with that of the preceding year it will be found that the amount of the appropriations was decreased from $9,627,709 to $7,961,418.57, a reduction of $1,666,290.43; the amount of the disbursements decreased from $11,849,642 to $11,389,835.09, a decrease of 3.8 per cent. The amount received from transfers to the Executive Departments and the organized militia decreased from $1,125,229.68 to $998,173.82. The amount received in the preceding year was largely increased by reason of the rearming and equipping of the organized militia. The amount available for disbursement at the close of the fiscal year decreased from $14,669,512.19 to $12,284,198.51, a decrease of $2,385,313.68.

SYSTEM OF ACCOUNTS.

The new system of accounts with the arsenals referred to in my last report has worked satisfactorily since its inauguration. A force of five clerks is engaged on the work in this office, and their familiarity with it is now such that they are able to keep it up to date without being required to work overtime, which was the case for a few months after the inauguration of the system. As the work of accounting is one requiring absolute accuracy, the limited number of mistakes which have been made bears evidence of the zeal and faithfulness of the clerks employed.

In conducting manufacturing operations at the various arsenals the methods followed for charging indirect expenses were not always uniform. Instructions have been issued rendering the practice uniform, and blank books have been furnished for keeping account of

such expenditures. In this connection I would invite your attention to the fact that under the present construction of the application of appropriations by the accounting officers of the Treasury Department it is held that each and every appropriation authorizing manufactures, repairs, or alterations in the shops of the various ordnance establishments shall bear its share of each and every item of such indirect expenses. This view as to the application of appropriations makes it necessary that every voucher covering the purchase of any article for indirect use in manufacturing operations shall show upon its face all the appropriations authorizing the work in the shops wherein such article is used. The plan proposed by this office is to consider the general expenses as a whole, and when their amount has been ascertained, to set aside the necessary amount for them, prorated among the several appropriations authorizing the work in the shops, but charging expenditures for indirect labor and smaller items of material against the smaller appropriations and those having limited life, leaving the purchase of supplies procured in larger quantities to the larger and continuing appropriations. It is obvious that it is not material which system of charging is used as the total amount charged against each of the several appropriations would in the end be the same, but the method proposed by this office is so much simpler and its advantages are so evident that it is proposed to ask Congress to authorize the making of charges for general expenses in the manner indicated.

In my last annual report I spoke of an effort to improve the system of accounting in the Ordnance Department so as to determine more accurately the cost of the different articles manufactured by it; and stated that this cost would thereafter include, besides the indirect shop expenses, a proper percentage to cover the pay of the officers and enlisted men of the establishment, the general repairs and improvements to buildings, the clerical expenses, deterioration, and in general all those expenses which a private manufacturer must take into account, except profit. This percentage has been determined to be for the Frankford Arsenal 9; for the Springfield Armory 14, and for the Rock Island Arsenal 11.4. In comparing Government manufacture with that at private establishments certain advantages characterize each method. The private manufacturer is not restricted to eight hours of labor per day; this may or may not be an advantage, but there is no doubt of the advantage resulting from his relief from the necessity for paying for fifteen days of vacation per year, for seven national holidays, and for Saturday half-holidays during the summer months. The time for which the Government in this manner pays, without return in labor, amounts to 10 per cent of the working time of the year. On the other hand, the Government has a right to charge a less interest rate on the value of its plant, because

its better credit enables it to borrow money at a less rate. Its losses by fire are also limited to those actually incurred, instead of being obliged to carry the "load" involved in the machinery of conducting insurance companies and the dividends to stockholders. Its high-class superintendence is also less liberally paid, and the deterioration of plant, like the insurance, is only that actually incurred, instead of being an amount which the manufacturer must often make large in order to cover himself against a lack of future orders, but which he rarely diminishes when the real cost of his plant has been actually covered. Added to all else is the profit, which the manufacturer will of course make as great as the conditions of industry allow. It is sometimes claimed that the private manufacturer has a stimulus spurring him to effort to reduce cost by improved methods and close supervision, which is lacking in a Government establishment. There is no necessity for the lack in Government establishments, if the career of the officers is made to be affected by their conduct of them; and there is the same possibility as in private etablishments of reward to employees for valuable suggestions. Success in diminishing private cost does not by any means signify lower prices to the Government, but rather greater profit to the manufacturer.

Below is a table showing the contract price and the arsenal cost of various manufactures of recent years. In some cases the contractors claim that their price was so low as to cause them a loss. The arsenal costs include all of the general percentages mentioned above; the comparison goes back as far as the improved system of accounts renders reliable. The evidence is in favor of Government manufacture.

Comparative cost of ordnance and ordnance stores purchased under contract and manufactured at arsenals.

Article.	Under contract.		At arsenals.	
	Price each.	Date of contract.	Price each.	Date of order.
3-inch field guns and carriages, model of 1902	$6,822.75	June 1, 1903	$4,534.47	
		Gun	2,242.72	Aug. 12, 1903
		Carriage	2,291.75	Aug. 14, 1903
3-inch field guns, model of 1902	2,499.63	May 22, 1903	2,242.72	Aug. 12, 1903
3-inch field guns, model of 1905	1,990.00	Nov. 12, 1905	1,491.90	Nov. 13, 1905
3-inch field-gun carriages, model of 1902	3,014.83	Aug. 22, 1904	2,292.05	Oct. 18, 1904
3-inch field-gun carriages, model of 1902	2,850.83	Oct. 19, 1904	2,292.05	Do.
3-inch field-gun carriages, model of 1902	3,010.00	Nov. 17, 1905	2,292.05	Mar. 16, 1905
3-inch field caissons, model of 1902	1,001.45	Aug. 27, 1904	1,056.77	Apr. 22, 1904
3-inch field caissons, model of 1902	1,499.00	July 21, 1905	1,183.81	Apr. 3, 1905
3-inch field caissons, model of 1902	1,325.19	.....do.....	1,183.81	Do.
3-inch field caissons, model of 1902	1,522.53	Dec. 8, 1904	1,183.81	Do.
3-inch limbers, model of 1902	810.43	Jan. 4, 1905	745.31	Do.
15-pounder barbette carriages, model of 1903	4,042.00	Mar. 6, 1906	3,642.37	Jan. 12, 1906
5-inch barbette carriages, model of 1903	2,498.81	Apr. 28, 1904	3,894.09	Feb. 2, 1904
Battery commander's telescopes	380.00	Apr. 18, 1904	186.30	Jan. 4, 1906
15-pounder shrapnel	3.96	Sept. 14, 1905	2.83	July 21, 1905
21-second fuzes	2.68	.....do.....	1.91	Do.
Weldon range finders	19.46	.....	10.51	Mar. 12, 1906
Ball cartridges for rifle, model of 1903, per 1,000	42.50	June 29, 1905	34.99	1905-6.

EXAMINATION AND SETTLEMENT OF PROPERTY RETURNS.

At the beginning of the year the auditing of returns was up to date, but of the returns and abstracts which had been examined 3 returns from arsenals and inspectors, 301 abstracts from arsenals, and 173 returns from the Army, militia, and colleges were not closed.

The following table exhibits briefly the work of the auditing of returns during the year:

	Number of returns examined and not settled on June 30, 1905.	Number of abstracts examined and not settled on June 30, 1905.	Received during year ended June 30, 1906.		Total.		Acted on during the year.				Examined and not settled, awaiting correspondence, June 30, 1906.	
							Examined.		Settled.			
			Returns.	Abstracts.	Returns.	Abstracts.	Returns.	Abstracts.	Returns.	Abstracts.	Returns.	Abstracts.
Arsenals and inspectors...	3	301	55	275	58	576	55	275	54	565	4	11
Army, militia, and colleges	173	.....	5,446	.....	5,619	.....	5,446	.....	5,249	.....	370	.....
Total.....	176	301	5,501	275	5,677	576	5,501	275	5,303	565	374	11

The 370 returns from the Army, militia, and colleges, which were not closed comprise a number of returns from the governors of States accountable for stores issued to the organized militia which can not be closed without authority of Congress. It has been reported that the governor of one State has been endeavoring to procure an appropriation from the State legislature to reimburse the United States for property lost.

The amending of section 1661, Revised Statutes, at the last session of Congress to provide for charging losses arising from avoidable causes against the quotas of the several States will enable this office to audit returns of States with greater dispatch.

In the case of two of the Executive Departments, against which charges of $203.37 and $917.86, respectively, have been raised for failure to account for stores, correspondence has been had with a view to submitting estimates to Congress to provide for reimbursement of this Department.

It was found that certain colleges were accountable for property when there was no officer on duty at them. These colleges were authorized to purchase the arms and equipments issued to them at reduced prices on account of their obsolete character. Many of them took advantage of the reduced prices, and thus closed their accountability.

SYSTEM OF PROPERTY ACCOUNTS.

During the year marked improvements have been made in the office records and in the form of rendering returns from the arsenals.

A record card of accountability has been introduced, on which is kept an account of the principal transactions affecting each officer's property accountability from the time he enters the service until he leaves it. As a supplement to this record of accountability, a card is kept which gives a continuous record of the officers accountable for ordnance property pertaining to each command and post.

It will be observed from the above tabulated statement that the records of the condition of the business of auditing accounts were kept under two general headings, namely, "Arsenals and inspectors," and "Army, militia, and colleges."

The new system provides for reporting the progress of the work under the following twelve headings, viz:

Arsenals and inspectors,
Artillery,
Cavalry,
Infantry,
Surgeons,
Philippine scouts,
Artillery districts,
Forts and posts,
Submarine mine property,
Militia (States, etc.),
Colleges, and
Miscellaneous.

Knowledge of the condition of each kind of return enables the office force to work to greater advantage and affords statistical information of importance.

Additional records have also been introduced which provide keeping account of—

"Stoppages from pay of officers to cover value of stores not properly accounted for."

"Amount deposited by officers to cover value of stores not properly accounted for."

"Amount charged against enlisted men to cover value of property lost, stolen, destroyed, etc."

"Value of property lost, stolen, destroyed, etc., and dropped from returns without being paid for or charged."

In case of the last named the records are kept for the cavalry and infantry so as to give the information by regiments, and for the field artillery by batteries. Considerable time and labor have been expended to give information showing the disposition of funds appropriated to procure ordnance stores for the Army, but until now little attention has been paid to the obtaining of information from the returns giving the consumption of the ordnance stores issued to the Army. By the system just introduced this office will be enabled to show the relative consumption by the various organizations comprising the cavalry, infantry, and field artillery, and to furnish comparisons between organizations of the economical use of ordnance material and of the effect of foreign service on the same.

The introduction of the above records and the simplifying of the method of correspondence has resulted in a saving of clerical work of

about 13 per cent. The improvements have been worked out under Maj. George Montgomery, Ordnance Department, U. S. Army.

CLASSIFICATION AND ACCOUNTABILITY FOR ORDNANCE AND ORDNANCE STORES AT THE ARSENALS.

For over a quarter of a century the classification of ordnance and ordnance stores was based largely on the character of the ordnance in use at the beginning of the period. The introduction of modern ordnance, requiring complicated and special mounts and equipments for each caliber, demonstrated that the system of classification formerly in use would not answer for the present day requirements. Under the former system of classification all cannon and machine guns were found in one class, all carriages for the same in another class, all accessories and equipments in another class, and all the spare parts for the same in still another class, so that the same articles constituting the equipment of a battery of field or coast artillery would be found accounted for under no less than four headings of classification. It will be seen how difficult it would be to find from a property return the complete equipment of a battery. The classification of ordnance and ordnance stores which has just been introduced is based on the principle that, as far as practicable, articles which are found together in service should be accounted for together on paper. The application of this principle suggested that the various articles of ordnance and ordnance stores should be grouped about the three principal methods of propelling missiles of warfare, (1) by artillery of position, (2) by mobile artillery, and (3) by small arms—each group being divided conveniently into classes.

The various articles which are in use in current service at the arsenals have also been arranged into five classes. Advantage was taken of the adoption of the new classification to introduce new methods in accounting for such stores. It has been recognized for a long time that the continued accounting by the use of headings of columns in a return for articles which are located permanently at an ordnance establishment precisely as articles are accounted for which are continually changing involved a great deal of unnecessary clerical work. The introduction of the new methods of accountability contemplates that articles in which the transactions are frequent be accounted for on a semiannual return provided with the necessary spaces for the entries of these transactions, and that articles in which the transactions are rare be accounted for by a card system which involves no change unless a transaction occurs in these articles. The semiannual return which has been introduced contemplates the continuous record of transactions in each article as it occurs, and for this purpose columns for " Receipts " and " Issues " are provided for under the heading of each article on each page of the return, and the

corresponding voucher number is entered on a column reserved for the purpose. As the entries are made directly on the return, its introduction dispenses entirely with the abstracts of receipts and issues which formerly constituted a part of each arsenal return. In addition, the method of entries is such that each page of the return is utilized to its capacity, resulting in a great saving not only in clerical work, but also in the amount of paper constituting each return. The various forms on which headings are printed are furnished for use in a loose-leaf binder so that no unnecessary sheets will be filed as part of a return. The return also provides for entry of the annual inventory taken each year, with the corresponding values of the stores so inventoried. It will be seen from the above description that the new system of accounting for property is nothing more or less than the introduction of a double-entry system of bookkeeping into property transactions.

In regard to the articles which are permanently located at an ordnance establishment, such as buildings, machinery, inspecting instruments, obsolete ordnance and ordnance stores, etc., it is now required that for each of these articles a duplicate card be prepared. When a transaction occurs in an article, the accountable officer furnishes a new card, bearing record of the latest transaction affecting the quantity of the article on hand. As the number of transactions in each article is rare, the number of substitute cards sent to this office will be correspondingly so. The number of articles at the ordnance establishments which will be accounted for by this method varies from 500 for one establishment to over 5,000 for another. The great saving of clerical work will be appreciated when it is considered that this means a reduction in the writing in of headings to this extent and the making of at least four entries for each article at the end of every semiannual period.

The work of auditing property returns has devolved during the year on 14 clerks, but due to the introduction of improved office blanks and methods it has been possible to reduce the force to 12 clerks. The work of auditing property accounts presents very little diversification, and much credit is due the clerks employed on this work for their constant application to their duties and the careful and painstaking manner in which they were performed.

SMALL ARMS.

United States magazine rifle, model of 1903.—The manufacture of these rifles has progressed satisfactorily during the year, and the regular troops in the United States were supplied with the earlier form in order to permit of their use during the target season. The improved rifle, having knife bayonets and rear sights, model of 1905, has since been issued to the troops in the Philippines, and imme-

diately after the maneuvers the improved rifle will be issued to the troops in the States and the first issue recalled. The behavior of the new musket has been a source of gratification, as but few faults have developed. The principal source of complaint has been the breakage of cocking pieces. In my report of a year since mention was made of the necessity for a redesign of the cocking piece to satisfactorily fulfill a new condition imposed by the revised infantry drill regulations. The cocking piece as redesigned, required an entirely different grade of steel, and during the transition period many of these component parts were made from material on hand and issued to the service. Reports of breakages have been received, but no trouble is anticipated from the parts made of the proper material. Other minor defects have also been developed, but corrective measures have been applied, and it is believed that the new musket will go into the service practically perfected.

Self-loading magazine rifles.—The test of the Schuboe auto-loading magazine rifle has been continued during the year. As the result of these tests, changes are being made in the rifle which may eventually render it satisfactory for service use. An auto-loading magazine rifle is also being developed at the Springfield Armory, and should be completed and subjected to test during the coming year.

Gallery practice rifles, caliber .22.—A design of a barrel and receiver for use with the United States magazine rifle, model of 1898, has been completed, and 500 of these rifles are in process of manufacture at the Springfield Armory. A similar design for the model of 1903 rifle has been completed, but the manufacture of rifles has been withheld, pending further experiments with what is thought to be an improved form of this small caliber weapon.

Automatic machine guns.—General Orders, No. 113, 1906, prescribe the organization of machine-gun platoons for each regiment of cavalry and infantry, and for the Porto Rico Provisional Regiment. The manufacture of guns and pack outfits has sufficiently progressed to permit the complete equipping of these platoons, with the exception of that of the Porto Rican regiment. The equipment of these platoons is rapidly progressing. The completion of a number of automatic machine guns, with wheeled mounts, for seacoast fortification, is not so far advanced, and it will probably be another year before any of these are ready for issue.

Fencing bayonets.—The triangular bayonet formerly used with the Springfield rifle has been utilized in the manufacture of fencing bayonets. The supply of these bayonets having been exhausted a new design conforming in general appearance to the model of 1905 bayonet has been adopted, and for future manufacture this design will be used.

SMALL-ARMS AMMUNITION.

The improvements in small-arms ammunition have been principally in the line of improved methods in manufacture and reduction in the cost of labor charges. Brass and lead have so advanced in cost that finished ammunition is somewhat more expensive than formerly, notwithstanding the improved methods of manufacture above referred to.

Contracts have been completed with each of the three following firms for 3,216,000 ball cartridges, model of 1903: Union Metallic Cartridge Company, Winchester Repeating Arms Company, and the United States Cartridge Company. It is anticipated that 5,000,000 rounds of model of 1903 ammunition will be procured under contract this year.

Occasional complaints have been received that the ammunition of Government manufacture is not as accurate as that manufactured by private firms. The ammunition manufactured by one of the private firms above referred to was issued for target practice by the regular troops, but was, after the first day's firing, turned in, with a request for Frankford Arsenal ammunition. It is believed, therefore, that the Government ammunition is as satisfactory as any that can be manufactured by measured charges. For the past year this department has been endeavoring to procure a machine for loading cartridges by weight, and the delivery of a foreign-made machine of this kind has been promised on October 15, 1906.

Two European nations—Germany and France—are believed to have adopted new bullets for their infantry rifles. These bullets differ from those previously in use principally in being of lighter weight and also in the form of the head. This department has been for a number of months experimenting with bullets of the class of the new ones mentioned, with the result that with a bullet weighing 150 grains, as against the present weight of 220 grains, a muzzle velocity of about 2,800 feet per second is attained, an increase of 600 feet per second over that of the present service bullet.

An increase of velocity, attained by diminishing the weight of the bullet, would not alone commend itself as a result to be striven for, for the reason that the lighter bullet would lose its velocity more rapidly, both by reason of its lighter weight and by reason of the increased resistance of the air resulting from its higher velocity; so that it would be expected that such a bullet would, at reasonable ranges, fall below the heavier one in velocity and energy, and that its trajectory for such ranges would be more curved. The offsetting feature of the new bullet is its shape, the point being much longer and sharper; and the influence of this is such that at all ranges up to 2,000 yards the velocity is greater and the trajectory flatter; at ranges up to 1,000 yards the energy is greater, while the accuracy is

at least as good as with the service bullet. The penetration of the new bullet into white pine boards is greater at 500 yards and approximately the same at 1,000 yards as that of the service bullet.

There is probably no element which interferes so much with the efficiency of infantry fire on the battlefield as misjudgment of the range. The flatter the trajectory may be the less influence does this element have, and therefore any change which decreases the curve of the trajectory within fighting ranges contributes most usefully to the efficiency of fire. The difference in the flatness of the trajectory is such that, for 1,000 yards range, while the maximum ordinate of the trajectory of the service bullet is 22 feet, that for the sharp-pointed bullet is only $12\frac{3}{4}$ feet. Targets which have been made at 500 and 1,000 yards indicate a mean radius of deviation from the center of impact slightly less for the sharp bullet than for the service bullet; but as this element has been determined for the service bullet as a mean of a large number of firings made under different conditions, it is not considered a safe assumption that the sharp bullet would, under the same circumstances, always give the better accuracy. Individual targets have been made with the service bullet which are as good as any which have been made with the sharp bullet.

In order to determine more exactly the influence of the shape of the head of the sharp bullet, bullets of the same shape as the service bullet, but shorter, so as to be of the same weight as the sharp bullet, have been manufactured and experimented with. These bullets have shown, as was to have been expected, about the same muzzle velocity as the sharp bullet, but the velocity has fallen off much more rapidly, so that at 500 yards range it has fallen below that of the service bullet, and the trajectory, while lying between those of the service bullet and the sharp bullet at 500 yards, has passed above that of the service bullet at 700 yards. The characteristic representing the influence of the form of the head in producing the resistance of the air to a projectile in flight is usually designated in American ballistic formulæ by the symbol "c;" computations for this characteristic, which have been made from the experiments thus far conducted, show its value for the service bullet and for the shorter bullet of the same form of head to be between 0.88 and 0.90, while for the sharp bullet the computed value, from firings made at the same time, of this characteristic is 0.558+.

It is thus seen that at fighting ranges the new bullet has the advantage of that of the service pattern in all ballistic elements of efficiency, and it is proposed therefore to adopt it as the service model.

The change in the bullet will require a slight change in the rifle, involving all those which have been already manufactured, which must therefore be turned in for alteration. The necessity for this change comes about as follows: In the early firing with bullets of the

new form the loss of accuracy was so great as to prohibit the idea of its adoption, unless the cause could be discovered and removed. In considering this feature it was noted that, because of the longer and sharper point of the new bullet, its full diameter was only reached at a section 0.2 of an inch farther back from the point than with the service bullet, with the result that the sharp bullet traveled this distance in the bore of the gun before reaching the rifling, and that while traveling this distance gases passed around and ahead of the bullet. This action of the gases, together with the fact that the bullet may not have taken the rifling truly, was believed to be the cause of the inaccuracy; and the belief was demonstrated to be correct by pulling the sharp bullet 0.2 of an inch farther out of the cartridge case, so that it should start at about the same relative position with respect to the rifling as the service bullet. Firings under these conditions brought the accuracy fully up to the service standard.

Pulling the bullet out of the case in this fashion, however, left it with only about one-sixteenth of an inch remaining in the case, a distance too small for security in transportation. In addition, by making the total length of the cartridge 0.2 of an inch greater, it precluded its use in the magazine and prevented its full ejection upon opening the breech. These difficulties have been met by unscrewing the barrel from the receiver, cutting 0.2 of an inch from its rear end, running the thread the same distance farther along on the barrel, rechambering, so as to permit the shoulder of the cartridge case to enter properly, and then screwing the barrel back into the receiver. The net result being only to make the barrel 0.2 of an inch shorter; an insignificant change. The different trajectory will also necessitate a regraduation of the rear sight.

Pushing the bullet 0.2 of an inch farther into the case in order to restore the cartridge to its original length leaves the case projecting somewhat beyond the section to which the bullet carries its full diameter; it is therefore necessary to cut about 0.07 of an inch from the cartridge case in order to permit the chamber of the rifle to be made to fit the bullet sufficiently close. This change will have to be made upon reloading with the new bullet and the proper powder charge all the ammunition which has thus far been manufactured. The indications up to the present time are that the weight of powder charge with the new bullet will be slightly greater than that with the service bullet and that the pressure will be a little higher; but these points can not be considered as finally determined, and may be modified by the use of a different kind of powder, possibly quicker in burning.

In carrying on the experiments bullets of different material and form have been tried. Difficulty was at first experienced in forming the sharp-pointed jacket, but it has been overcome.

It is not proposed to alter the Krag-Jörgensen rifles now in existence or the ammunition therefor, as this material will be ultimately replaced by that of the newer model.

Reduced-range cartridges.—Experiments have been made with reduced-range cartridges furnished by private firms, as well as with a cartridge of this class manufactured by the Department. These cartridges are for use on ranges which have not much more than 600 yards available, and are intended to give sufficient accuracy at the range named to permit satisfactory target practice with sufficiently low remaining velocity at that range to provide against injurious results from the bullets which have not been stopped by the butts.

SMALL-ARMS TARGET PRACTICE

Target material.—Experiments have been made with a form of target devised by Lieut. Arthur Williams, Engineer Corps. While many favorable reports were received from this target, the consensus of opinion seems to be that the Brinton or service target is preferable. Experiments are being conducted with a bookbinder's-board silhouette target to replace the steel-frame silhouette.

EQUIPMENTS.

Few changes have been made in the equipments issued to cavalry, infantry, and artillery during the year. The cup, formerly made of steel heavily tinned, is now made of aluminum. The aluminum cup was adopted only after an extensive service trial. An effort is being made to purchase satisfactory meat cans and canteens of aluminum.

Gun slings.—The gun sling manufactured for and issued with the model of 1903 rifle has been the subject of considerable criticism from expert shots. The sling was adopted upon the recommendation of the board for the revision of small-arms firing regulations, its primary object being to serve as a carrier for the musket. Its use was prescribed during the target season, and reports on this form of sling are now being received. Prior to the target season, however, experimental slings were devised, having as a primary object the support of the gun in firing, as a secondary object the carrying of the gun, and as a tertiary object the utilization of the short slings on hand above referred to. One of these experimental forms will probably be adopted should the short sling be found unsatisfactory.

INTRENCHING TOOLS.

Sufficient sets of intrenching tools for infantry have been obtained to equip about 60,000 men, except that satisfactory pick mattock handles have not been delivered. By direction of the honorable the Secretary of War, 18 companies of infantry were supplied with

intrenching tools and with experimental carriers for hand axes, pick mattocks, and shovels, prior to the maneuvers to be held this summer. Half of these carriers in each company are made of leather, and the remaining half of duck, so that the relative desirability of the two classes of material for this purpose will thus be determined. The merits of ball-handled shovels as compared with those with crutch handles will also be determined.

SERVICE GUNS AND MORTARS.

In my last annual report I spoke of the influence of erosion in limiting the life of heavy guns, and of the possible necessity of finding some method of securing the necessary power less expensive than that involved in using the very high velocities of projectiles now employed, with the accompanying rapid wearing away of the rifling, in such manner as to destroy the accuracy of the gun after a few rounds. Going into the subject in more detail and considering the 12-inch gun of the model of 1900 as an example, we have for the life of this gun, firing a projectile of 1,000 pounds weight with a velocity of about 2,500 feet per second, only about 60 rounds. As the gun is capable of firing for a considerable interval at the rate of 45 rounds per hour, it is seen that the limit of its life could be reached in less than an hour and a half. It has been considered that, in attempting to run by fortifications guarding the entrance of a harbor, the period that would elapse from the time that the leading vessel of the fleet would come within range until the last vessel would pass beyond the range of the coast guns would be about two hours; it is therefore evident that a new 12-inch gun would not last through such an engagement. Similar statements can be made with regard to guns of smaller calibers, although as the caliber diminishes the admissible velocity increases. The 6-inch gun of the model of 1900, firing a projectile of 100 pounds weight with a velocity of 3,000 feet per second, would have a life of 150 rounds, corresponding to about an hour and a quarter at the rate at which the gun can be fired. It needs only a statement of the situation to show the necessity for doing something to meet it, notwithstanding that the accuracy of the guns could be restored by relining them, at much less than their original cost.

By lowering the velocity of the 12-inch projectile to 2,250 feet per second the life of the gun is increased to 200 rounds, and by similarly lowering that of the 6-inch projectile to 2,600 feet per second the life of the gun goes up to 450 rounds. The penetration of armor plate is, of course, reduced by this process, that of the 12-inch gun at 10,000 yards coming down from about 10½ inches to about 9 inches and the range at which its projectile would penetrate 12

inches of armor plate being reduced from about 8,000 yards to about 6,000 yards, Krupp hard-faced armor being referred to in both cases.

To restore the offensive power the most obvious course is an increase of the caliber of the gun, and the following considerations indicate that there is nothing against such a course and a great deal in its favor. A 16-inch gun has been successfully built and tested, and there is no reason why this caliber should not be adopted for our guns of the highest power if it should be considered necessary. But let us examine an intermediate caliber. The design of a 14-inch gun has been laid down in this office of which the weight is 49½ tons (111,000 pounds), the weight of the projectile is 1,660 pounds, and such construction has been adopted as will involve a muzzle velocity of 2,150 feet per second. The charge of powder required to produce this velocity is about 280 pounds, as against 366 pounds for the 12-inch gun of the model of 1900.

By reason of the lower velocity required and the consequent smaller powder charge, it is possible to make the 14-inch gun proportionally shorter than the 12-inch gun, and the smaller charge of powder also involves a less diameter of powder chamber and therefore, with the same thickness of wall of the chamber in calibers, a less exterior diameter of the gun over the breech. These elements of saving are so considerable that the weight of the 14-inch gun becomes actually less than that of the 12-inch, and as a lower maximum pressure is needed it is possible to attain all the strength which will be used without employing the most expensive steel. The muzzle energy of the 14-inch projectile will be about 15 per cent greater than that of the 12-inch, and because both of its lower velocity and its greater weight the retarding influence of the air will be much less upon this projectile, so that the gain of energy will be in greater proportion with each increment of range. The life of the gun before its accuracy should show impairment will be about 240 rounds, corresponding to about six and one-half hours of continuous firing at the rate at which it is thought that it can be fired. Because both of its lighter weight and of the cheaper material of construction, the cost of the gun will be less than that of the 12-inch gun, while the cost of the charge of powder will be also less than that for the 12-inch gun by about $70.

The cost of the 14-inch armor-piercing shot will be about $100 more than that of the 12-inch shot, so that the total cost of a single round will be about $30 greater. Taking into consideration, however, the rapid deterioration of the 12-inch gun, and adding the cost of relining to that of the ammunition, which would correspond to the number of rounds making relining necessary, it appears that the cost per round, including this deterioration, for the 14-inch gun is only about 68 per cent of that for the 12-inch gun. These statements refer to rounds

fired in action; with practice rounds, for which cast-iron projectiles are used, the cost of the projectiles is only about 3 cents a pound, instead of 15 cents, as for the armor-piercing projectile; the projectile for practice will thus cost only $18 more for the 14-inch gun than for the 12-inch gun, and with a saving of $70 on the powder charge the total cost of a practice round is less by about $52. At 10,000 yards the penetration of the 14-inch projectile through Krupp armor is about 11 inches, while that of the 12-inch projectile is about 10½ inches; the range at which the 14-inch projectile will penetrate 12-inch Krupp armor is about 8,700 yards, as against 8,500 yards for the 12-inch. Summarizing, it appears that by using in the situations requiring the greatest power a 14-inch gun, with 2,150 feet per second muzzle velocity of projectile, instead of the 12-inch gun, with 2,500 feet per second initial velocity, we would secure a lighter gun, a cheaper gun, a heavier projectile, greater muzzle energy, a still greater proportion of energy at each distance beyond the muzzle, and a life four times as long.

The rapidity of fire would be affected somewhat unfavorably for the 14-inch gun by the greater weight of projectile to be handled, but it is intended to so mount this gun that the loading angle shall be smaller than that for the 12-inch gun, the gun to be loaded in a horizontal position, or perhaps at a slight depression, which should preserve practically the rapidity of fire of the 12-inch gun.

All the advantages seem thus to be on the side of the larger caliber, and the inquiry seems pertinent why we were ever led to seek increase of power by means of the very high velocities which have been employed at the expense of so many elements more valuable and not dissipating so rapidly as the projectile approaches its target. A partial answer is that a demonstration of the destructive effect of the large charges of powder necessary to produce the high velocity was required for its appreciation, and this could only be afforded by experience. It may also be said that the efforts of constructors of ordnance had been for so long directed to the increase of velocity of the projectile as limited by the bursting effect of powder, which was restrained both by the control of its rate of burning and by the strength of construction of the gun, that the current of this effort tended to keep on flowing in the same direction until brought up against the rock of erosion. How long this obstacle will limit advance can not of course be said.

The Taft Board for the revision of the report of the Endicott Board on coast defense has recommended the use of the 14-inch gun in place of the 12-inch in situations where, as above stated, the highest power is required, and this Department will hereafter construct guns of that caliber, abandoning as a maximum caliber the 12-inch, which had been tacitly adopted.

The relative advantages and disadvantages of high velocities and larger calibers are set forth in more detail in Appendix I to this report, prepared with much care by Maj. Charles B. Wheeler, Ordnance Department.

In the meantime the subject of the control of erosion of seacoast guns has continued to receive the attention of the Department. Higher velocities being usually obtained by using larger charges of slower powder in guns of increased length, it is desirable to know whether the same increase in erosion would result in case these higher velocities were obtained by means of quicker powders, giving greater pressures, in shorter guns. A series of tests which it is hoped may throw light on this subject has been inaugurated. Another series of tests has also been begun to determine the relative power of resistance to erosion of various kinds of steel. It is hoped that these tests may enable some conclusion to be reached as to the kind of steel best suited for use in the manufacture of tubes for cannon.

Serious accidents have occurred in our naval service from flare backs. The term "flare back" has been applied to the rush of flame or heated gas which sometimes occurs when the breech of a gun is opened soon after a shot is fired.

While no serious danger is apprehended in the land service from such flare backs, which are of very infrequent occurrence therein, it has been considered advisable to investigate their nature and the causes which produce them, with a view to taking such steps as may be required to entirely eliminate them. These investigations are still in progress.

From the observation thus far made it seems probable that the gases remaining in the bore after firing are inflammable when mixed with air. When the breech is opened the supply of air is admitted and a spark would then cause inflammation with a rush of gas from the breech of the gun. The spark needed to cause the explosion may come from unconsumed and smoldering pieces of cartridge-bag material remaining in the chamber, or from the incandescent globules of powder residue which are sometimes found adhering to the walls of the bore.

In my report of last year I referred to the tendency of the breech-blocks of 10-inch and 12-inch rifles, models of 1895 and 1900, to rotate under firing pressures. Automatic devices to prevent accidental rotation have now been applied to these guns.

EXPERIMENTAL GUNS.

10-inch Brown segmental-tube wire gun.—No progress has been made in the test of this gun during the year, the repairs to the breech mechanism not having yet been made.

6-inch Brown segmental-tube wire gun.—This gun was delivered at the Sandy Hook Proving Ground October 4, 1904, and has been undergoing test since that time under a programme approved by the Board of Ordnance and Fortification. The test is nearing completion, and it is hoped that a report of the results obtained will be received early in the coming year.

6-inch wire-wound gun, Crozier design.—This gun was manufactured at the Watervliet Arsenal under an allotment from the Board of Ordnance and Fortification, and was delivered at the proving ground February 21, 1905. Since that time it has been undergoing test under a program approved by that Board.

Unfortunately the breech mechanism of this gun was in the shop undergoing minor repairs at the time the shops were destroyed by fire, and it has been necessary to undertake the manufacture of a new breech mechanism before the tests of the gun can be completed.

Semiautomatic 3-inch 15-pounder R. F. gun.—This gun has been under test at the proving ground since June 3, 1905. This test is now nearing completion, and it is hoped that a report of the results will be received early in the coming year.

Semiautomatic 6-pounder guns and mounts.—Four of these guns and mounts have been procured under allotments made by the Board of Ordnance and Fortification and have been undergoing tests at the proving ground under a programme approved by that Board. A suitable powder for these guns has been developed, and the tests are nearing completion.

MOUNTAIN ARTILLERY.

The proposed modification of the Vickers-Maxim 75 mm. mountain gun to 3-inch caliber has been delayed owing to a complication resulting from the necessity of changing a large amount of shrapnel on hand to fit the new caliber. It is hoped that the work of altering these guns may be taken in hand during the coming year and pushed to completion.

The improvement of the 75 mm. mountain gun carriage by attempted increase to 45 degrees of the maximum elevation at which the gun can be fired and of the length of recoil on the carriage has been given attention, but a satisfactory design has not as yet been completed.

PACK OUTFITS.

During the past year attention has been given to the design and manufacture of pack outfits for Colt automatic machine gun, Maxim automatic machine gun, and 75 mm. mountain gun. An American model has been developed in which many parts are applicable to all of these outfits. The work has progressed satisfactorily, a large number having been completed.

REEL AND CART FOR MOBILE ARTILLERY.

Designs are under way for a reel and cart to be used for transporting telephones and the necessary wire, field glasses, battery commander's telescope, and other material for the fire control of battalions and regiments of mobile artillery.

FIELD ARTILLERY.

3-inch field artillery material.—The manufacture of this material has progressed well during the year. A satisfactory form of fuze setter has been developed, and the manufacture of a sufficient number to provide one for each two caissons in service has been undertaken. In case these fuze setters are damaged in action or are rendered unserviceable from any cause, it is desirable that a secondary means of rapidly setting the time fuzes of shrapnel be at hand. To meet this requirement a form of hand fuze setter has been devised and is now undergoing test.

All batteries in the regular service and 13 batteries of the organized militia have been equipped. Thirteen additional batteries for the organized militia are complete, except that wheels and armor-plate shields have not been delivered by the contractors. As soon as these parts shall have been received issue can be made. Funds are on hand for the manufacture of 8 more batteries for the organized militia and of 6 for a reserve.

This material has received during the past summer a service test at the various maneuver camps which have been established and upon the long marches to and from these camps. Certain weaknesses have been reported. The most serious have been in the wheels, of which the hubs are alleged to have lacked stiffness, and the fellies to have been too weak to resist crushing between the spokes. The hubs are being strengthened, and the bent rims of the fellies are being replaced by fellies in eight sections considerably deeper in a radial direction than the bent rims. Careful experiments have shown that the resistance to a crushing force applied between the spokes is as great with the sectional felly, even when the force is applied directly over the joint, as with the bent rim. Another weakness which has been quite generally reported is that of the side rails, to which the ammunition chests are attached. These have been broken in such manner as to indicate that the strain producing the fracture was an upward one, resulting from throwing the chest upward so violently as to bring a hard strain upon the fastenings holding it down and the parts to which it was attached. Such action could only be produced by passing at a rapid gait over an obstacle.

It is entirely practicable to make the field material of such strength as to resist almost anything which can be done to it by horses; but

this can only be done at the expense of increased weight, which must always be hauled about, in order that the great strength required by occasional rapid movement over rough ground may be had. The increase in strength of the wheels has added about 12 pounds to the weight of each, or about 24 pounds to that of each vehicle. The weight behind the teams was already greater than was desired, being something like 700 pounds per horse, and the addition is something which it would have been well to avoid. Reports from the maneuver camp at Fort Riley, where there was a provisional regiment of field artillery, are to the effect that, notwithstanding such rapid movement and rough usage as produced several overturns of vehicles, the strength of the material was found to be sufficient. The regimental commander states that, except in some minor particulars, the field artillery material was thoroughly satisfactory. It seems very doubtful whether the necessity for these extremely rapid movements of field artillery, over ground not perfectly smooth, is so great as to justify the increase of weight made necessary in order to provide the strength required to preserve the material.

A number of militia batteries have now been supplied with the new 3-inch field artillery material, and others are rapidly being furnished with it. This material, while much more effective than that which it replaced, is also more complicated and requires more attention and skill for its care and use. It embodies hydraulic cylinders, stuffing boxes, springs, gear wheels, and bearing surfaces, all elements of mechanical complication and all tending to require something of a machinist's training for the skillful artilleryman. The care being provided for, the effective use of this material, requiring indirect pointing from positions at which the target is not visible and a degree of fire control and direction never attempted with the earlier material, constitutes probably even a greater advance over the training formerly required than does the care. The organization of the Regular Army now provides for thirty batteries of mobile artillery. For anything like a first-class war at least 250 batteries would be required. It is apparent that there is no hope of the maintenance in time of peace of even a fair proportion of this number in the regular service. The reliance of the country must, therefore, be largely upon organizations of some kind of which the members shall be self-supporting and devoting only a portion of their time to military training.

The militia batteries are such organizations, and by recent appropriations increasing the amount which the United States is willing to devote to them they are given very considerable material assistance, but there is no good provision for imparting to them that instruction which, in so technical an employment, can be had only from those who acquire the necessary skill in the knowledge and use of

the material in the actual practice thereof as a profession. It is believed that no more profitable use could be made, during a portion of the year, of a considerable number of officers of field artillery than to assign them as instructors of militia batteries, under a proper system to be prescribed. Practical instruction in firing could probably be best given by joining the militia batteries with the regular ones in the summer encampments; but much valuable instruction in the care of the material, and theoretical explanations of the use thereof in the field, could well be given at the armories and on the drill grounds of which the militia batteries have use.

2.38-inch field gun on long recoil carriage.—This material, which was designed at the suggestion of the Board of Ordnance and Fortification, has been completed and 38 rounds have been fired at the Rock Island Arsenal with satisfactory results. It has been sent to the Sandy Hook Proving Ground for further test under a programme approved by that Board. It is expected that this test will be taken in hand and pushed to completion during the coming year.

3.8-inch field artillery material.—The pilot gun and carriage have been completed and sufficiently tested, so that orders have been given for the manufacture of a battery of four guns and carriages during the current year. This gun fires a projectile of 30 pounds; double the weight of that of the 3-inch gun. It therefore is an example of heavy field artillery in which a considerable increase of power has been obtained at some sacrifice of mobility. In the continual conflict between power and mobility it seems probable that such a gun would find a place, an estimate of occasion for its use governing the extent to which it should be supplied in making preparation for war.

Field howitzer material.—Entirely satisfactory designs of long-recoil carriages for 3.8-inch and 4.7-inch howitzers have not as yet been developed, but studies have been made, and this important and difficult work will be given further attention during the current year. A 3.8-inch field howitzer has been designed which will fire the same 30-pound projectile that is used with the 3.8-inch rifle and will have a muzzle velocity of about 900 feet per second. The mobility of this material will be about the same as that of the 3-inch field gun. The 4.7-inch field howitzer on long-recoil carriage will fire a 60-pound projectile, with a muzzle velocity of about 900 feet per second. This work would have been completed some time ago but for the lack of officers, from which the Department has suffered for several years past, but from which relief is now in sight.

Automobile forge and battery wagon.—The design of this vehicle has been delayed in an endeavor to obtain guaranteed air-cooled motor of sufficient power, but on account of the rush of other work manufacturers have not been willing to take up any special designs during the past year and little progress has been made.

SIEGE MATERIAL.

As a result of the test of the 4.7-inch siege gun and carriage which was completed during the past year, it has been decided to manufacture an experimental battery of four of these guns and carriages, and steps to that end have already been taken.

The design of a 6-inch siege howitzer and carriage have been completed in this office, and their manufacture has been undertaken. It is hoped that they will be completed during the coming year.

SEACOAST CARRIAGES.

No funds were appropriated at the last session of Congress for a new installation of seacoast guns and carriages in this country. Further appropriation was made to complete the carriages to be installed in the insular possessions and which have been under manufacture during the past year. They will all be in readiness when emplacements are provided. In addition to carriages being made at arsenals, contracts exist with the following private manufacturers, namely:

15-pounder rapid-fire carriages, model of 1903, with the American and British Manufacturing Company.

4.5-inch shields for 5 and 6 inch barbette carriages, with The Midvale Steel Company.

6-inch disappearing carriages, L. F., models of 1903 and 1905, with the Bethlehem Steel Company.

Of the contracts mentioned in my last report the Bethlehem Steel Company has completed deliveries of 15-pounder rapid-fire guns and carriages, model of 1902, and the Wellman-Seaver-Morgan Company has completed deliveries of 6-inch disappearing carriages, L. F., model of 1903. No 6-inch disappearing carriages, L. F., model of 1905, have as yet been delivered.

Carriage for the type 16-inch breech-loading rifle.—The completion of the design for this carriage has been delayed on account of the nondelivery of a 6-inch disappearing carriage, L. F., model of 1905, as it is desired to subject to thorough test certain features in that carriage before proceeding along the same lines with the 16-inch.

10-INCH EMERY DISAPPEARING CARRIAGE.

Mr. Emery has continued work during the year on the 10-inch disappearing carriage of his design, being made under a contract in accordance with the provisions of the fortifications act approved April 21, 1904, in such manner as he has deemed best. Additional material for its construction has been obtained.

AUTOMATIC SIGHTS.

Experiments with automatic sights, to which reference was made in my last annual report, have been continued during the year, but no definite conclusions have been reached as yet.

TELESCOPIC SIGHTS.

3-inch telescopic sight.—The change to the system of direct illumination of the cross wires has been effected and the transfer of the deflection scales to the rear end of the cradle is nearly completed. A contract has been made with Queen & Co. (Incorporated) for a number of these sights. The design continues to give satisfaction.

2-inch telescopic sight.—The design of this sight has been completed and 45 have been ordered. The telescopes are ready for delivery, and the remaining parts are well advanced. These sights are for the smaller sizes of rapid-fire seacoast guns.

Telescopic sights, models of 1898 and 1898 M.—The alteration of the interior deflection scales and least reading on the micrometer deflection screw has proceeded satisfactorily. As 3-inch telescopic sights are placed on 12-inch carriages, model of 1897, it is intended to remove the models of 1898 and 1898 M, and use them for replacing the older and less satisfactory design, model of 1897.

IMPROVEMENTS IN INSTALLED SEACOAST CARRIAGES.

Electric firing of seacoast guns.—Designs of firing circuits for each individual mount for guns have been completed and a large percentage of those required have been assembled; the remainder are under manufacture.

12-inch mortar carriages.—The 369° electrical contacts, safety-firing switch cables, and conduits have been under manufacture during the past year and satisfactory progress has been made. The work on interposition of cast-steel beams between the racer and hydraulic recoil cylinder, substitution of continuous grooves for the five throttling holes in the cylinder, addition of a break to prevent accidental rotation of the racer, and of improved counter-recoil buffers has proceeded satisfactorily during the year.

10-inch disappearing carriages, L. F., model of 1894.—Designs are now in preparation for the alteration of these carriages to provide improved traversing and elevating mechanisms, counterbalance device, electric retracting gear, and high sighting platform with 3-inch telescopic sight on the left-hand side.

Loading platforms for subcaliber practice.—The work on this material has proceeded satisfactorily.

Counter-recoil throttling valves.—A number of disappearing carriages have been supplied with this improvement, the object of which

is to secure better control of the return of the gun to battery, and the later models will be provided as fast as funds and time will permit.

RANGE-FINDING INSTRUMENTS.

Range finders for infantry and cavalry.—The Weldon range finders to be issued to each company of infantry and each troop of cavalry are under manufacture at the Frankford Arsenal and will be supplied at a considerably less cost than when they were formerly purchased from private manufacturers. A number have been issued and the remainder will soon be completed.

Lewis depression position finders, Type A, and azimuth instruments, model of 1900.—Alterations to provide for the illumination of cross wires and scales for these instruments are being made as the instruments can be spared from service. This opportunity is being utilized to subject them to a general overhauling.

Material for fire control and direction system at seacoast fortifications.—One hundred deflection boards, 43 set forward rulers, 54 wind component indicators, 50 plotting boards for difference charts, 50 battle chart boards, and several experimental instruments have been completed. Two hundred Whistler modified plotting boards have been altered, and 151 Pratt ballistic boards have been changed into range boards. Satisfactory progress is being made in the manufacture of Whistler-Hearn plotting boards, plotting boards for use with submarine mines, and difference chart scale arms.

Range-finding instruments for mobile artillery.—Fifty battery commanders' rulers will shortly be completed. Plotting boards for mobile artillery have been manufactured; in view of a possible improved design large quantities have not been made.

MAINTENANCE OF THE ARMAMENT OF FORTIFICATIONS.

The division of the seacoast and field armament, for the purpose of maintenance and improvement, into districts continues to operate very satisfactorily, and the service guns and mortars have been maintained in a good state of efficiency during the year. In order to more closely observe the action of service material under service conditions, one of the semiannual inspections which district armament officers are required to make, has been made during the target practice whenever practicable, and the results have been so satisfactory that this practice will be continued.

GAS CHECK PADS.

The experiments thus far conducted to determine the best form and composition for gas check pads for seacoast guns of large caliber have shown that by the use of a thinner pad more satisfactory results can be obtained than with a thick pad, even when made of the

usual tallow-asbestos composition. Two of the new compositions experimented with have been so promising that it is believed that the adoption of either will result in practically eliminating the troubles heretofore experienced incident to the softening of the pad from the heat of rapid firing.

Comparative tests of these two compositions are still in progress, and a decision as to which of the two will be adopted for service will soon be reached.

BANDING OF PROJECTILES.

The centrifugal force due to the velocity of rotation imparted to projectiles when fired from high-power guns has, in many cases, caused the split bands to be stripped from the projectiles. To overcome this difficulty bands are now being made in the form of continuous rings, which are forced into their seats by being passed through conical dies. It has been found that continuous ring bands can be successfully applied to projectiles of all calibers, and that form of band has been adopted for service.

Tests of enlarged bands made with 12-inch rifles indicate that increasing the diameter of the rear portion of the band just in front of the sealing lip may slightly prolong the accuracy life of the rifle, but the results were not sufficiently conclusive to warrant the adoption of the enlarged form. The erosion was very rapid when these bands were used, but it is not clear whether this increased erosion was due to the form of the band or to a general breaking down of the metal of the bore as a result of the large number of rounds which had been fired from the gun used in the test.

SEATING OF PROJECTILES IN MORTAR FIRING.

Experiments conducted to determine the effect of allowing the projectile of a 12-inch mortar to rest on the charge and at a distance of from 0.9 inch to 1 inch in rear of its proper loading position have shown that an appreciable loss in velocity and pressure results.

POWDER.

With a view to securing greater uniformity in the specifications for powder issued by this Department and by the Navy Bureau of Ordnance, a joint army and navy board, consisting of officers of the Navy and of this Department, was convened on March 12, 1906, for the purpose of preparing specifications for the manufacture and test of smokeless powder. As a result of the investigations of this board it is hoped that the specifications for smokeless powder will be considerably simplified and improved.

In my report of last year I referred to the fact that some of the smokeless powders manufactured prior to 1900 and 1901 had been

found not to meet the requirements of more recent tests. These powders are being gradually consumed in target practice, and tests of them (which continue to be made at frequent intervals) indicate no deterioration in storage, and it is not thought that any of this powder will be lost.

ARMY POWDER FACTORY.

Congress at its last session made an appropriation of $165,000 for the establishment of an army smokeless powder factory. Steps are being taken for the selection of a proper site for the establishment of this factory, and when this site has been selected the work of erection of the factory will be pushed vigorously to completion. In the meantime plans and specifications for buildings and machinery are in preparation.

ARTILLERY PRACTICE.

Reports received during the year indicate general satisfaction with the material issued for the purpose. The adoption of capped projectiles for seacoast rifles of 5-inch caliber and upward was not attended by any difficulty or confusion, and for the practice during the coming year caps will be provided for 12-inch mortar projectiles, as well as for rifle projectiles.

Tests of smoke-producing compound as a shell-filler have not indicated that any material advantage will be secured in practice with 1-pounder projectiles, but the results have been so promising that further experiments are to be undertaken to determine the suitability of this material as a bursting charge for 18-pound projectiles used in subcaliber practice with 12-inch mortars. In order to simulate as far as practicable service conditions, 12-inch mortar subcaliber practice with 75 mm. tubes and 18-pounder projectiles, has been arranged for three zones, numbered 1, 2, and 3, using angles of elevation between 45° and 65°. The ammunition will have propelling charges adjusted to give muzzle velocities of, respectively, 550, 625, and 700 feet per second, covering all ranges between 2,000 and 4,150 yards. Each round will have stenciled upon the projectile in front of the band the number of the zone for which it is to be used. A range table has been prepared prescribing the limits of these zones and containing other necessary firing data.[a]

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[a] A new design of extractor for dummy projectiles has been prepared, and steps have been taken looking to the manufacture of a sufficient number of these extractors to provide each artillery post with the number needed for drill purposes.

The difficulties experienced with the subcaliber tubes used with 15-pounder R. F. guns referred to in my report of last year have been satisfactorily overcome, and the new form of subcaliber tube (subcaliber cartridge) has given satisfaction.

The instructions for the care and use of drill primer outfits originally contemplated the issue of these outfits to seacoast artillery companies, but as the result of many reports and information received since the issue of these primers began, it has been decided that more satisfactory results will be derived from issuing two drill primer outfits to each post ordnance officer and charging him with the duty of resizing and reloading the drill primers for use as required at the post. The form of the drill primer outfit box has been altered to contain only the necessary reloading tools, including a set for resizing the primer bodies. The primer bodies, button wires, serrated wires, and closing caps will be issued in bulk. One hundred drill primer bodies has been fixed upon as the proper supply for a post garrisoned by two companies and 200 for a post garrisoned by three or more companies. The use of these outfits reduces the cost of the primers used at drill from 60 cents to about 12 cents each.

Reports from the service indicate that the caliber .30 subcaliber tube for the siege guns is unsatisfactory, owing to its limited range and the difficulty of accurately determining the points of impact of the projectiles. Steps will therefore be taken to design a tube of the same caliber and using the same ammunition as that which has given such satisfactory results in subcaliber practice with seacoast guns of 4-inch caliber and upward.

CLOTH FOR POWDER BAGS.

In order to avoid as far as possible the danger of premature ignition of powder charges from flare backs or from the presence in the chamber of the gun of unconsumed and smoldering pieces of cloth remaining from the preceding round, either one of two steps may be taken, viz, to treat the cloth so as to render it noncombustible, or to adopt a kind of cloth so inflammable that it is certain to be all consumed upon firing. In my report of last year I referred to the use of chemically treated noncombustible material for powder bags, and stated that while no reason could be seen for any bad effect of this cloth on smokeless powder during storage, it was not considered safe to assume this to be a fact without actual trial. Tests to decide this question, which are in progress, indicate that the stability of the powder will not be affected, but definite conclusions have not been reached.

Tests have been conducted during the past year to determine the suitability of a cartridge cloth composed of smokeless powder. It was found that this cloth was entirely consumed in firing, and left no residue in the chamber which might set fire to the powder of the succeeding round. Its suitability for use as an igniting charge for smokeless powder, thus doing away with igniter of black powder, has

also been tested, but the results of this test have not been satisfactory. It is to be further borne in mind that this smokeless powder cloth, being very inflammable, increases the danger of setting fire to the charge from accidental sparks, and it has been adversely reported upon for this reason.

TESTS OF TYPE 8-INCH RIFLE.

This rifle, which was completely worn out by the endurance test to which it was subjected, has been cut into sections and is being gradually dismantled in order to determine the changes, if any, that have taken place in the shrinkages as a result of the prolonged firing to which the gun was subjected. It is hoped that the work of dismantling this gun will be completed during the coming year. Considerable importance is attached to this test, as it is expected that it will determine whether a built-up cannon assembled with the shrinkage determined by the formulas adopted by this Department behaves in the manner called for by the theory on which these formulas were deduced.

PRIMERS.

In order to use the same form of primer with 5-inch and 6-inch rapid-fire guns as is used with seacoast guns of larger caliber, certain changes in the firing mechanisms of these guns were necessary. These changes have been completed, and it is expected that mechanisms of the new design will be supplied to all 5 and 6 inch rapid-fire guns at an early date.

PREMATURE BURSTS.

Report was received at this office during the past year that a number of cast-iron shell had burst in the bores of 5-inch guns during target practice. As a result of this report a series of tests was made at the Sandy Hook Proving Ground to determine, if possible, the cause of these premature bursts. The results were not entirely conclusive, but appeared to indicate that the premature explosions were due to a leakage of gas between the fuzes and their seats in the bases of the projectiles. In order to avoid a recurrence of this difficulty base covers, similar to those used with armor-piercing projectiles having high explosive bursting charges, have been adopted for all projectiles used in target practice, whether the bursting charge is of black powder or of high explosive.

ISHAM SHELL.

My annual reports for 1898, 1899, and 1902 contain a description of this shell and the tests thereof made prior to September, 1902. These tests were of a preliminary nature, to demonstrate whether a cast-steel shell of this kind, designed for carrying a large charge of explosive gelatin, furnished a means of safely discharging from

service guns high explosives of a character too sensitive for use in the present service projectiles.

In the continuation of these preliminary tests two of these shells were, on January 22, 1903, fired from a 12-inch gun with charges adjusted to give high pressures. The first shell, filled with 172 pounds of explosive gelatin, left the gun whole and appeared steady in flight, the recorded maximum chamber pressure being 42,200 pounds per square inch. The second shell, filled with 183 pounds of explosive gelatin, exploded prematurely in the bore after a travel of about 42 inches and burst the gun, the maximum chamber pressure in all probability not exceeding 50,000 pounds per square inch.

This bursting of the gun was attributed to the frozen state of the explosive gelatin, which is reached at about 39° F., but this is a condition which would exist in service unless the magazines were heated in winter. The service high explosives do not require the magazines to be heated.

In the early part of last year it was decided to continue these experiments by firing the Isham shell, loaded with explosive gelatin, against a target representing the side of a battle ship with 12-inch hard-faced armor. The first shell was fired August 10, 1905, with about 1,400 feet per second striking velocity and struck near the center of the target. The shell detonated on impact, breaking into small fragments and slightly abrading the face of the plate and making a dish-shaped indentation about 13 inches in diameter and 1.5 inches deep at the middle point.

As far as any appreciable injury to the plate or backing was concerned the effect of this shell was practically confined to the displacement of the loose sand about the foot and front of the target and the bodily movement of the entire target about 4 inches.

Mr. Isham then requested that the second shell be fired against a similar target, but with a suitable tank in front filled with water, to ascertain the damage to the under-water structure of a battle ship that would result from the pressure transmitted through the water from such a shell exploding in the air. His request has been approved under certain conditions, which have been communicated to him. This is the present status of the experiments with this shell, the total cost of which to date has been $33,604.66, in addition to the value of the burst gun.

It is expected by the inventor that the results of this test will disprove the deductions drawn from the results of previous firings with shell of this and other designs—that an armored structure can not be wrecked by guns fired with shell designed for outside explosion only. The Isham shell embodies this condition in two fundamental features, namely, the sensitiveness of the explosive and the fragility of the projectile.

COPPER DEPOSIT IN THE BORES OF GUNS.

It has been found that continued firing of seacoast guns causes a deposit of copper to form on the rifling, which in some cases has been of sufficient amount to appreciably reduce the diameter of the bore. Usually the wear of the guns will compensate for this copper deposit, but investigations have been made to determine how best to remove it in order to avoid all chance of trouble, and it has been found that it can be removed in a very simple manner with a 25 per cent solution of strong ammonia in water or of a solution of carbonate of ammonia of corresponding strength. By the use of a tight-fitting sponge and this solution the accumulation of copper can be removed from the bore of the gun in a few hours.

3-INCH SALUTING GUNS.

The conversion and issue of 3-inch muzzle-loading guns to breech-loaders for saluting purposes, referred to in my reports of the past three years, have continued. One has been issued to each post for use as morning and evening gun and for firing salutes. They have proved so satisfactory that it has been decided to issue one additional to each post designated as a saluting station to return the salutes of foreign vessels of war. One hundred and eighty have been thus converted and provided with mounts, and these, with the 15 for which estimates will be submitted to Congress this coming year, will be sufficient to carry out the above programme.

To avoid the expense and inconvenience attending the sending of the cartridge cases for these guns to an arsenal or depot for resizing, a comparatively inexpensive resizing set has been designed and added to the reloading and cleaning outfit now issued with these guns. Five of these resizing sets were first made, and when subjected to a thorough service test were found satisfactory. Fifty more are now in process of manufacture, and when completed will be issued to district ordnance officers and to the ordnance officers of isolated posts.

RELINING OF SEACOAST GUNS.

In 1903 the Department decided to undertake the relining of one or more seacoast guns with the object of determining the practicability of thus rendering serviceable guns which are now unserviceable or that may from time to time become unserviceable from erosion. The importance of these investigations is clearly set forth in the detailed report on the erosion of the bores of guns forming Appendix I of this report.

The gun selected for relining was the type 10-inch gun, No. 1, which had successfully withstood 292 rounds without sustaining any injury that could be detected other than that due to the erosive effects of the powder gases. This erosion had become so great as to practically destroy the accuracy of the gun.

The work was completed in January, 1906. The lining tube was inserted from the rear and extended to a point 152 inches from the rear end of the powder chamber, being held from forward movement in firing by a shoulder and secured against rotation in firing by knurling at the front end, spline screws at the rear end, and the compression due to the shrinkage employed in assembling.

This gun since being relined has been fired 52 rounds, in the last 8 of which the powder charges were gradually increased until a maximum chamber pressure of 53,150 pounds per square inch was obtained, the standard pressure being 38,000 pounds. While rubber impressions and star-gauge measurements of the chamber and bore indicate that the method adopted in lining this gun has been successful, it has been deemed advisable to continue the test further before a decision is reached as to the course to be followed hereafter.

INSPECTOR OF ORDNANCE, RICHMOND, VA.

Maj. Lawson M. Fuller, Ordnance Department, performed the duties of inspector in Richmond from July 1, 1905, to December 31, 1905, and Maj. Odus C. Horney, Ordnance Department, from January 1, 1906, to June 30, 1906, in addition to their duties in the office of the Chief of Ordnance. The material covered by the following contracts was under inspection during the year, before the close of which all of it was delivered.

The Tredegar Company: Contract of January 19, 1905, 1,000 cast-iron projectiles for 12-inch mortars, 300 cast-iron projectiles for 12-inch guns, and 500 cast-iron projectiles for 10-inch guns; contract of June 21, 1905, 350 cast-iron projectiles for 10-inch guns, and 250 cast-iron projectiles for 12-inch guns.

The Richmond Iron Works: Contract of January 19, 1905, 300 cast-iron projectiles for 4.72-inch Armstrong guns and 6,500 cast-iron projectiles for 2.95-inch subcaliber tubes for 12-inch mortars; contracts of March 24, 1904 and December 23, 1905, for 200 and 50 2½-inch Lyle life-saving guns. The Richmond Iron Works also furnished 450 cast-iron projectiles for 12-inch mortars, included in the contract dated June 9, 1905, with the Taylor Iron and Steel Company, Highbridge, N. J.

James W. Carr: Contract dated January 17, 1905, 200 cast-iron projectiles for 8-inch guns; contract of January 25, 1905, 2,000 cast-iron caps for projectiles.

J. B. Kendall, Washington, D. C.: Contract of April 15, 1905, 1,100 cast-iron caps for projectiles.

BETHLEHEM STEEL WORKS.

During the year this office was in charge of Capt. William H. Tschappat, Ordnance Department, who also inspected work in prog-

ress at the Taylor Iron and Steel Company, the Carpenter Steel Works, and the Wyoming Shovel Works.

During the year work was in progress on 20 contracts, comprising the following material:

7 15-pounder R. F. guns and carriages, model of 1902.
21 sets of 6-inch R. F. gun forgings.
30 4½-inch shields for 5-inch and 6-inch barbette carriages.
2,000 15-pounder common steel shell, ribbed cavity.
200 4-inch common steel shell.
170 3-inch field caissons, model of 1902.
1,000 6-inch A. P. shell.
10 6-inch disappearing carriages, model of 1903.
10 6-inch disappearing carriages, model of 1905.
500 3-inch C. I. shot.
1 set of steel forgings for 12-inch mortar, model of 1886–1890 Mi.
1 set of forgings for 2.38-inch field rifle, model of 1905.
5,600 3-inch common steel shell (field).
15,000 3-inch common steel shell (seacoast).
2,000 6-inch A. P. shot.
52 sets hardened protective shields for 3-inch field gun.
20 sets hardened protective shields for 3-inch caisson.
36 3-inch field guns, model of 1905.
36 sets of forgings for 3-inch rifle, model of 1902.
20 sets forgings for 3-inch R. F. gun, model of 1903.
3 16-inch A. P. shot.
3 16-inch A. P. shell.
2 forgings for 6-inch wire-wrapped gun.

Besides the above, work was in progress on 43 shields with supports, etc., for 15-pounder rapid-fire gun, model of 1903; 3 shields for 3.8-inch field gun, 1 shield for 6-pounder rapid-fire gun, 5,419 miscellaneous forgings, 432 miscellaneous castings, 1,500 finished hubs for 3-inch field material, the pressing of 10,242 flange steel parts, and about 300,000 pounds of steel bars, ordered by ordnance establishments and other manufacturers.

The following was completed during the year:

7 15-pounder guns and carriages, model of 1902.
7 sets of 6-inch R. F. gun forgings.
30 4½-inch shields for 5-inch and 6-inch barbette carriages.
2,000 15-pounder common steel shell, ribbed cavity.
13 3-inch field caissons, model of 1902.
598 6-inch A. P. shell.
500 3-inch C. I. shot.
1 set 12-inch mortar forgings.
1,000 3-inch common steel shell (field).
1 set forgings for 2.38-inch field rifle.
8 sets hardened protective shields for 3-inch field gun.
36 sets forgings for 3-inch field gun.
5 sets forgings for 3-inch R. F. gun.
2 forgings for 6-inch wire-wrapped gun.

Besides the above there were completed 3 shields for 3.8-inch field gun, 5,257 miscellaneous forgings, 272 miscellaneous castings, 1,092 finished hubs for 3-inch field material, the pressing of 10,242 flange steel parts, and about 200,000 pounds of steel bars.

TAYLOR IRON AND STEEL COMPANY.

250 8-inch C. I. shot.
500 3-inch C. I. shot were completed and shipped during the year.

THE CARPENTER STEEL WORKS.

About 110,000 pounds of steel for bayonet blades and other purposes was inspected and shipped during the year.

THE WYOMING SHOVEL WORKS.

Sixteen thousand eight hundred intrenching shovels were completed and shipped during the year.

INSPECTOR OF ORDNANCE, SHARON, PA.

The inspection work at Akron, Ohio; Cleveland, Ohio; Alliance, Ohio; Shelby, Ohio; Sharon, Pa.; Pittsburg, Pa., and contiguous localities was in charge of Capt. J. H. Rice, Ordnance Department, until March 31, 1906, with office at Akron, Ohio, on which date he was relieved by Capt. Jay E. Hoffer, Ordnance Department, and the office transferred to Sharon, Pa.

The Wellman-Seaver-Morgan Company, Akron and Cleveland, Ohio.—During the year this company completed its contract for 25 6-inch disappearing carriages, L. F., model of 1903, 3 of which had been delivered the preceding year. The date of final delivery fixed by the contract as August 19, 1905, was extended to October 20, 1905, for improvements directed by the Department and embodied in the carriages. Final delivery was effected April 11, 1906.

The Morgan Engineering Company, Alliance, Ohio.—At the beginning of the year this company was employed on an uncompleted contract dated April 28, 1904, for ten 5-inch barbette carriages, model of 1903, one of which had been delivered May 29, 1904. The final delivery was due January 10, 1905, but was not effected until October 10, 1905, owing to difficulties experienced in manufacturing and in obtaining acceptable steel castings.

The Warner & Swasey Company, Cleveland, Ohio.—At the beginning of the fiscal year this company had uncompleted contracts for 20 battery commander's telescopes, 119 Swasey depression position finders, one 25-foot horizontal-base range finder, one 8-foot horizontal-base range finder, six sets of testing instruments for Swasey depression position finders, and contracts for equipping 100 Swasey depression position finders and 222 3-inch objective telescopic sights, model of 1904, with new system of direct cross-wire illumination. During

the fiscal year contracts were made with this company for altering the deflection scale of 96 3-inch telescopic sights, model of 1904, and for 45 telescopes for 2-inch objective telescopic sights, model of 1906. All the above contracts have been completed with the exception of the 45 telescopes for 2-inch telescopic sights, model of 1906. These on June 30, 1906, were 60 per cent completed and will probably be delivered prior to August 2, 1906, the date of final delivery fixed by the contract. The work done by this company has continued to be satisfactory.

The Driggs-Seabury Ordnance Corporation, Sharon, Pa.—The contracts on hand with this company during the year were for 116,150 1-pounder large-capacity steel shell, 1 experimental 6-pounder gun and mount, 368 3-inch field limbers, model of 1902, and 234 3-inch field caissons, model of 1902. Of the 116,150 1-pounder large-capacity steel shell, the order for 55,000 was canceled and procured elsewhere. The contract fixed the final date of delivery as December 23, 1904, but the company did not succeed in completing the remaining 61,150 until April 30, 1906. The experimental 6-pounder gun and mount were delivered May 5, 1906. No deliveries have been made on the 3-inch field caissons and limbers, the dates of the final deliveries of which, with allowance granted for changes in design ordered, are as follows: Limbers, October 15, 1906; 164 caissons, January 16, 1907, and 70 caissons, December 31, 1906. The probable dates of final delivery are as follows: Limbers, May 1, 1907; 164 caissons, February 1, 1907, and 70 caissons, May 1, 1907. The delay is due to difficulties experienced by the company in establishing a plant for the manufacture of this material and in procuring material and competent workmen.

American Axe and Tool Company, Glassport, Pa.—A contract was made December 12, 1905, with Motley Green & Co., of New York, for 3,000 intrenching hand axes, handled, to be delivered on or before February 23, 1906. These axes were made by the American Axe and Tool Company at its works at Glassport, Pa., but final delivery was not effected until April 23, 1906.

In addition to the above, material for contractors and for other ordnance establishments was under inspection at the works of 14 different manufacturers in various localities. The principal items were as follows:

232,005 pounds of steel of all grades requiring test.
11,369 feet of steel tubing.
11,800 pieces twist-link chain.
421 springs.
5,600 polls for pick mattocks.
136 axles for 3-inch field limbers and caissons, model of 1902.
1 set shield plates for 2.38-inch field carriage, model of 1905.
1,362 oil-can bodies.
10,000 steel heads for 3-inch shrapnel.

The total value of all contracts and orders under inspection during the year was $1,238,141.69. The total value of material inspected and delivered during the year was $493,532.37.

INSPECTOR OF ORDNANCE, BALTIMORE, MD.

Capt. Lawson M. Fuller, Ordnance Department, performed the duties of inspector in Baltimore in addition to his duties in the office of the Chief of Ordnance.

Detrick & Harvey Machine Company.—Under contract with this company, dated February 6, 1905, ten 6-inch disappearing carriages, L. F., model of 1903, were manufactured. The date of final delivery was December 4, 1905, but, due principally to the difficulty in obtaining material, the contract was not completed until March 29, 1906.

Ellicott Machine Company.—Under contract with this company a range tower for Sandy Hook Proving Ground was manufactured and delivered.

MIDVALE STEEL WORKS.

The work of the inspecting officer at the Midvale Steel Works included not only the inspection of material manufactured at these works, but also that manufactured by 23 other contractors in Philadelphia and vicinity, and since August, 1905, has included also the manufacture of powder at the works of the E. I. Du Pont Company, Wilmington, Del.

This inspection has been performed during the year by Capt. Samuel Hof, Ordnance Department, U. S. Army, in addition to his duties as assistant to the commanding officer of Frankford Arsenal, as, owing to the continued shortage of officers in the Department, it has been impracticable to assign one to this duty exclusively.

The work comprised 187 different orders or contracts. The total value of the material under inspection was $807,319.12, of which that to the value of $546,134.72 was completed.

The principal articles inspected were: 496,808 pounds gun forgings; 250,480 pounds tire steel; 253,282 pounds flange steel; 122,336 pounds steel castings; 73,313 pounds of bronze castings; 523,576 pounds of miscellaneous steel forgings; 23 shields for 5-inch gun carriages; 6,193 steel springs; 1,000 medals of honor; wood for wheels, spokes, and neck yokes for 3-inch field material; 108 3-inch objective telescope sights, model 1904; 367,183 pounds smokeless powder for cannon; 109,346.7 pounds smokeless powder for .30-caliber small arms; 13,800 pounds black saluting powder; 125,480.5 pounds alcohol.

THE UNITED STATES RAPID-FIRE GUN AND POWER COMPANY; AMERICAN AND BRITISH MANUFACTURING COMPANY; SCOVILL MANUFACTURING COMPANY.

At the beginning of the fiscal year the United States Rapid-Fire Gun and Power Company had 7,000 rounds of 15-pounder steel shell ammunition yet to deliver under the original contract of April 15, 1898. Of this amount 4,000 rounds were delivered during the year, several other lots having failed in the ballistic tests. In the same period this company also completed the conversion of 25 3-inch wrought-iron guns to breech-loading saluting guns, and finished a 6-pounder semiautomatic gun and mount contracted for the preceding year.

The American and British Manufacturing Company.—This company completed 40 3-inch field carriages contracted for in 1904, and have the work on 24 additional carriages and 70 3-inch field caissons well advanced. In addition to this they delivered the balance of the 15-pounder steel shell in the ballistic test of which there had been previous difficulty, a number of orders for projectiles of minor calibers, and 40 1-pounder subcaliber tubes and extra sets of fixtures.

During the year they received a contract for the manufacture of 15 15-pounder barbette carriages on which work is progressing. They also received an order from Frankford Arsenal for 31,600 shrapnel cases, on which satisfactory deliveries are being made.

The Scovill Manufacturing Company.—This company completed the delivery of 25,000 1-pounder steel shell under a contract of the preceding year and an additional order of 50,000 of the same caliber. They also received a contract for 5,000 3-inch field shrapnel and 5,000 combination fuzes. The work on this last contract has been much delayed by changes in design and can not therefore be completed within the original contract time.

The work at the establishments mentioned was under Capt. W. S. Peirce, Ordnance Department, U. S. Army, stationed at the Springfield Armory and assistant to the commanding officer there.

COWDREY MACHINE WORKS, FITCHBURG, MASS.

This company during the present fiscal year completed the manufacture of cast-iron projectiles under four different contracts with the Department. These projectiles were of 2.8-inch, 3.8-inch, 4-inch, and 4.8-inch caliber, and were inspected by Lieut. Walter G. Penfield, Ordnance Department.

Archibald Wheel Company, Lawrence, Mass.—This company is engaged in the manufacture and repair of wheels for mobile artillery. During the present fiscal year contracts have been entered into for the repair of 1,544 wheels. Lieut. Walter G. Penfield, Ordnance Department, was the inspector at these works.

SANDY HOOK PROVING GROUND.

The proving ground was commanded during the year by Col. Charles S. Smith, Ordnance Department, U. S. Army, who is also president of the Ordnance Board, president of Board for Testing Rifled Cannon, and armament officer of the Sandy Hook armament district.

Firings for experimental and proof purposes have been conducted daily, weather permitting.

The following material, received at the proving ground, has been subjected to ballistic test:

222 lots of projectiles.
2 lots of shrapnel.
3 guns.
142 lots of powder.
2 lots of fixed ammunition.

The firings during the year have involved the expenditure of 87,601 pounds of powder, 750 pounds of high explosives, and 7,365 rounds of fixed ammunition, a total of 13,183 rounds having been fired, while 39 fragmentation tests were made.

The railroad, by means of which the proving ground is connected with all points outside, has proved a source of convenience and economy in the transportation of men and material. The total amount of freight shipped over this railroad during the year amounted to 37,429,498 pounds, requiring a total car movement of 1,088 cars. The total number of passengers carried during the year was 144,900. Under the authority contained in the fortifications act, approved March 3, 1905, about 1.6 miles of railroad have been straightened by relaying the track from a point near the proof battery to what is known as the Y, which gives a straight track outside of the zone of fire from the proof battery to the lower end of the Hook, a distance of about 5 miles.

New construction.—The observation, range, and plotting tower, authorized by the fortifications act, approved April 21, 1904, has been completed. The structure consists of a steel framework resting on a concrete base and supports the instrument room, where a Swasey depression position finder, type A, has been installed, together with a plotting board.

A set of quarters for the locomotive engineer, authorized by the sundry civil act, approved March 3, 1905, was erected during the past year.

There has also been constructed a brick building, for housing 3 locomotives and 1 locomotive crane, authorized by the sundry civil act, approved April 28, 1904. The plans and specifications for the construction of the barracks for enlisted men, authorized by

the fortifications acts, approved June 6, 1902, and June 25, 1906, are being modified, in order that the building may be erected within the amounts appropriated.

The work of preparing plans and specifications for the erection of one machine and smith shop, carpenter and plumber shop, power house and paint shop, including power plant, authorized by the sundry civil act, approved June 30, 1906, has been taken in hand.

Shops.—The shops have been fully occupied during the year with experimental work of the proving ground, together with work in connection with the armament installed in the Sandy Hook district. This work was seriously interfered with when the machine, carpenter, paint, and plumbing shops, together with the power plant, were destroyed by fire on November 28, 1905. As soon as practicable after the fire temporary shops were fitted up in vacant buildings, where such tools and machinery as had been saved from the flames were installed. The power for operating shops and the electric lighting system is obtained at the present time by utilizing the generators and steam engine and the electrical laboratory.

Instruction of officers.—The class, during the year, consisted of from four to six officers. Practical instruction was given in the chemistry of powders and explosives, applied electricity, and metal-working machines. The student officers showed commendable interest in their work.

Chemical-laboratory work.—Each officer was required to make at least one complete chemical analysis of samples of black and smokeless powder; to conduct tests prescribed for the acceptance of nitrocellulose and nitroglycerin powders; to manufacture in small quantities nitrocellulose and one other nitro compound; to determine the composition of the gas produced after the explosion of nitrocellulose.

Through the courtesy of Mr. H. F. Brown, of the International Smokeless Powder and Chemical Company, the officers were given an opportunity to witness the manufacture, at Parlin, N. J., of smokeless powder on a large scale.

Machine-shop work.—The programme for practical instruction in this department consisted of graded exercises on the lathe, universal milling machine, planer and shaper, and practical instruction in foundry and blacksmith work and the polishing and electroplating of metal. The work in this department was brought to a close when the shops were destroyed by fire, on November 28, 1905, so it was not practicable for officers to finish this course.

Department of electricity.—Since the fire on November 28, 1905, the electrical laboratory, which had been used for instructing student officers, has been used for supplying power and light to the proving ground, and therefore has not been available for the use

of those officers. All student officers took an active interest in the work of this department. A system of night lectures was inaugurated, and the greater part of the work, both practical and theoretical, was done at night, as the officers were occupied with the proof work during the day.

ROCK ISLAND ARSENAL.

This arsenal was commanded during the year by Col. Stanhope E. Blunt, Ordnance Department, U. S. Army.

The Secretary of War approved on January 16, 1906, the recommendations of the Chief of Ordnance and of the Chief of Engineers for the transfer of a portion of the reservation of the Rock Island Arsenal from the Ordnance Department to the Engineer Corps in connection with construction of a lock by the latter Department under the river and harbor act to provide harbor and access thereto for the city of Moline. The tract, about 10 feet wide, which has been transferred, extends along the north shore of the arsenal from the lock to the head of the island, and also embraces the entire portion of Benhams Island and of the wing dam extending to the eastward up the river from the head of Benhams Island. The work of the Engineer Department incident to the Moline Harbor will include the raising and strengthening of this wing dam and, as one effect, will raise the water and increase its head in the water-power pool, augmenting thereby the arsenal's available water power.

Artillery store shed.—The 3.2-inch field-artillery material in service in the Army has been replaced with the 3-inch, and that for the militia is being exchanged as fast as the new material is completed. The 3.2-inch material must be stored as a reserve supply. As no building is available for this purpose, a design has been prepared and estimate for its construction submitted.

Stable.—An appropriation of $9,000 for a stable required to provide accommodations for public horses and for private horses of officers allowed by law was made in the sundry civil bill approved June 30, 1906. This will, however, only provide a building of one-half the necessary capacity. A complete building will be constructed with the funds available and used for a portion of the public and private horses.

Hospital.—For over forty years a wooden structure, erected for temporary use during the civil war, has been used as a hospital, but in the lapse of time has become in a deplorable condition, totally unsuited for housing the sick. Estimate has for several years past been submitted, and renewed last year, when it was contemplated to erect quarters for the hospital steward, with necessary accommodations for dispensary, emergency hospital treatment, and surgeon's office, such a structure to take the place of the old hospital, and the

sick, when the illness was of a nature to demand it, to be sent to one of the hospitals in the neighboring cities. For this purpose an appropriation of $10,000 was made in the sundry civil bill approved June 30, 1906, and measures have already been taken to commence construction of the proposed building. It will probably be completed during the fiscal year.

Rock Island wagon bridge.—The bridge from the arsenal to the city of Rock Island, with viaduct extending over the railroad tracks in that city, was constructed a number of years ago when the amount of traffic and the weight of its separate units was much less than at the present time. For present conditions the bridge was not only of insufficient strength, but of inadequate width, and in lapse of years the superstructure deteriorated, especially that portion extending over the railroad tracks in Rock Island, where smoke from locomotives had caused very material reduction in sectional area of the steel bars. A thorough examination of the bridge was made last June, and, following report of the results, an appropriation of $125,000 for the construction of a bridge and viaduct was made in the sundry civil bill approved June 30, 1906. Plans and specifications are now being prepared for the new bridge, and it is hoped that the construction can be completed during the fiscal year.

Water supply and fire protection.—Experience with two disastrous fires in recent years having shown that the water supply for current use and particularly for fire protection was inadequate, an appropriation of $18,692 for increasing the water supply for fire protection by the enlargement of the present pump house, including extra machinery, was made in the sundry civil bill approved June 30, 1906, and measures will be taken during the year for installing the new system.

Water power improvement.—The excavation of rock, earth, and other material from the tail race of the Government water power, authorized by the sundry civil bill approved March 3, 1901, was completed December 31, 1905, under a contract which had been entered into with the Moline Water Power Company. The total amount of rock excavated was 74,120 cubic yards, in addition to 272,177 yards of gravel, sand, and marl, providing a channel with a width of 350 feet and a depth of 3 feet below low-water mark, which secures a tail race with ample accommodations both for the arsenal water power and for the Moline Water Power Company.

Power plant.—To the 104 electric motors previously installed in the shops, two of 20 horsepower and one of 5 horsepower have been added during the year, bringing the total up to 107 motors, with an aggregate of 2,539 horsepower for all the shop motors.

Additional machinery in shops of the arsenal and armory rows.—Forty-nine machines of various kinds have been added in these shops

during the year, most of them being procured to complete the plant necessary for manufacture of the wooden bodies and metal mouthpieces of the new model knife bayonet scabbard and of the various parts of the bayonet for the magazine rifle and of the rear sight, model of 1905, these articles of equipment having all been adopted during the year and none of the special machinery previously in the plant being suitable for their fabrication.

Arsenal shops.—For convenient and economical prosecution of work these shops are divided into machine, foundry, and forge shops; polishing, plating, equipment, and tine shops; carpenter and paint shops, and the harness shop.

In the first group, in addition to the usual repair work and to the manufacture of practically all of the metallic parts of articles of issue fabricated at this arsenal during the year, the principal operations of the shops have included:

1 4.7-inch siege carriage and limber, model of 1904.
1 3.8-inch field carriage and limber, model of 1904.
1 2.38-inch field carriage and limber, model of 1904.
107 wheeled mounts for V. M. automatic machine gun, caliber .30.
1 6-inch siege howitzer carriage, model of 1906.
2 siege limber caissons, model of 1906.
2 sets of test tools and gauges for insuring interchangeability of the various parts of wheeled mounts.
Various orders for 3-inch field artillery material, model of 1902.
Cleaning and repairing and putting in serviceable condition 124 3.2-inch rifles; 131 3.2-inch carriages; 121 3.2-inch caissons; 160 3.2-inch limbers; 12 3.2-inch battery wagons; 7 artillery store wagons; 2 5-inch siege carriages and limbers; 2 Gatling guns, carriages, and limbers; 2 7-inch mortar carriages; 3 Hotchkiss carriages, caliber 1.65 inches; 6 75-mm. V. M. carriages and guns.

Of the above the 4.7-inch, the 3.8-inch, and the 2.38-inch material was completed and successfully subjected to preliminary tests at this arsenal. The 6-inch siege howitzer carriage is well in hand. Of the 107 wheeled mounts ordered fabricated, one was completed and shipped to the Sandy Hook Proving Ground for test. Work on the remainder of the order was suspended pending the results of this test. Recently work has been resumed, and the remaining 106 mounts are well advanced. The order for the 2 siege limber caissons, model of 1906, has but recently been received, and but little progress has been made on these two vehicles.

The total of the orders for 3-inch field artillery material, model of 1902, received at this arsenal comprises 166 3-inch field carriages, 648 3-inch field limbers, 312 3-inch field caissons, 69 battery wagons, 69 forge limbers, 69 store wagons, and 69 store-wagon limbers, as well as miscellaneous orders for gauges and templets for the use of inspectors, and spare parts for the repair or replacement of parts in service.

Of the above orders, 116 carriages, 498 limbers, 292 caissons, 38 each of battery wagons, forge limbers, store wagons, and store-wagon limbers have been completed. The remainder of the various orders for 3-inch field material enumerated above is also finished except as follows: Wheels for all of the vehicles have been contracted for, but have not yet been delivered, the hardened steel plates for shields for 48 carriages and 20 caissons have not been delivered by the contractor, and the completion of the carriages and caissons is consequently delayed.

In addition to the above a large number of miscellaneous parts of 3-inch field material for alteration, repair, or replacement of that in service and in store have been completed during the year, and in addition a number of parts have been fabricated and furnished to contractors for use upon material they are making for the Government.

Work upon all of the orders for 3-inch field material could have been completed this fiscal year had contractors been prompt in the deliveries of armor plate and of wheels. The force employed in the machine shop at the beginning of the year numbered 260 machinists, with a suitable complement of machinist's helpers and laborers. This force has been gradually reduced by discharge and resignation until at present only 162 machinists are employed.

The principal new work in the polishing, plating, and allied shops has been the manufacture of the metal parts of the new bayonet scabbard, for which special devices, including wire-forming machines with special equipment for such work as the work continued, have been installed, producing an increased output and at considerable reduction of the earlier cost.

A number of experimental aluminum meat cans have been fabricated in which were incorporated modifications designed to overcome defects reported in those first issued for trial, the hinge piece being enlarged and the can stiffened by rolling it over an aluminum wire.

The supply of cavalry and horse equipments deemed essential for a reserve having been practically completed, the manufacture of these articles during the past year has been considerably less in amount than in the immediately preceding years, and the force of harness makers, which in July, 1905, was 269, has been reduced until at the close of the year only 91 of these mechanics were employed. While the manufactures were not conducted in complete sets, the output for the year may be approximately stated as equivalent to about 25,000 sets of infantry equipments, 15,000 sets of cavalry equipments, and 10,000 sets of horse equipments, with a large amount of artillery harness and a great variety of small parts of equipments of various kinds.

Armory shops.—The changes in design of bayonet and sights and

their related parts, which compelled cessation of work thereon in the latter part of the last fiscal year, retarded completion of these new parts during the year, as fixtures, tools, and gauges for their fabrication had first to be prepared. To insure interchangeability, not only between the parts of the rifle manufactured at the Rock Island Arsenal, but also with corresponding parts of arms produced at the Springfield Armory, gauges for these new operations were all furnished this arsenal from Springfield. It had also at first been intended that fixtures for the new operations should be made at the Springfield Armory, but in consequence of pressure of work at the latter establishment preparation of these new fixtures was ultimately directed at Rock Island.

At the close of the preceding year the components necessary for the completion of 18,000 rifles, with the exception of the sights, bayonets, and related parts, had been completed, but failing these parts none of the arms have been assembled. During the past year the new parts for these 18,000 rifles, with the exception of the leaf, have been completed and 5,000 of the rifles, except the rear sight leaf and related parts, have been assembled. The remaining portion of these 18,000 arms will be assembled as soon as the necessary number of rear-sight leaves can be fabricated, which will be early in the present fiscal year.

In addition to the new parts for the rifles above mentioned, all of the components of 36,375 rifles, except the new model bayonets, sights, and related parts, have been completed, and these new parts for that number of arms are now in the shops in various stages—largely toward the completed condition. All of these arms will be assembled in the earlier part of the new fiscal year.

Proving ground.—The furnishing of the proving ground with all the necessary conveniences and instruments for experimental and proof work with mobile artillery has been completed, and this equipment has been used during the year in the preliminary tests of the pilot 4.7-inch siege gun and carriage, model of 1904, the pilot 3.8-inch field gun and carriage, model of 1904, and the pilot 2.38-inch field gun, model of 1905, and carriage, model of 1904. For each of these carriages the preliminary tests included firings for the selection of a suitable powder for use in the gun, and firings for projectile velocity, gun recoil velocity, and recoil cylinder pressures necessary for the verification of the correctness of the dimensions of the throttling bars of the recoil cylinders. The possession of proving ground facilities at this arsenal has enabled these dimensions to be finally determined and the carriages completed in all respects before being forwarded to the proving ground at Sandy Hook for more extensive tests, and has therefore resulted in great saving of time in the final tests of this new material.

The proving ground work for the year has included the firing of a total of 1,291 rounds and the proof test of 81 3-inch field carriages, model of 1902; 71 3-inch field guns, model of 1902; 24 3-inch field guns, model of 1904, the proof and preliminary test of the 3 pilot guns and carriages referred to above, and the test of 11 lots of powder to determine their suitability for use in certain calibers of guns. The material thus proved and tested embraces not only material made at Rock Island Arsenal, but also material made at the Watervliet Arsenal and by private contractors. The completion of such an amount of proof work has added materially to the labors and made large demands upon the time of the officers stationed at this arsenal.

Value of stores under manufacture.—The total value of all the stores under manufacture during the fiscal year ending June 30, 1906, was $2,607,125.10, and of this amount articles to the value of $1,367,824.36 have been completed and turned into store. More than half of the excess of the value of stores under manufacture over that finished is accounted for by the unfinished magazine rifles, completed, however, in all respects except assembling, and the new knife bayonets, rear sights, and related parts.

SPRINGFIELD ARMORY.

The armory has been commanded during the year by Col. Frank H. Phipps, Ordnance Department.

All the buildings and grounds have received the needed attention.

Objection having been made by citizens living in the neighborhood of the targeting house to the constant noise made by the firing, it is probable that a new location will be secured and a targeting house erected thereon.

Fire extinguishers have been placed in all the buildings, and the elevator in the main arsenal has been provided with a larger piston, so it now works satisfactorily.

The appropriation of $2,500 for resurfacing Pearl street, recently made, will be expended as soon as possible. As the city desires to increase the size of its water pipes now running through this street, and as the gas mains are old and rotten, directions have been given to replace these pipes at once, as this work must be done before the resurfacing of Pearl street is attempted.

Manufactures.—The following principal arms were manufactured during the year: Two hundred and eighty-one model of 1903 rifles, with rod bayonets and model of 1903 sights, and 66,293 for the knife bayonet, with model of 1905 sights; also 31,310 model of 1903 rifles for knife bayonets, without the rear sight. These latter are being provided with sights as rapidly as possible.

In order to supply the number of upper bands, front and rear sights, and hand guards, which the change from the rod to the knife bayonet made necessary, both to equip the daily product and the

large number of rifles unassembled, which accumulated after work on the old model of these parts had been suspended, night work was commenced in December last and continued until June 30, 1906.

The target house being completed sufficiently for the purpose, the work of targeting the rifles was commenced March 15, 1906, ten men being employed. About 500 rifles per day are now being targeted.

Since the issue of the model of 1903 rifle, with model of 1903 sights (rod bayonet), to the Regular troops, complaint has been made of defects in the cocking pieces and a few other components. The causes of these defects have been carefully investigated and, it is believed, corrected. New parts are being substituted for those about which there has been any suspicion.

There have also been made experimental sabers, barrels for drill cartridges, aiming devices, hospital-corps knives, components and spare parts for the rifle, appendages, gauges for the model of 1903 rifle and model of 1905 bayonet for Rock Island Arsenal. Designs have been made and drawings furnished Rock Island Arsenal; also for all fixtures, tools, and dies used in the manufacture of the new parts of the United States magazine rifle, model of 1903, made necessary by the adoption of the knife bayonet and model of 1905 sight.

The usual repairs and alterations of ordnance material have been made, also fabrication of miscellaneous articles, and many improvements in methods of manufacture.

Ninety Vickers Sons & Maxim automatic machine guns were sent here for inspection and acceptance. In order to ascertain how nearly the gun forwarded here as a model agreed with the drawings furnished, careful measurements were made and compared with the drawings. Many differences were found, and the drawings were corrected accordingly. About half of these guns were overhauled, examined, and made ready for issue. A number of guns of this model are to be made at the works of the Colt's Patent Fire Arms Manufacturing Company, the inspection of which will devolve upon an officer from this armory.

The reduction in the number of rifles to be made during this fiscal year would naturally involve a reduction of the force, but in order to prevent the throwing out of work of a large number of men, the night force having been discontinued, only such men as were notoriously inefficient were dropped, and the vacancies occurring from natural causes will not be filled.

The usual tests, experiments, and reports on inventions and ordnance material presented have been made during the year.

FRANKFORD ARSENAL.

This arsenal has been commanded during the year by Col. Frank Heath, Ordnance Department, U. S. Army, who is also a member of the Board for Testing Rifled Cannon. The principal articles manu-

factured include cartridges of all classes for small arms, shrapnel for field artillery, fuzes and primers for all services, sights, quadrants, range finders, battery commanders' telescopes, range and deflection boards, and other instruments for the control of both seacoast and field artillery fire, together with many spare parts and accessories.

During the year the wing of the cartridge factory, in which is located the loading room, has been extended 36 feet, adding 1,650 square feet of floor space to this room. The extension harmonizes with the older part of the building and adds greatly to the efficiency and to the safety of this department by permitting further separation of the loading machines, thereby reducing the danger to the operatives in this room.

An abandoned boiler room in the machine shop building has been converted into a brass foundry, which is fulfilling all expectations as to economy and efficiency.

The water-supply system for which Congress appropriated funds has been completed, and the necessary adjuncts provided for utilizing its full advantages in case of fire.

Fuze and primer department.—The experiments for the improvement of existing material and the development of new designs have been continued, resulting in many modifications, the most important of which is the return to the ring resistance type of plunger for all fuze plungers, the arming resistance of which can be made great enough for safety in handling and transportation. The only projectiles in which the centrifugal fuze has been retained are those for mountain guns, howitzers, and mortars, in which guns the maximum acceleration which the projectiles receive in the bore is very low. This change was the result of the experience of the past year, which clearly demonstrated that the ring resistance fuze in projectiles insures a much larger percentage of bursts, both on direct and oblique impact, than the centrifugal fuze. The ring resistance plunger is also simpler and cheaper to manufacture.

Results of recent firings at the proving ground give all the necessary data for the graduation of the Frankford Arsenal twenty-one-second fuze for time of burning in flight, and the work of assembling a large number of machined parts is now proceeding rapidly. These firings show the total time of burning of the fuze in flight to be twenty-three seconds, demonstrating that the fuze as now constructed will permit of effective shrapnel fire at the extreme ranges of the new field guns. The action of the concussion plunger has been so adjusted that the burst of the shrapnel, when used with the fuze set at zero, as canister, takes place at from 10 to 50 feet from the muzzle of the gun.

Very promising results have been obtained with experimental combination fuzes for the new 3.8 inch, 4.7 inch, and 6-inch siege material.

Continued attention has been given to the development of the use of automatic machines in manufacturing parts of fuzes. Six of these machines are now in successful operation, and two more have been ordered. They require little attention, and work with remarkable uniformity and accuracy.

Shrapnel.—The experimental work with shrapnel has been along the same lines as the previous year, and has had for its object the development of a shrapnel possessing a maximum of strength to resist stresses due to the shock of the discharge, combined with minimum weight of case. A great increase in the strength of the case has been secured by requiring the case to be drawn hot and omitting the subsequent process of annealing. This leaves the case somewhat harder and increases the cost of machining, which is amply repaid with the increased efficiency of the shrapnel.

As a result of a series of tests, a steel head, somewhat smaller in diameter than the aluminum head heretofore used and lighter in weight, has been adopted for 3-inch shrapnel. This head is much stronger to resist a side blow on impact than when made of aluminum. The shape of the head is considerably improved by the use of steel, and it is much cheaper.

An instrument known as the fuze setter, for accurately and rapidly setting fuzes to the time desired, has been designed, manufactured, and issued to the service.

Preparation of high-explosive ammunition.—In connection with the preparation of high-explosive ammunition special attention has been given to the training of men in loading the explosive into the projectile and in filling and assembling the fuze thereto, for upon the thoroughness and care with which this work is performed depends the safety and efficiency of ammunition of this class. The Department is now prepared to supply this ammunition to the service in any reasonable quantity.

Department of sights and instruments for fire control.—This department has been engaged during the year, employing two shifts of eight hours each, in developing and manufacturing panoramic sights, battery commanders' telescopes, Weldon range finders, plotting boards, etc. Successful efforts have been particularly directed to attain the extreme accuracy in these instruments required by modern conditions and at the same time to have all parts of one instrument, especially the sights, interchangeable with corresponding parts of the other. This has been secured by the introduction of suitable gauges, reducing variations in dimensions, and by careful inspection.

Small-arms cartridge department.—The total number of cartridges manufactured during the year was 58,409,315. Successful efforts have been made to improve the powder for these cartridges. A more perfect granulation has been secured by increasing the pressure under

which the colloid is run from the presses. This has reduced the shrinkage in drying and enables the prescribed dimensions of the grain to be maintained with greater uniformity.

A cartridge using a jacketed bullet for the caliber .45 automatic pistol and caliber .45 revolver was designed and furnished for the test of type weapons of this class.

WATERVLIET ARSENAL.

This arsenal was commanded during the year by Lieut. Col. I. MacNutt, Ordnance Department, who is also a member of the Board for Testing Rifled Cannon. It is the Army Gun Factory and supplies a large percentage of the cannon of all calibers used in the military service, together with the spare parts, tools, etc. The value of all material under manufacture during the year was $1,559,970.07, of which material to the value of $850,679.74 was completed.

The electrical equipment described in the last annual report continues to give entire satisfaction, and has resulted in the increased output anticipated, amounting to from 25 to 50 per cent on the different machines. Six induction motors, aggregating 140 horsepower, have also been installed for group driving, and individual motors have been applied to several of the larger machines in addition to those on the gun lathes.

The lower shops have been equipped with motors for group drives, replacing the main belt and shaft drive from the water power in the form of electric current, which is now utilized in the gun shop at an annual saving of about $800.

The grounds and buildings have received more than the usual attention during the year. The roads have been repaired, sidewalks relaid, and new sidewalks built, largely by the labor of the enlisted men. Sections of the arsenal wall in bad repair have been rebuilt. The quarters of the enlisted men, the outbuildings, and the roofs of the lower shops have been repainted, and water mains in the vicinity of the lower shops needed for adequate fire protection have been laid.

Material improvements have also been made in the gun shop. The entire interior has been painted, greatly improving the lighting and the general appearance. Return pumps have been installed in the heating system, so that hot water formerly wasted is now returned to the boilers. The east wing, formerly used as a smith shop, has been converted into a comfortably arranged, well-lighted grinding room with exhaust for carrying off the dust. The two 30-ton cranes in the north wing, formerly driven by a square shaft, have been provided with modern trolleys and 5-ton auxiliary hoists for the rapid handling of light loads, more than doubling their efficiency.

The pattern room in the lower shop has been overhauled and enlarged, pattern racks have been built, and the patterns classified,

sorted, and catalogued, so that any particular pattern desired can be immediately reached.

The manufacture of 24 8-inch and 24 7-inch rifles for the Navy Department is well advanced. It is expected that all of the 8-inch guns will be completed about January 1, 1907, and the 7-inch guns a month or two later.

The work done at this arsenal during the year was considerably less than for the preceding year, with a reduction in the number of employees from 496 to 377.

The output during the year has been the equivalent of—

Four 12-inch mortars.
Three 10-inch rifles.
Eleven 8-inch rifles, Navy.
Eighteen 7-inch rifles, Navy.
Thirty 6-inch rapid-fire guns.
Eighty 5-inch rapid-fire guns.
One 3.8-inch field rifle.
Nine 3-inch rapid-fire guns.
Thirty 3-inch field guns.
One 2.38-inch field gun (experimental).

Appropriations are not sufficient to employ this fine plant, a considerable portion of which must therefore stand idle during the year.

WATERTOWN ARSENAL.

This arsenal has during the year been under the command of Maj. F. E. Hobbs, Ordnance Department, U. S. Army.

The manufactures include gun carriages for various calibers, parts for the modification and repair of carriages mounted at seacoast fortifications, implements, targets, maneuvering material, and steel castings or forgings of moderate size required in manufactures at other arsenals.

The following gun carriages have been completed during the fiscal year: Five 10-inch disappearing carriages, model of 1901; fourteen 6-inch disappearing carriages, model of 1903; three 6-inch barbette carriages, model of 1900; forty-two 75 mm. Vickers-Maxim mountain gun carriages; one 6-inch barbette carriage, model of 1900, remodeled; four 15-pounder Driggs-Seabury carriages, remodeled; one 10-inch disappearing carriage, model of 1896, repaired; and work is in progress on two 12-inch disappearing carriages, model of 1901; three 10-inch disappearing carriages, model of 1901; two 12-inch mortar carriages, model of 1896 MII; twenty 15-pounder barbette carriages, model of 1903; one 15-pounder Driggs-Seabury carriage, remodeled.

The other important items of manufacture during the year were 33 sets of parts for remodeling 12-inch disappearing carriages, model of 1897; 606 sets of brake attachments for ammunition trucks; 7

counterbalance devices for 12-inch disappearing carriages, model of 1901; 240 lanyard attachments for disappearing carriages; 29 sets of elevation disks and pointers for 12-inch disappearing carriages, models of 1897 and 1901; 60 buffer valves and sets of pipes for 6-inch disappearing carriages, model of 1903; 21 subcaliber loading platforms for disappearing carriage; 269 dummy projectiles; 214 dummy projectiles, modified; 933 cast-iron projectiles, capped; 2 steel racers for 12-inch mortar carriages, model of 1896, machined; 20 rocket guns for the Signal Corps; 20 heavy gun targets; 30 rapid-fire gun targets.

The total value of material under manufacture during the year was $1,272,362.84. The value of material completed was $690,122.85.

Machine and erecting shops.—A number of new machine tools have been installed in these shops during the year, and the efficiency of the shops has been further increased by the addition of electric cranes to replace those operated by hand power, the installation of a power elevator for the north wing of the machine shop, and by putting concrete foundations under several large machine tools in the south wing. The use of jigs and templets in machine operations is being extended as rapidly as practicable whenever the number of carriages or parts to be manufactured warrants the expense of preparing these accessories.

The needed replacement of machine tools which are worn out or of insufficient power can be partially accomplished under appropriations recently made. The crane system in the erecting shop needs to be improved to permit the economical manufacture of carriages for guns of 12-inch or higher caliber, and the crane way should be modified or replaced as early as practicable.

Smith shop.—This shop has been busily employed to its full capacity during the fiscal year and has produced some 240 tons of tested steel forgings of satisfactory physical qualities, in addition to a large amount of miscellaneous smith work. A large percentage of the forgings were made from steel ingots produced in the arsenal foundry, permitting prompt production and avoiding the delays incident to the purchase of billets from private steel makers.

The present forging capacity is limited, and the plant is not so conveniently arranged as is desirable. The weight of the largest forging made was 3 tons and the length of the longest about 18 feet. Such forgings tax the existing facilities to their utmost.

Plans and estimates have been prepared for improving and modernizing this shop and for increasing its facilities so as to permit the manufacture of forgings for cannon of small caliber as well as those required in carriage work.

Pattern shop.—The inadequate facilities for the manufacture of patterns have made it necessary to have a considerable number of

those needed during the year manufactured by private firms at increased cost and, in many cases, with vexatious delay in deliveries. The present conditions will be corrected within a few months by the appropriation made at the last session of Congress for modifying a part of the pattern storehouse for use as a pattern shop.

Foundry.—This shop has produced during the year about 2,000,000 pounds of steel, iron, and bronze castings. The quality of the product has been very good, the percentage of loss from all causes being exceedingly small. The capacity of the small plant for producing steel castings has been practically doubled, so far as the production of individual castings is concerned, by the successful prosecution of experiments permitting the metal melted in two blows of the converter to be utilized for a single casting, if desired.

The replacement of the wooden parts of the foundry building with fireproof material, which was referred to in my last annual report, is urgently needed to guard against the possibility of a disastrous fire, which might extend to other buildings. The present conditions are dangerous, though the system of fire protection is extensive. An estimate of cost of this work has been submitted.

Testing laboratory.—Very much of the work at the testing laboratory has been of a routine nature connected with current Department manufactures, tests for other departments of the Government, and private tests. Investigative tests for the Department have included a continuation of examination of the metal in a 17-ton steel ingot fluid comprest by the Harmet process, frictional resistance tests on 6-inch projectiles in the rifle bores of sections of tubes, using different grades of metal for the rotating band, and examination of the conditions with reference to initial strain in the 8-inch B. L. rifle No. 1, type, after the long-continued firing incident to its endurance tests at the Sandy Hook Proving Ground.

In the class of investigative tests on industrial materials, work has been chiefly directed to concrete, plain and reenforced, in continuation of the comprehensive series of tests planned some years ago; the general current interest attaching to concrete tests among manufacturers and practicing engineers of the country has made this series one of immediate value. The tests of concrete columns have been especially highly considered by the American Society for Testing Material. The results thus far obtained in this particular series may be summarized as clearly indicating that high ultimate strength may be reached by each of the three current methods of practice—that is, by the use of rich mortars or concretes, by means of sufficient longitudinal reenforcement, and by means of adequate hooping or other external lateral support. Rigidity of the columns will be attained by the use of rich cement mixtures or by means of longitudinal steel bars. The rigidity of the mortar or concrete itself

is effected practically only by the use of rich cement mixtures. Economy of cost, to attain compressive strength, will be promoted generally, within limits, by the plentiful use of cement.

Endurance tests of steel under repeated alternate stresses have been continued from former years. In tests of this class there is no display of ductility, all grades of metal behaving alike in the ultimate rupture of the steel without development of appreciable elongation or contraction of area.

An increase in the appropriation for the testing laboratory is recommended, to permit the machines to be operated more nearly to their capacity, that a greater amount of investigative work may be performed, having for its object the solution of important questions pertaining to the use of construction materials, for which there is great demand both from individual engineers and technical societies. The testing facilities of the laboratory are well adapted to this purpose, but to carry on such tests additional funds are needed for personnel and for the required test material.

Under authority of the act of Congress approved April 28, 1904, there has been granted to the Commonwealth of Massachusetts, through its board of Metropolitan park commissioners, a right of way through the arsenal reservation, along the southerly boundary adjacent to the Charles River, for public use as a park and park drive in continuation of other parks and drives being laid out and constructed along that river by the Commonwealth of Massachusetts. The park commission expects to commence grading operations at an early date and will remove the existing gas plant. In anticipation thereof, and with funds provided by Congress therefor, an electric-light system has been installed for the arsenal grounds and all the buildings.

Northern armament district.—The commanding officer of this arsenal is the armament officer of the northern armament district and is charged with maintaining in an efficient condition the seacoast armament from Maine to the eastern entrance of Long Island Sound. The necessary inspections of the armament and the repair or modification work required in this connection have been well conducted during the year, and the armament is maintained in very satisfactory service condition.

NEW YORK ARSENAL.

This arsenal was commanded during the year by Col. John E. Greer, Ordnance Department, U. S. Army, who is also chief ordnance officer, Department of the East, armament officer of the central armament district, and performs inspection duties.

The arsenal being mainly a purchasing and shipping agency without facilities for manufacturing, its operations are necessarily those of purchasing, receiving, and issuing stores to the Army and militia; it also received through the custom-house such stores as are purchased abroad.

Its other operations are necessarily confined to the care and preservation of the public buildings and the property stored therein, except that all work incident to the office of the chief ordnance officer, Department of the East, the armament officer of the central armament district, and the inspector of ordnance is attended to by the arsenal employees.

Stores purchased, received for the Army et al., were contained in 9,819 packages, weighing 1,047,312 pounds, and were inspected, examined, and stored. Stores issued to the Army et al., packed and delivered to the depot quartermaster, were contained in 10,284 packages weighing 1,473,883 pounds.

All buildings, walks, roads, drains, and gutters have been kept in repair and the grounds cared for and improved.

This arsenal is regarded as of great importance to the Ordnance Department as a purchasing and shipping agency and place of temporary storage of ordnance stores, but its principal value is as a depot for arming and equipping troops, especially of a military expedition in time of war.

AUGUSTA ARSENAL.

This arsenal was commanded throughout the year by Lieut. Col. David A. Lyle, Ordnance Department, who is also a member of the board on life-saving apparatus under the Secretary of the Treasury, chief ordnance officer, Department of the Gulf, and armament officer of the southern armament district. Since March 20, 1906, this officer has been absent on leave of absence on surgeon's certificate of disability; and during this period and the previous absences of Lieutenant-Colonel Lyle on duty the arsenal was commanded and the duties of armament officer and chief ordnance officer were performed by Maj. J. W. Joyes, Ordnance Department. The latter officer reported for duty as assistant at this arsenal December 2, 1905.

This arsenal is a depot for supplying ordnance and ordnance stores to the Department of the Gulf and to the National Guard and educational institutions in the South Atlantic and Gulf States. It embraces also the office of the chief ordnance officer of the Department of the Gulf and that of the armament officer of the southern armament district and has a small machine shop and foundry engaged upon work incident to alterations and repairs of the seacoast armament in that district.

During the past fiscal year manufactures aggregating in value $3,085.20 have been in progress in these shops and manufactured articles to the value of $2,727.20 completed. In addition, these shops have worked in conjunction with the resident and other machinists in the armament district upon numerous repair and alteration orders.

One set of officers' quarters unoccupied for over fifteen years has been completely renovated, new sanitary water-closets provided for shops, barracks, and enlisted men's cottages, a 12-station intercommunicating telephone system purchased and partly installed, and the usual work of preservation and repair of buildings, grounds, fences, etc., attended to.

The sanitary condition of the post is all that could be asked, except the method of disposing of sewage from the enlisted men's cottages, the new water-closets for which can not be installed until a more plentiful water supply is obtained.

The water supply is expected to be made satisfactory for purposes of normal use and fire protection during the following fiscal year, as a very reasonable proposition has been approved by the city of Augusta for ample supply.

Complete plans and specifications for the proposed installation of the new machinery provided for by the appropriation of $50,000 made in 1904 have been prepared and submitted. They contemplate a plant ample in range and capacity for all demands for repairs and alterations of armament in the southern district and of equipments in the Department of the Gulf, and for a considerable quantity of useful manufactures.

The extent of the business of the arsenal is indicated by the number of money vouchers, 350; of property issues, 487; and of property receipts, 197; requisitions from troops, 424.

BENICIA ARSENAL.

This arsenal was commanded during the year by Maj. J. W. Benét, Ordnance Department, who is also chief ordnance officer, Department of California, and armament officer of the western armament district.

The manufactures have consisted of target material for seacoast forts, field batteries, and small-arms target practice, parts of guns and carriages to replace parts broken or of obsolete design in the western armament district, and cast-iron caps for cast-iron projectiles. A large number of seacoast projectiles are being tapped for fuze plugs and grooved for base covers.

All of the service cast-iron projectiles for seacoast guns at Benicia Arsenal were capped, and tools were manufactured and issued for capping such projectiles at the seacoast forts in the western armament district.

Cartridges for target practice and saluting purposes were manufactured and issued for the field and seacoast guns on the Pacific coast.

Six hundred and seventy-five thousand pounds of brown prismatic powder for various calibers of navy guns were transferred to

Benicia Arsenal from Mare Island Navy-Yard and afterwards repacked.

The following arms were cleaned and repaired: Six hundred and forty-four rifles, caliber .30, model of 1898; 150 rifles, caliber .30, model of 1898, for U. S. Marine Corps, and 445 carbines, caliber .30, model of 1899.

The facilities of the establishment for doing machine work and for handling stores have been somewhat increased and improved during the year.

The damage done by the earthquake of April 18, 1906, was repaired at a cost of about $1,800. The arsenal buildings were not severely injured, but most of the chimneys had to be replaced, and repairs to roofs and plastering were necessary.

The following represents the volume of work during the year: Expenditures, $75,972.28; total weight of stores issued on quartermaster's bills of lading, 1,762,518 pounds; total weight of stores received on quartermaster's bill of lading, 1,881,589 pounds; number of separate issues, 1,506; number of separate receipts, 603; number of requisitions received, 675.

UNITED STATES POWDER DEPOT.

This depot has been commanded during the year by Maj. (now Lieut. Col.) O. B. Mitcham, Ordnance Department, who also performed inspection duty during the same period.

It is used for the storage, preparation, and issue of powder and high explosive material, as well as of ammunition for field, siege, and seacoast guns. The position of the depot, 5 miles from Dover, N. J., renders it admirably fitted for the purpose for which it was originally intended. The buildings referred to in the last annual report, as for the enlargement of the depot and under contract for construction, have been turned over by the contractors. Their completion was greatly delayed beyond contract time. An appropriation of $20,000 for part of the necessary machinery for the new shops has been made in the sundry civil bill for the current fiscal year. The purchases will be made as early as practicable and the machinery put in place.

Appropriations have been made for a steel standpipe for an increase of the water supply and for the purchase and installation of pipes, hydrants, etc., for increased fire protection. Both will, no doubt, be fully installed during the present year.

The rock-crushing plant, in addition to furnishing stone for macadamizing roads and for railroad ballast, delivered to the contractors for buildings nearly 6,000 tons of broken stone for concrete work.

The construction of the railroad for the post has been carried on during the past year, and large quantities of material, such as rails,

fish plates, spikes, etc., have been purchased. It is hoped that with the funds available for the present fiscal year the track will be nearly completed.

On June 30, 1906, the number of employees was 65. The total disbursements for the fiscal year 1905–6 were $204,687.99. The number of receipts and issues of stores during the year were 708, involving the handling in and out of 24,542,637 pounds of freight.

MANILA ORDNANCE DEPOT.

The depot was commanded during the year by Maj. E. B. Babbitt, Ordnance Department, who is also chief ordnance officer of the Philippines Division. His assistant during the year was Capt. D. M. King, Ordnance Department, U. S. Army. Capt. John R. Proctor, Artillery Corps, was on temporary duty at the depot from April 28 to May 19, 1906.

The general character of the work done at the Manila Ordnance Depot is in manufacturing, repairing, and in supplying stores to troops.

Office building.—The office building, to which reference was made in my last report, has been completed. It is a substantial two-story building of reenforced concrete 2 feet thick. The building was erected by day labor and with the superintendence of the depot foreman, the bids for its erection by contract having been rejected as too high. The old office rooms, which are in the quadrangle containing the shops, will be used for shop purposes, new and large machinery being necessary in connection with the armament of the seacoast fortifications now building.

Enlisted men's barracks.—New galvanized-iron roof and new roof trusses have been placed over the enlisted men's barracks. The timbers of the old roof were so badly eaten by white ants as to render the building unsafe.

Storehouse.—Storehouse No. 11 was removed from Plaza de Moriones to the north side of the reservation where casemates 1 to 6 formerly were located.

Moat.—The moat next to Fort Santiago has been cleared, and the level raised above tide water.

Roads.—A road has been built in the rear of the carpenter shop to permit hauling to the lumber shed and to No. 11 storehouse without going through the shop area.

Trees.—About 50 young trees have been set out around the depot grounds.

Repairs for the constabulary.—During the year arrangements were made for repairing ordnance material belonging to the constabulary, and for supplying them from the depot.

WORK AT THE DEPOT.

Harness shop.—In the harness shop the work done consisted principally in the manufacture of leggings, revolver holsters, saddlecloths, waist belts, etc., for sales to officers. Re-covering saddles, and canteens, repairing unserviceable leather equipments turned in by troops serving throughout the division, and repairing personal equipments of officers as authorized by Army Regulations.

Tin shop.—In the tin shop, the principal work consisted of retinning canteens, meat cans, tin cups, and spoons. Manufacturing and repairing tin and zinc cases for repacking ammunition, etc.

Armory.—In the armory the usual number of workmen were employed in overhauling, cleaning, repairing, and rebluing small arms and other metal equipments, such as United States magazine rifles, and carbines, caliber .30, Springfield carbines, caliber .45, revolvers, and pistols of various makes, saber and bayonet scabbards, and in overhauling sabers, bayonets, etc.

Machine, blacksmith, and paint shops.—In these shops the work consisted mainly in overhauling, repairing, painting, and preserving the various types of artillery and machine guns, with their carriages, accessories, and spare parts.

Carpenter shop.—In addition to the usual work of manufacturing packing boxes, cutting and dressing lumber for the construction and repair of depot buildings, repairing arm chests and parts of gun carriages, limbers, caissons, etc., about 800 arm racks were altered and overhauled for use with the United States magazine rifle, model of 1903.

Foundry.—The foundry was closed for the greater part of the fiscal year, as the work in this department is limited and of small importance.

Plating plant.—In the plating plant 1,584 curb bits, turned in by troops in an unserviceable condition, were cleaned and nickel plated during the fiscal year. The nickel-plating plant was operated in connection with the machine shop and is under the superintendence of the foreman of the latter.

Employees.—The clerical force of the depot and office of the chief ordnance officer of the division is the same as stated in the last annual report, excepting that one of the clerical positions at a salary of $1,320 has been abolished. During the month of June there were only 8 American clerks and 1 native clerk actually on duty at the depot. Four of the clerks returned to the United States during the fiscal year.

Issues and receipts of stores.—All the troops serving in the Philippines are supplied with ordnance and ordnance stores from the depot, either directly or indirectly. The character and extent of this

business will be appreciated from the fact that the total number of issues made during the year amount to 1,492, involving a total weight of stores of 831 gross tons. The number of vouchers for stores received was 876; 1,469 requisitions for ordnance and ordnance stores were received from troops in the division.

Sales.—The total sales made at the depot during the fiscal year amounted to $15,187.53.

Returns examined.—One thousand two hundred and seventy-two returns of ordnance and ordnance stores were received from troops serving in the division, given a preliminary examination, and forwarded to this office for settlement. The errors found in such returns are reported to the accountable officer by letter from the Manila depot before the returns are sent to Washington.

The letters received during the fiscal year aggregated 11,740, and the letters sent 10,243. The vouchers for cash sales numbered 1,621 and for disbursements 371.

Fiscal affairs.—The expenditures made at the Manila Ordnance Depot during the year amounted to about $70,000.

THE ORDNANCE BOARD.

Membership of the Ordnance Board June 30, 1906:

Col. Charles S. Smith, Ordnance Department, U. S. Army; Lieut. Col. William L. Marshall, Corps of Engineers, U. S. Army; Maj. Rogers Birnie, Ordnance Department, U. S. Army; Maj. George L. Anderson, Artillery Corps, U. S. Army; Maj. Beverly W. Dunn, Ordnance Department, U. S. Army.

The following is a list of the principal subjects reported upon from July 1, 1905, to June 30, 1906:

Reference No.	Subject.	Date of report.
	GUNS.	
22396	McClean 1-pounder automatic gun, improved, Mark II	Oct. 20, 1905.
38522	6-pounder semiautomatic guns and mounts; Benét-Hotchkiss (U. S. Ordnance Co.), Driggs-Seabury Ordnance Corporation, U. S. Rapid Fire Gun and Power Co., American and British Manufacturing Co.	Sept. 29 and 30, 1905.
32545	6-pounder gun ruptured at muzzle	Apr. 18, 1906.
4044	3-inch nickel-steel gun tube	Mar. 14, 1906.
38603	15-pounder semiautomatic gun and mount, M. 1903	Indorsements: Aug. 22, 1905; Oct. 11, 1905.
38157	Vickers-Maxim 75 mm. mountain gun, converted to 3-inch caliber.	Nov. 6, 1905.
38499	2.38-inch field gun, carriage and limber, M. 1905	Indorsement: Apr. 11, 1906.
38480	3.8-inch field gun, carriage and limber, M. 1904	June 7, 1906.
38539	4.7-inch siege gun and carriage, M. 1904	Apr. 14, 1906.
3710, 38153	6-inch wire-wound guns: Brown Wire Gun Co., Crozier gun.	Feb. 3, 1906. Dec. 7, 1905.
37631	10-inch B. L. rifle, M. 1900	Indorsement: Oct. 5, 1905.
38292	10-inch B. L. rifle, lining tube	Apr. 27, 1906.
11381	Gas check pads, five 12-inch	Indorsement: Sept. 14, 1905.
37999	Gas check pads, U. S. Ord. Co	Feb. 23, 1906.
3032, 11381, 37631	Gas check pads, experimental; Nonfluid oil; Gerdom; Sy-George; asbestos wire cloth covering.	Apr. 24, 1906.
11381	Firing mechanism and safety lanyard for guns on disappearing carriages.	Dec. 20, 1905.
11381	Contact clip for Horney firing mechanism, M. 1903	Jan. 16, 1906.

Reference No.	Subject.	Date of report.
	GUNS—continued.	
35396	Heavier guns than 12-inch in seacoast fortifications	Nov. 22, 1905; indorsement, Dec. 8, 1905.
38961	Qualities of steel for gun tubes, to diminish erosion	Jan. 26, 1906.
34348A	Removal of copper deposit from bore of guns	Indorsement: Sept. 30, 1905.
	CARRIAGES.	
37489	10-inch D. C. L. F., No. 1, M. 1901	Dec. 22, 1905.
35062	6-inch barbette carriage, M. 1900, No. 32, Builders Iron Foundry.	Feb. 17, 1906.
37514	5-inch barbette carriage, M. 1903, No. 1	Oct. 7, 1905.
35524	Effect of jolting 3-inch field limber and caisson filled with ammunition.	Mar. 3, 1906.
25537	.30 caliber wheeled mount, M. 1905, No. 1, for Vickers-Maxim automatic machine gun.	Apr. 5, 1906.
23565F	Flexible armored conduit of firing circuit on 6-inch D. C., M. 1903.	Oct. 4, 1905.
37791	Safety plastic metallic packing in cylinders of 10-inch D. Cs.	Indorsement: Dec. 26, 1905.
38303	Modified shot truck for 12-inch B. L. M. carriage, M. 1896	June 8, 1906.
	FUZES.	
38788	Fuzes for 6-pounder and 15-pounder shell against torpedo-boat plate.	Indorsement: Aug. 16, 1905.
30024–BBB	Medium-caliber detonating fuzes	Indorsement: Oct. 27, 1905.
17586	Detonating fuzes, medium and large caliber	Indorsement: Oct. 18, 1905.
23100	Medium-caliber field detonating fuzes, picric-acid reenforce, etc., at high temperatures.	Indorsement: Nov. 22, 1905.
30024–BBB	Minor-caliber detonating fuzes	June 2, 1906.
38505	Watson base-percussion fuzes in 3-inch C. I. shell	Indorsement: Mar. 1, 1906.
35543	Comparative trials of delay and nondelay detonating fuzes in capped A. P. projectiles.	July 20, 1905.
	POWDER.	
38792	Lucciani powder for 3-inch field gun	Indorsement: Apr. 18, 1906.
25284	Int. smokeless powder, 6-inch, tested in 6-inch rapid-fire gun, M. 1897.	Indorsements: Mar. 16, 1906; Apr. 2, 1906.
38917	Stabilite, a quick-drying smokeless powder offered by Du Pont Co.	June 4, 1906.
25284	Granulation tests of smokeless powder	Indorsement: Sept. 14, 1905.
26870	Proposition to reblend charges of smokeless powder at the powder depot.	Indorsement: July 8, 1905.
6667	Krupp smokeless-powder cloth as an igniter	Indorsement: Sept. 12, 1905.
25284	Krupp powder cloth for powder bags	Indorsement: Aug. 3, 1905.
22653	Absorption of moisture by powder in storage cases	Indorsement: Nov. 20, 1905.
28070	Accidental discharge of saluting charge in 5-inch siege gun at Fort Jay.	Sept. 15, 1905.
23100	Ammonal, high explosive for shell charges	Indorsement: Sept. 19, 1905.
38861	La Motte explosive	Indorsement: Oct. 26, 1905.
28070	Cartridge bags rendered noninflammable by chemical treatment.	Sept. 15, 1905.
	PROJECTILES.	
32366	Isham shell	Oct. 21, 1905; indorsement: Aug. 22, 1905.
24171	Ammunition for 5-inch siege gun	Nov. 20, 1905; indorsement: Aug. 23, 1905.
38921	Method of assembling bands on projectiles, continuous ring.	Indorsements: Dec. 19, 1905; May 9, 26, 1906.
37514	Experimental bands for 6-inch projectiles	Indorsements: Aug. 11, 1905; Oct. 13, 1905.
31627	Modified form of rotating band for 12-inch projectiles	Feb. 16, 1906.
30024 BBB	Tools for loading projectiles with explosive D by hand	Indorsement: Dec. 18, 1905.
4044	Effect of exploding steel shell charged with high explosive in 3-inch nickel-steel tube.	Mar. 14, 1906.
	RANGE FIRING.	
38195	12-inch mortar subcaliber tube, division of field into zones, etc.	Apr. 17, 1906.
37438	Determination of zones and ballistic data for 1,046 and 824 pound capped shell in 12-inch mortar, M. 1886.	Sept. 20, 1905.
26215	Effect on velocity, pressure, and range of projectile resting on powder charge instead of properly seated, 12-inch B. L. mortar.	Indorsement: July 21, 1905.
	SIGHTS.	
29328	Warner & Swasey 8-foot horizontal base range finder and 6-foot Warner & Swasey range finder, also Aubry telemeter for field service.	Feb. 2, 1906.

Reference No.	Subject.	Date of report.
	SIGHTS—continued.	
38545	Warner & Swasey panoramic sight for 3-inch field carriage	Aug. 19, 1905.
36020	Davis automatic sight on 6-inch D. C., M. 1898	Indorsements: Aug. 28, 1905; Sept. 25, 1905; Jan. 27, 1906.
36020	Clarke automatic sight on 4.72-inch Armstrong rapid-fire gun.	Sept. 2, 1905.
4513	Scott automatic sight for 12-inch D. C	Aug. 25, 1905.
36020	Flemming automatic sight	Indorsement: Sept. 27, 1905.
38545	Goerz panoramic sight for 3-inch field guns	Oct. 11, 1905.
38545	Goerz reflecting telescope sight (periscope) on 12-inch D. C., M. 1901.	May 4, 1906.
37664	Panoramic rear sight for 3-inch field material, M. 1902, modified with strengthened bracket support.	Aug. 23, 1905.
37848	Eye cap for 3-inch telescopic sights	Indorsement: Sept. 27, 1905.
	MISCELLANEOUS.	
30160	Firing dynamo for 12-inch B. L. mortars	Mar. 16, 1906.
31138	Magneto firing box for seacoast guns	July 7, 1905; Apr. 30, 1906.
23850	Semple day tracer for projectiles	Indorsement: Sept. 28, 1905.
23565E	Lamp holders for breech of guns	Jan. 29, 1906.
36292	Lobner time interval recorder	Indorsement: Jan. 19, 1906.
24085	Lanyard clip to prevent premature firing 12-inch mortars.	Indorsement: Nov. 25, 1905; Jan. 18, 1906; Apr. 7, 1906.
26207 23667 24085	Premature firing of mortars at target practice	Indorsements: July 19, 1905; Sept. 20, 1905.

The following papers are submitted as appendices to the report:

Appendix I.—Erosion of high-power guns. (17 plates.)

Appendix II.—The limit of the accuracy life of the musket.

Very respectfully,

WILLIAM CROZIER,
Brigadier-General, Chief of Ordnance.

The SECRETARY OF WAR.

APPENDIX I.

EROSION OF HIGH-POWER GUNS.

Prepared by Maj. C. B. WHEELER, Ordnance Department, U. S. Army.

(17 plates.)

In recent times the efforts of artillerists to increase the power of guns have been chiefly confined to an increase in the muzzle velocity of existing calibers. Such increase in power was made possible by improved methods of construction and the use of higher grades of steel forgings, but was largely affected by the adoption of smokeless powders. As the manufacture of these powders progressed and the knowledge of their possibilities increased, powder charges were enlarged and guns were increased in length in order that projectiles might be subjected longer to the influence of the powder pressures, which are better sustained than was the case with those of the older powders. These increases in the power of guns of our seacoast service are well illustrated by Plate I, in which it will be noted that the power at the muzzle of the latest 12-inch guns, for example, is 1.75 times that of the model of a few years ago. The increase in power shown by curve No. 2 over that represented by curve No. 1 resulted entirely from the adoption of smokeless powder; the power indicated by curve No. 3 resulted from adapting guns to the better utilization of smokeless powders. These increases in the power of existing calibers have, for the moment at least, been checked by the resulting greater erosion of the bore, beginning at the origin of motion of the projectile and continuing forward for some distance from it. In cases where nitrocellulose powders have been used, the wearing away is unaccompanied by the deep gutterings and pitted surfaces characteristic of brown powder erosion; but there appears to be, especially in large guns, a tendency to gutter in the bottom of the grooves on the side away from the bearing surfaces of the lands.

The extent of this erosion and the consequent damage to the gun has caused an investigation of the advisability of increasing the life of guns already constructed by using them at a lower power than that permitted by their strength, and in the future of maintaining the advantage of guns over armor by constructing them of larger calibers, especially when required for given work.

The extent and character of this erosion is well illustrated by Plates II, III, IV, and V, referring to 6-inch, 10-inch, and 12-inch guns.

EROSION OF 6-INCH RIFLES.

In Plate II there have been plotted the increases in diameter of lands as a function of the travel of projectile in calibers. The character of the wear of the bores as shown by these curves is similar to that

of all guns. This erosion is, as stated before, great in the neighborhood of the seat of the projectile, decreasing toward the central part of the bore and then increasing or tending to increase toward the muzzle. Of the three guns which are of about the same power, it will be seen that 6-inch gun No. 17 is the least worn; it consumed the greatest amount of powder, also used the least number of charges of nitroglycerin powder. The Bofors gun is very much less worn than that of the Vickers-Maxim Company, although it consumed more powder and sustained a considerably greater number of excessive pressures.

The greater enlargement of the Vickers-Maxim gun, assuming that it is not deficient in tangential resistance, is apparently due to the heavier charges of powder with higher muzzle velocities combining to wear from heat and friction, and to the character of the twist of the rifling. Attention is invited to the following tables for more detailed information in regard to these guns:

TABLE I.

Gun.	Length of bore.	Chamber capacity.	Weight of charge.	Muzzle velocity.	Pressure per square inch.
	Calibers.	*Cub. in.*	*Pounds.*	*Ft. sec.*	*Pounds.*
U. S. model of 1897	45	1,278	28	2,600	37,000
Bofors	49	1,220	25	2,658	34,000
Vickers-Maxim	45	1,731.5	35	2,775	35,000

Gun.	Number of lands and grooves.	Depth of grooves.	Width of lands.	Width of grooves.	Twist of rifling.
		Inches.	*Inches.*	*Inches.*	
U. S. model of 1897	36	0.04	0.15	0.3736	Increasing 1 in 50 to 1 in 25 calibers.
Bofors	44	.037	.137	.290	Increasing 1 in 70 to 1 in 30 calibers.
Vickers-Maxim	24	.05	.20	.60	Straight for 7+ calibers; thence increasing.

TABLE II.

Gun.	Number of rounds.	Powder consumed.	Average per round.	Excessive pressures per square inch.		
				40,000 to 50,000.	Over 50,000.	Highest.
		Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
6-inch No. 17	351	9,385	26.74	13	1	62,680
Bofors	374	8,966	23.97	51	[a] 9	[b] 51,500 / [c] 68,500
Vickers-Maxim	211	7,014	33.24	23	1	50,930

[a] Six with black powder. [b] Smokeless powder. [c] Black powder.

An apparent advantage of the method of rifling in the Vickers-Maxim gun exists when its erosion is compared with that of guns with rifling having a twist at the origin. This is shown in the preservation of the height of the lands near the origin by reason of the more pronounced wear or erosion in the grooves in the straight portion (the erosion of the grooves is not shown in the diagram). The erosion of this gun, as compared with that observed in the other guns, suggests that the twist of rifling affords protection to the grooves and that the wear is proportionately greater on the top surfaces of the lands where twist of rifling is present. The results indicate that the actual wear

is greater both on lands and grooves with straight grooves at the origin, producing more rapid enlargement of the bore, with consequent lack of obturation in seating the projectile. This, combined with the character of twist, causes inaccuracy of flight or tumbling of the projectile with standard band to occur with a less number of rounds than in guns rifled with a twist that begins at the origin; an increase in the dimensions of the rotating band to preserve stability in flight will therefore be required with this gun at an earlier period.

Nitroglycerin powder was used in 17 of the first 80 rounds in gun No. 17; in 148 of the first 230 in the Bofors gun, and chiefly in the first 160 rounds in the Vickers-Maxim gun, so that the two latter are about equal in this respect.

The erosion or increase in the diameters of the lands and grooves of the Crozier and Brown 6-inch wire guns is shown in Plate III. These guns are of very great power, having been designed to give a muzzle velocity of about 3,300 feet per second, requiring a charge of about 72 pounds of nitrocellulose smokeless powder. The working maximum pressure is about 42,500 pounds per square inch. Lack of stability in the flight of the projectiles was first observed in each gun at about round 45. In comparing the wear of the lands of the two guns, the large contraction of the bore, as shown by the contraction of the bottoms of the grooves of the Brown gun, should be taken into consideration. This plate has been inserted for comparison with Plate II.

EROSION OF 10-INCH RIFLES.

The data pertaining to the erosion of guns of this caliber are confined to the results of firings made from the 10-inch type and the 10-inch wire-wound gun (Crozier design).

The following table gives the characteristics of these guns:

TABLE III.

Gun.	Weight.	Projectile.	Charge.	Pressure per square inch.	Velocity.	Muzzle energy.
	Tons.	*Pounds.*	*Pounds.*	*Pounds.*	*Feet per sec.*	*Foot-tons.*
Service	30	575	250	37,000	1,975	15,550
Crozier	30	575	267	42,000	2,100	17,560

Gun.	Rounds fired.		Mean charge.		Mean pressure per square inch.	Maximum pressure per square inch.
	Brown powder.	Smokeless powder.	Brown powder.	Smokeless powder.		
	Number.	*Number.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
Service	286	6	220	115	32,800	61,000
Crozier	275	.....	267	.....	40,800	46,000

Gun.	Enlargement along middle length of chamber.	Number of lands and grooves.	Depth of grooves.	Width of lands.	Width of grooves.	Twist of rifling.
	Inch.		*Inch.*	*Inch.*	*Inch.*	
Service	[a] 0.003–0.005	60	0.06	0.15	0.3736	Increasing 1 in 50 to 1 in 25 calibers.
Crozier	.007– .015	60	.06	.15	.3736	Do.

[a] After 244 rounds.

It will be observed that the curves showing enlargement of the bore of these two guns are similar, the wear included between points 12 and 20 calibers from the beginning of the rifling being less than that before and after these points.

The 10-inch type gun was fired 292 rounds, of which all but 6 were with brown prismatic powder. Of the total number of rounds fired, 244 gave pressures above 35,000 pounds per square inch, the maximum pressure being 62,600 pounds per square inch.

The erosion of the tube at and for some distance in front of the seat of the projectile is so great as to destroy the accuracy of fire, and for this reason the gun is considered unserviceable. Up to about the two hundredth round the accuracy of the piece was not materially affected by this erosion. Soon after this, however, it was found that the projectile with service band did not take the rifling well enough to insure accurate flight, and at the two hundred and eighteenth round a rotating band of the same form as the service band, but with a diameter greater by 0.1 inch, was used. The accuracy of fire was thus restored and the gun again rendered serviceable until the two hundred and fiftieth round, when a further increase in the diameter of the band was necessary. At the two hundred and eighty-eighth round the advantage of this further increase disappeared.

The Crozier wire-wound gun was fired 275 rounds, of which 231 rounds gave pressures between 40,000 and 45,000 pounds per square inch. The greater erosion of this gun is believed to have resulted from the larger charges and the higher pressures used in the test.

EROSION OF 12-INCH RIFLES.

The following table gives the characteristics of the guns shown in the diagram, which is confined to the results of the test of the following: 12-inch type gun; 12-inch gun, No. 40, model of 1895, and 12-inch gun, No. 2, model of 1900:

TABLE IV.

Gun.	Weight.	Length of bore.	Capacity of powder chamber.	Number of lands and grooves.	Width of grooves.	Depth of grooves.
	Pounds.	*Calibers.*	*Cub. in.*		*Inch.*	*Inch.*
12-inch type gun	111,504.6	35	12,113.5	72	0.3736	0.06
12-inch, No. 40, model of 1895	115,000.0	35	12,183.0	72	.3736	.06
12-inch, No. 2, model of 1900	132,380.0	40	17,183.0	72	.3736	.06

Gun.	Width of lands.	Twist of rifling.	Weight of powder charge.[a]	Maximum pressure per square inch.	Weight of projectile.	Muzzle velocity.
	Inch.		*Pounds.*	*Pounds.*	*Pounds.*	*Ft. sec.*
12-inch type gun	0.15	1 turn in 50 to 1 turn in 25 calibers.	435	38,000	1,000	1,950
12-inch, No. 40, model of 1895	.15	.....do.....	275	38,000	1,048	2,250
12-inch, No. 2, model of 1900	.15	.....do.....	375	38,000	1,048	2,550

[a] Smokeless powder charges.

The record of the 12-inch type gun includes round 220, in all of which brown prismatic powder was used. Of these rounds 135 gave pressures above 35,000 pounds per square inch. The erosion of this gun has proceeded so far as to affect the accuracy of fire. The effect of this erosive action was not material until after the one hundred and eighty-fifth round, at which time it was noticed that the travel of the projectile in the bore had decreased and that the service bands did not take the rifling satisfactorily. At the one hundred and ninetieth round the diameter of the band was increased 0.1 inch, with marked increase in the accuracy.

Twelve-inch rifle, model of 1895, No. 40, has been fired 300 rounds, of which approximately 106 gave pressures greater than 35,000 pounds per square inch. In all of the firings with this gun nitrocellulose smokeless powder was used, excepting an occasional round of brown prismatic powder. The lands are nearly obliterated. The number of rounds fired in this gun before inaccuracy was first discovered is not known.

The use of an enlarged band was begun in this rifle with round No. 290, and 6 rounds were fired with good results, but after this the tumbling of the projectile in flight became so pronounced that firings were suspended with round 300.

The Ordnance Board reported that it can not be expected to secure rotation of the projectile by any further enlargement of the band, or to restore the gun by rerifling the bore in part, as had been previously proposed. It was noted that the wearing away of the rifling in the rear portion of the bore was very rapid in the latter firings with enlarged band, and that it was also accompanied by pronounced scoring of the surface.

The Board was unable to determine whether or not the excessive wear in the last 12 rounds should be attributed most to the extra forcing of the enlarged band or to the disintegrated condition of the bearing surface, which might have induced nearly the same effect if the service band had been continued in use.

The erosion in 12-inch gun, model of 1900, No. 2, after 48 rounds is very great, and is considered to be due almost entirely to the higher power of this gun. The propelling charges used were exclusively of nitrocellulose smokeless powder.

The direct and immediate effect of this erosion, when it has proceeded far enough, is the tumbling of the projectile in flight, due to lack of rotation, and this tendency to tumble increases with the power of the gun. The lack of rotation results from the shearing of the lands of the rotating bands on the projectiles, upon the bearing surfaces of which the pressures per unit of area are very great, even in unworn guns of medium power; so when the rifling near the seat of the projectile is worn away the velocity acquired by the projectile before reaching contact with effective rifling is such as to cause the bands to be overpowered. In this connection it may be remarked that the practice of making forcing cones in guns by tapering the lands only, and thereby decreasing the amount of bearing surface for rotation, may be considered as in effect decreasing the life of guns by an amount depending upon the metal so removed in manufacture, and it is thought it would be wise to consider a discontinuance of this method.

The following table shows the approximate pressures per square inch upon the lands of rotating band, required to give rotation to projectiles in the guns mentioned therein:

TABLE V.

Gun.	Muzzle velocity per second.	Maximum powder pressure per square inch.	Pressure per square inch on land of rotating band.
	Feet.	*Pounds.*	*Pounds.*
6-inch, model of 1897 MI	2,600	38,000	58,000
6-inch, model of 1900	3,000	38,000	71,000
6-inch	[a] 3,300	[a] 42,500	[a] [b] 86,000
	[a] 3,600	.....	[a] 105,500
10-inch, model of 1888	2,250	38,000	48,800
10-inch, model of 1900	2,550	38,000	52,700
12-inch, model of 1888	2,250	38,000	48,000
12-inch, model of 1900	2,550	38,000	51,500

[a] Theoretical.

[b] Represents probable pressures on lands of rotating bands of projectiles in 6-inch wire guns now undergoing test.

NOTE.—The rifling in all of the above guns increases from 1 turn in 50 to 1 turn in 25 calibers at or near the muzzle.

Attention is invited to the increase of pressure on the driving surfaces of bands due to increases in muzzle velocities, especially in the cases of the 6-inch guns. These pressures on the driving surfaces can be reduced, and it is probable the life of guns can be increased by reducing the widths of the rifling grooves and increasing the number of lands and grooves. This is made possible by the fact that while the driving pressures are great the shearing strains on the lands of the bands, owing to the width of the latter, are very small. The ability of the rotating bands to withstand the pressures indicated is due probably to the very limited period during which the forces act.

Plate VI is indicative of the comparative theoretical pressures on the lands of a 6-inch gun to give rotation to the projectile when different forms of rifling curves are used.

In this case the maximum pressure on the base of the projectile is assumed to be 47,000 pounds per square inch and its muzzle velocity 3,300 feet per second. About five-thirteenths of the time the projectile is in the bore is spent on the forcing slope, which is the part most affected by erosion.

At the present time sufficient experience has not been had to justify an exact statement as to the limit of the number of rounds that can be fired from seacoast guns, of 6-inch, 8-inch, 10-inch, and 12-inch calibers before their replacement will be necessary because of the lack of accuracy caused by erosion, but Plate VII indicates what is believed to be a conservative estimate of such limit.

If the muzzle velocities of the above guns of 8-inch and higher calibers were decreased to 2,150 feet per second, their probable life would be extended, as shown by Plate VIII, which has been made to include the 16-inch gun.

The probable effect on the life of a gun, of increasing the muzzle velocity, is shown for the 6-inch, 10-inch, and 12-inch guns, and the effect of increasing the pressure is shown, for the 6-inch gun with a muzzle velocity of 3,300 feet per second, on Plate IX, in which the destructive effect of high velocities is indicated.

A joint Army and Navy Board recently convened to consider the subject of a proper supply of reserve ammunition was guided in making its recommendation as to the proper amount to be supplied by the speed of naval vessels and the rapidity of fire of the various guns composing the armament. The opinion was expressed that hereafter a fleet will not attempt to reduce a fortification by bombardment, and that it will only be in range of guns of seacoast forts during the time that is estimated as necessary to run by. Considering the speed of vessels of the present day, it was assumed that the time required from the instant that the first ship of a fleet comes within range until the last ship passes out of range, having in mind tortuous channels and obstructions, will be about two hours.

Based upon the results of target practice, in which but a limited number of rounds are fired in any series, it was estimated that the following number of rounds could be expended in an engagement of two hours, namely:

TABLE VI.

Caliber.	Rounds per piece.
6-inch	250
8-inch	180
10-inch	120
12-inch	90

The number of shots per hour expected to be expended at battle is shown by Plate X, which has been extended to include 16-inch guns.

At the rate shown in that plate, the lives of guns continuously employed, expressed in hours, would be as shown in Table VII.

TABLE VII.

Caliber and model.	Muzzle velocity.	Life of gun.	Number of rounds sustained fire per hour.	Life of gun.
	Ft. sec.	*Rounds.*		*Hours.*
6-inch, model of 1897	2,600	450	125	3.6
6-inch, model of 1900	3,000	150	125	1.2
6-inch, W. W	3,300	45	125	.36
8-inch, model of 1888	2,200	275	85	3.23
8-inch	2,150	350	85	4.12
10-inch, model of 1888	2,250	230	60	3.83
10-inch, model of 1900	2,550	75	60	1.25
10-inch	2,150	315	60	5.25
12-inch, model of 1888	2,250	200	45	4.44
12-inch, model of 1900	2,550	50	45	1.11
12-inch	2,150	280	45	6.22
14-inch	2,150	245	36	6.81
16-inch	2,150	210	30	7.0

It will be noted that our 6-inch, 10-inch, and 12-inch guns used at their highest power can not be expected, even if perfectly new, to last through an engagement of greater duration than $1\frac{1}{4}$ hours. This lack of staying power is sufficient, it is thought, to condemn them as a part of existing or future armament, and it remains to ascertain what measures should be taken in order that gun superiority shall not be sacrificed. The data show that the lives of our guns can be prolonged to

an extent which may be considered reasonable and necessary by reducing the muzzle velocity. Table VII shows the amount of advantage to be gained by reducing the muzzle velocity to 2,250 or 2,150 feet per second. In order to ascertain the effect of such reduction upon penetrative power of projectile at battle ranges and the penetrative value of projectiles of larger calibers, let it be assumed that the weights of the projectiles of the different calibers considered are proportional to the cubes of the calibers.

Plate XI shows the remaining velocities and the penetrations in Krupp armor as a function of the range. It will be observed that the penetrative power of the 14-inch projectile, greater at ranges above about 9,000 yards, is below that range practically the same as that of the 12-inch gun, model of 1900, having a muzzle velocity of 2,500 feet per second, while its racking and explosive effect will be considerably greater at all ranges. Similar data in regard to the 15-inch and 16-inch guns are also indicated.

Table VIII[a] gives more complete data in regard to these guns.

TABLE VIII.—Ranges beyond which projectiles of the guns stated will not penetrate 12-inch and 7-inch Krupp cemented armor when placed normally to the trajectory and when placed so that the trajectory makes an angle of 35° with the normal to the plate.

Formula used; $t^{0.7}=\frac{w^{0.5}v}{d^{0.75}}\times\frac{1}{\log^{-1}3.1594}$

t=thickness penetrated, inches.
w=weight of projectiles, pounds.
v=velocity of projectiles, feet per second.
d=diameter of projectiles, inches.

12-INCH KRUPP ARMOR.

Caliber.	Muzzle velocity.	Weight of projectile.	Normal impact.		Impact at 35° to normal.	
			Velocity required to penetrate.	Limiting range for penetration.	Velocity required to penetrate.	Limiting range for penetration.
	Ft. sec.	*Pounds.*	*Ft. sec.*	*Yards.*	*Ft. sec.*	*Yards.*
6-inch	2,600	106	3,061	.....	.....	.....
	3,000	106	3,061	.....	.....	.....
8-inch	2,200	316	2,200	Muzzle.	.....	.....
10-inch	2,250	604	1,881	2,850	2,162	648
	2,550	604	1,881	4,132	2,162	2,733
12-inch	2,250	1,046	1,639	6,050	1,883	3,420
	2,550	1,046	1,639	8,700	1,883	6,090
14-inch	2,150	1,660	1,460	8,700	1,678	5,500
15-inch	2,150	2,043	1,380	10,800	1,580	7,150
16-inch	2,150	2,400	1,342	12,050	1,543	8,300

7-INCH KRUPP ARMOR.

6-inch	2,600	106	2,098	2,058	2,412	735
	3,000	106	2,098	3,520	2,412	2,197
8-inch	2,200	316	1,508	4,834	1,733	3,074
10-inch	2,250	604	1,306	8,814	1,501	6,400
	2,550	604	1,306	10,240	1,501	9,600
12-inch	2,250	1,046	1,124	15,300	1,291	11,140
	2,550	1,046	1,124	16,500	1,291	13,730
14-inch	2,150	1,660	1,001	25,000	1,151	19,000
16-inch	2,150	2,400	.....	.....	.....	.....

[a] Also submitted to committee No. I of the Taft Board.

Further data in regard to the exterior ballistics of the 12-inch, 14-inch, 15-inch, and 16-inch guns of medium power are also included in Plates XII, XIII, and XIV.

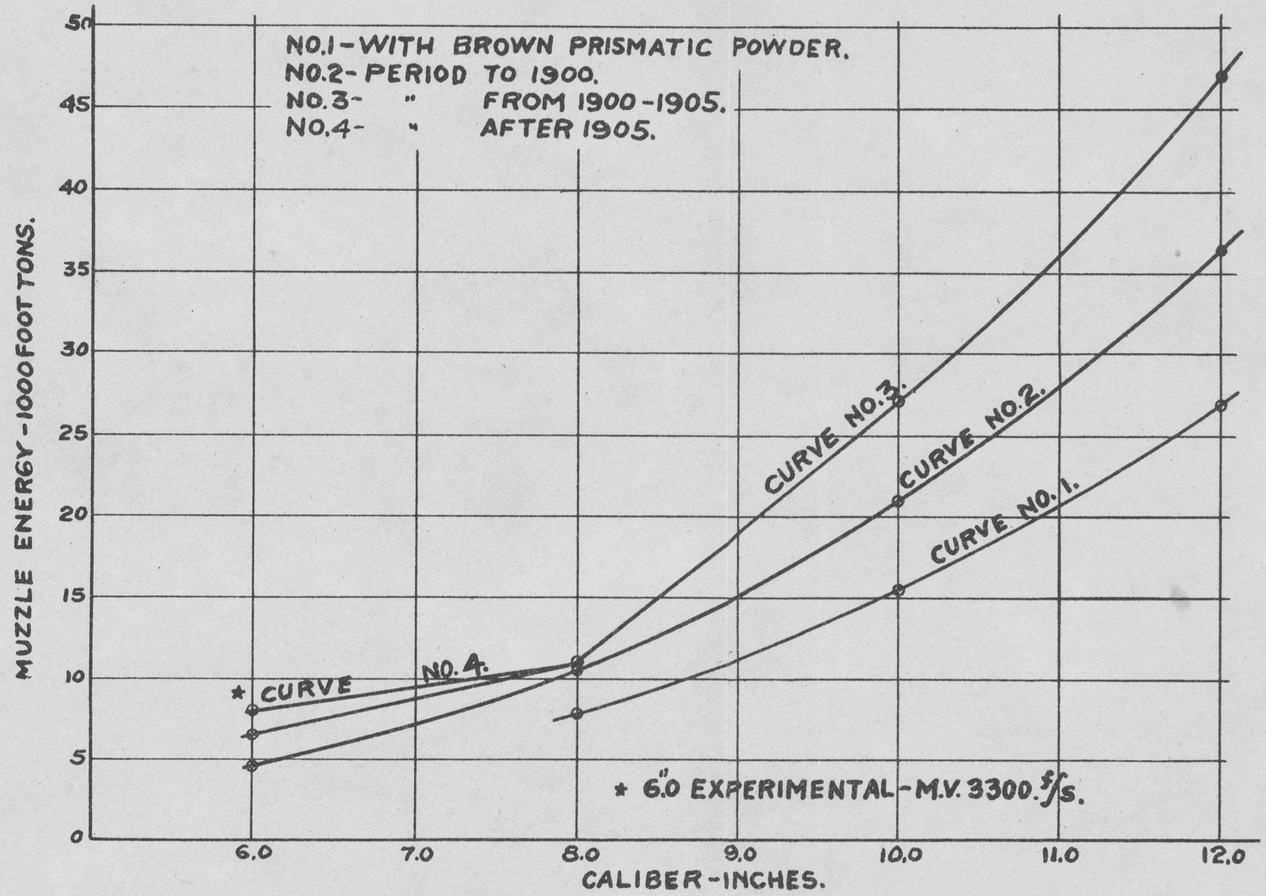
The importance of the information contained in Plate XI will perhaps be better understood by comparing it with Plate XV, which indicates the penetrative power of projectiles of 12-inch navy guns, which are types of those used in foreign navies, compared with that of our seacoast projectiles of the same caliber.

It is thought that sufficient data have been furnished to show the impracticability of placing dependence in actual engagement upon our existing guns of the model of 1900, owing to their lack of stamina. If, then, guns of these powers are required, the only conservative and proper course to follow would appear to be to use guns of a larger caliber having a muzzle velocity such as will insure them a reasonable life and to reduce the muzzle velocities of existing guns by an amount which is necessary to insure them a fitting period of usefulness. A satisfactory muzzle velocity for 6-inch guns is judged to be from 2,600 to 2,700 feet per second, and for 8-inch, 10-inch, 12-inch, and larger calibers from 2,150 to 2,250 feet per second. Plate XVI shows the remaining energies of the projectiles of such a system of medium power guns of calibers from 8 inches to 16 inches, and the probable cost of the guns and carriages is shown by Plate XVII.

The cost of the guns of such a system would be moderate, since the use of metal of the highest physical qualities would not be required.

It is estimated that the cost of a 14-inch gun would not exceed that of the 12-inch gun, model of 1900. The proposed reduction in the muzzle velocity of the 12-inch gun, model of 1900, assumes necessarily the use of a gun of larger caliber and of medium power to replace it in situations where the same or greater power is necessary, the choice of the caliber to be in each case determined by the location and the particular work required.

The cost per round from the 12-inch gun, model of 1900, including deterioration of gun, is $1,348.26, and that of the 14-inch gun would be $925.78, so that the result of the substitution of the latter gun for the former would be a less cost per round and a more powerful gun lasting longer.



MUZZLE ENERGY AS FUNCTION OF CALIBER.

PLATE II.

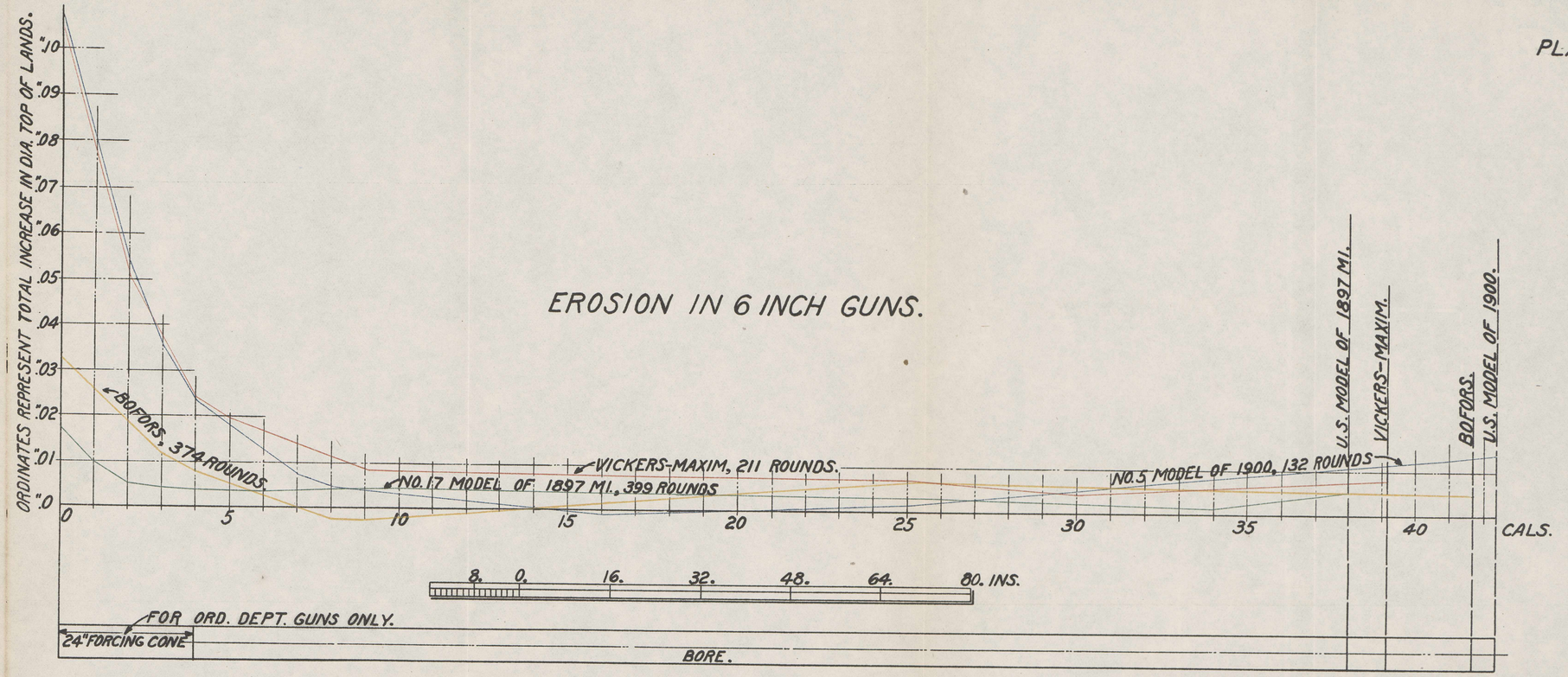

EROSION IN 6 INCH GUNS.
ORDINATES REPRESENT TOTAL INCREASE IN DIA. TOP OF LANDS.
".10
".09
".08
".07
".06
".05
".04
".03
".02
".01
".0
BOFORS, 374 ROUNDS.
WICKERS-MAXIM, 211 ROUNDS.
NO. 17 MODEL OF 1897 MI., 399 ROUNDS
NO. 5 MODEL OF 1900, 132 ROUNDS
U.S. MODEL OF 1897 MI.
VICKERS-MAXIM.
BOFORS.
U.S. MODEL OF 1900.
0
5
10
15
20
25
30
35
40
CALS.
8.
0.
16.
32.
48.
64.
80. INS.
FOR ORD. DEPT. GUNS ONLY.
24" FORCING CONE
BORE.

PLATE III.

EROSION IN 6-INCH WIRE GUNS.

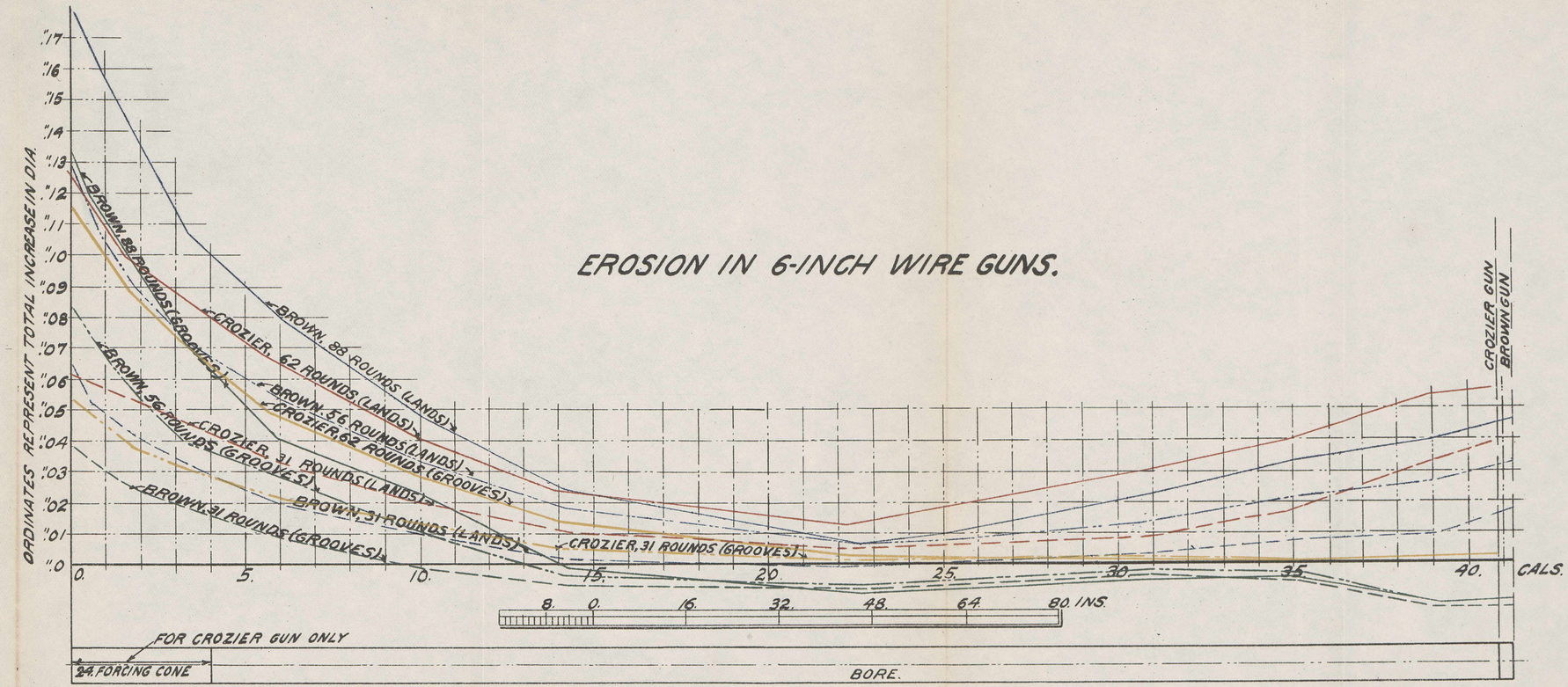


PLATE IV.

EROSION IN 10-INCH GUNS.

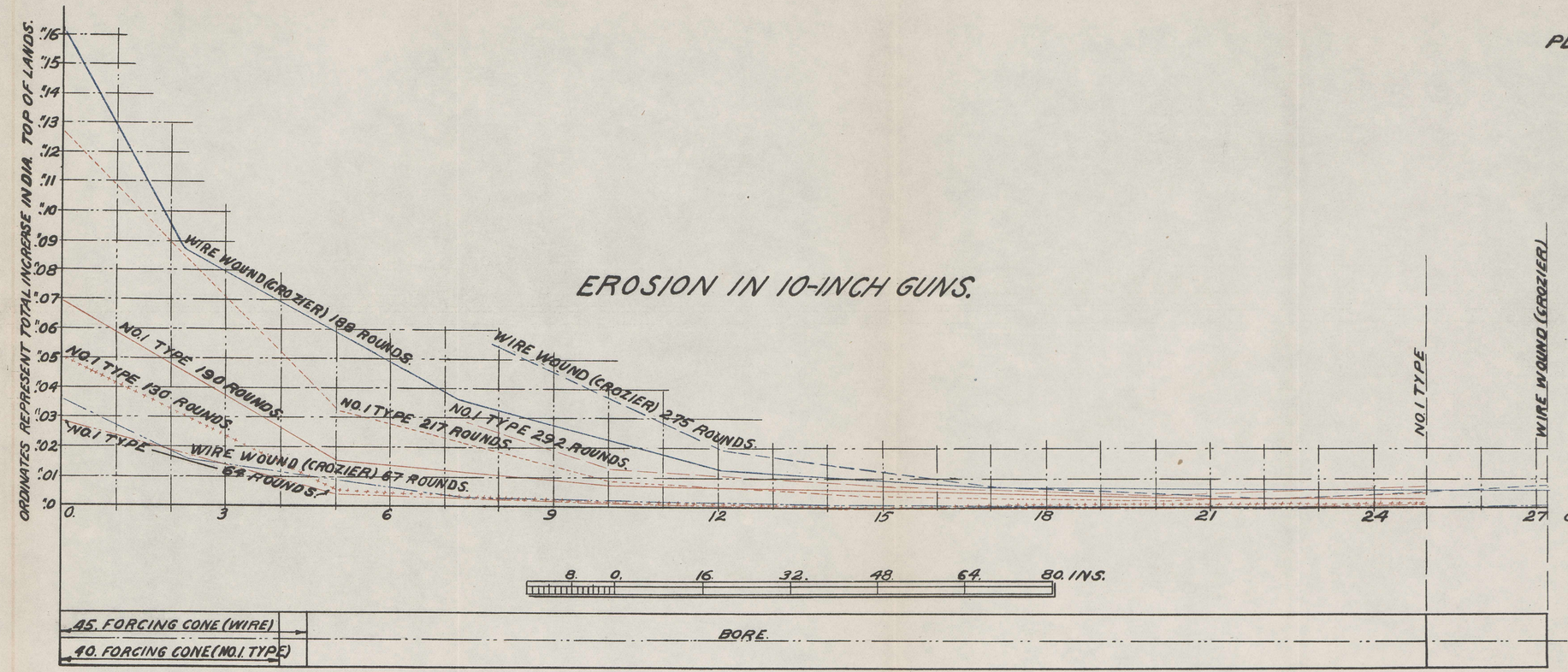


PLATE V.

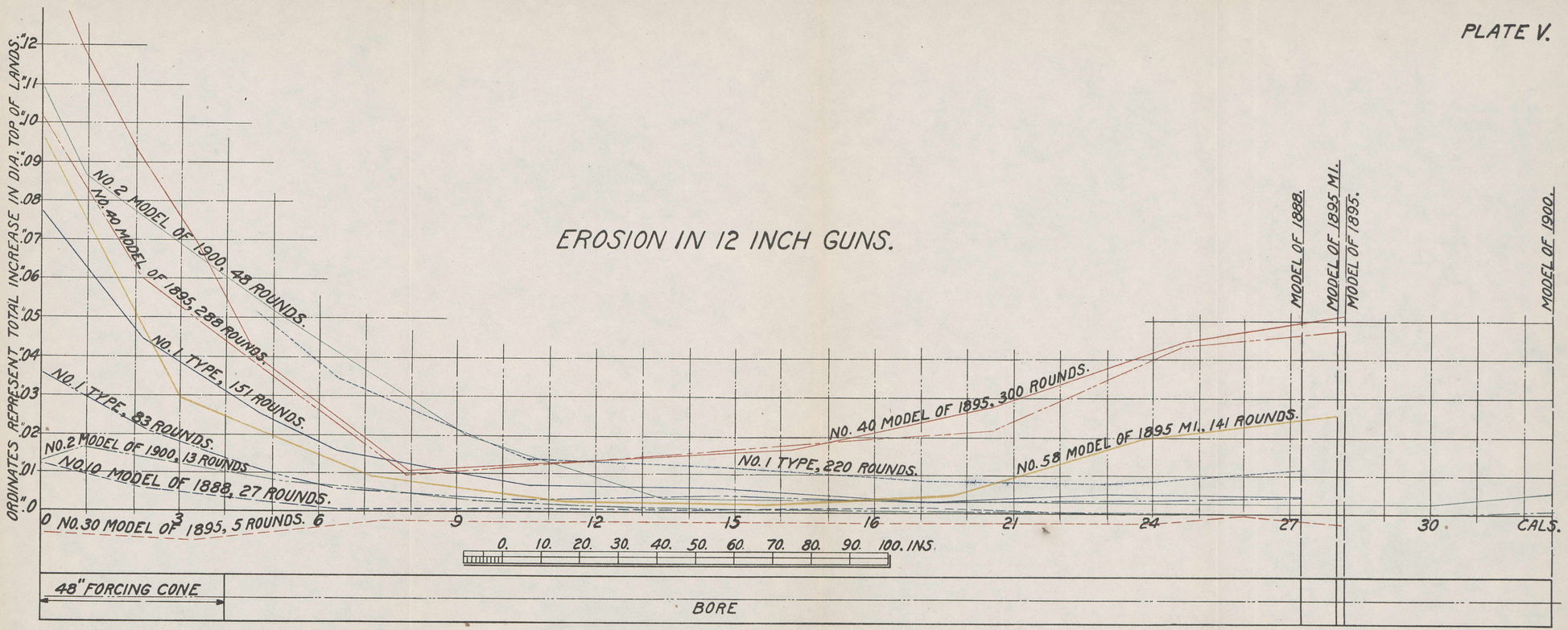

EROSION IN 12 INCH GUNS.
ORDINATES REPRESENT TOTAL INCREASE IN DIA. TOP OF LANDS.
.12
.11
.10
.09
.08
.07
.06
.05
.04
.03
.02
.01
.0
NO. 2 MODEL OF 1900, 48 ROUNDS.
NO. 40 MODEL OF 1895, 288 ROUNDS.
NO. 1 TYPE, 151 ROUNDS.
NO. 1 TYPE, 83 ROUNDS.
NO. 2 MODEL OF 1900, 13 ROUNDS.
NO. 10 MODEL OF 1888, 27 ROUNDS.
NO. 30 MODEL OF 1895, 5 ROUNDS.
NO. 40 MODEL OF 1895, 300 ROUNDS.
NO. 1 TYPE, 220 ROUNDS.
NO. 58 MODEL OF 1895 MI., 141 ROUNDS.
MODEL OF 1888.
MODEL OF 1895 MI.
MODEL OF 1895.
MODEL OF 1900.
0
3
6
9
12
15
16
21
24
27
30
CALS.
0. 10. 20. 30. 40. 50. 60. 70. 80. 90. 100. INS.
48" FORCING CONE
BORE

PLATE VI.

NO.1-PRESSURE ON LANDS, RIFLING CURVE UNIFORM, 1 TURN IN 25 CALIBERS.
NO.2-POWDER PRESSURE ON BASE OF PROJECTILE - POUNDS PER SQ. INCH.
NO.3-PRESSURE ON LANDS FOR SEMI-CUBIC PARABOLA, 0 TO 1 TURN IN 25 CALS.
NO.4- " " "
NO.5-VELOCITY OF PROJECTILE, FEET PER SECOND.
NO.6-PRESSURE ON LANDS FOR SEMI-CUBIC PARABOLA, 1 TURN IN 50 TO 1 IN 25 CALS.
ALL CURVES ARE PLOTTED AS FUNCTIONS OF TIME

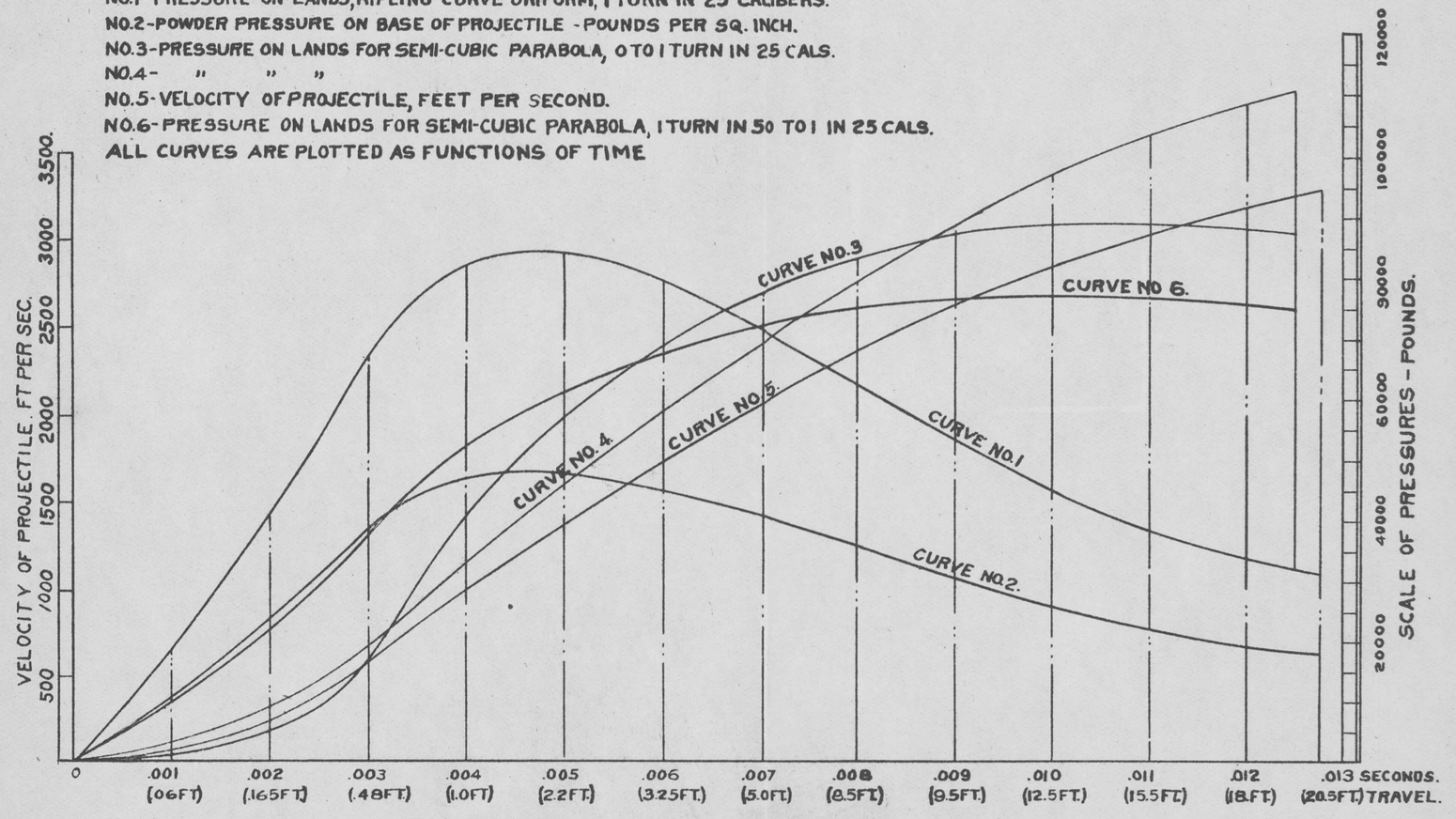


PLATE VII.

CALIBER	MODEL	MUZZLE VELOCITY
6.0	1897	2600
8.0	1888	2200
10.0	1888 & 95	2250
12.0	1888 & 95	2250

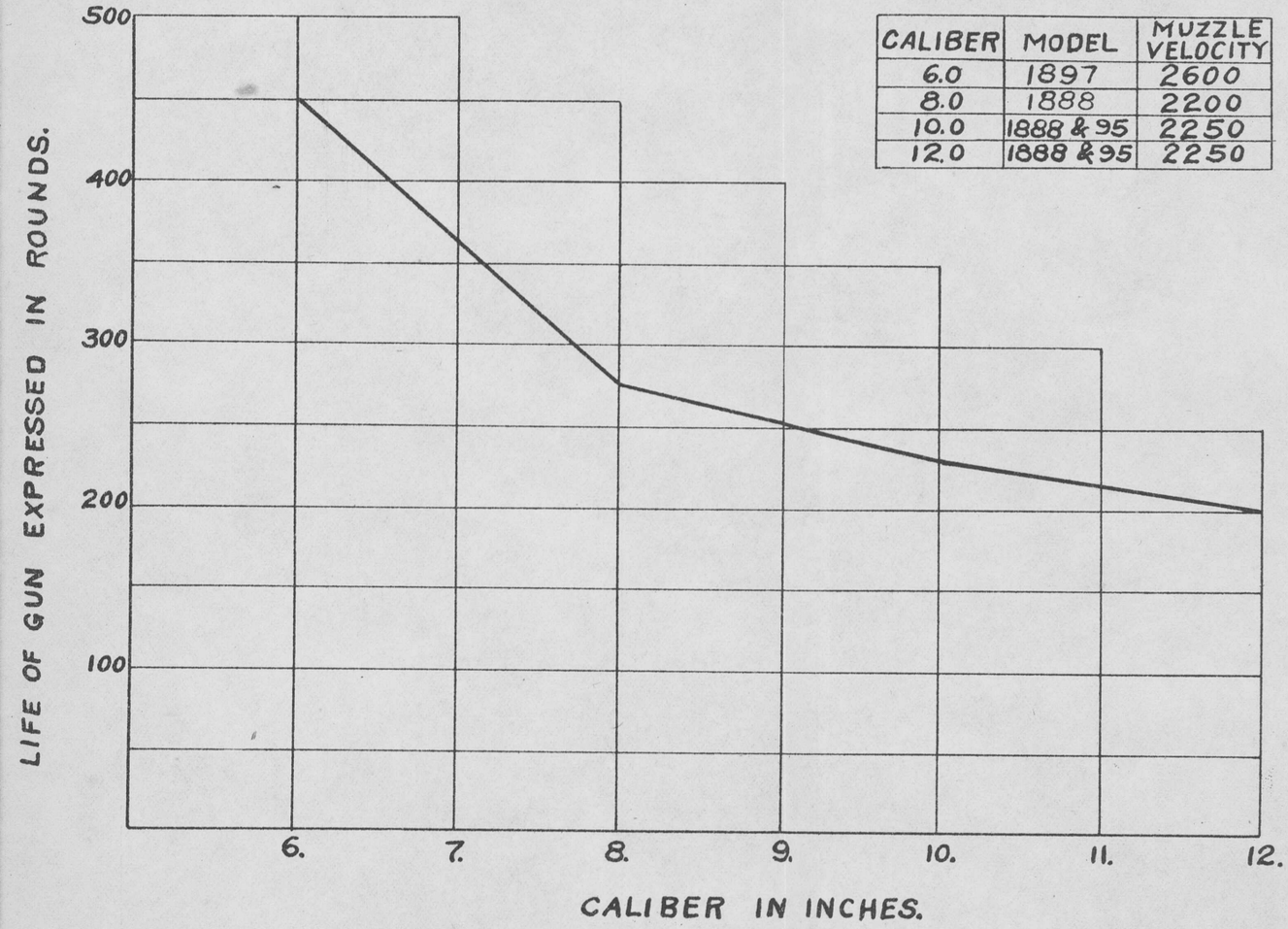
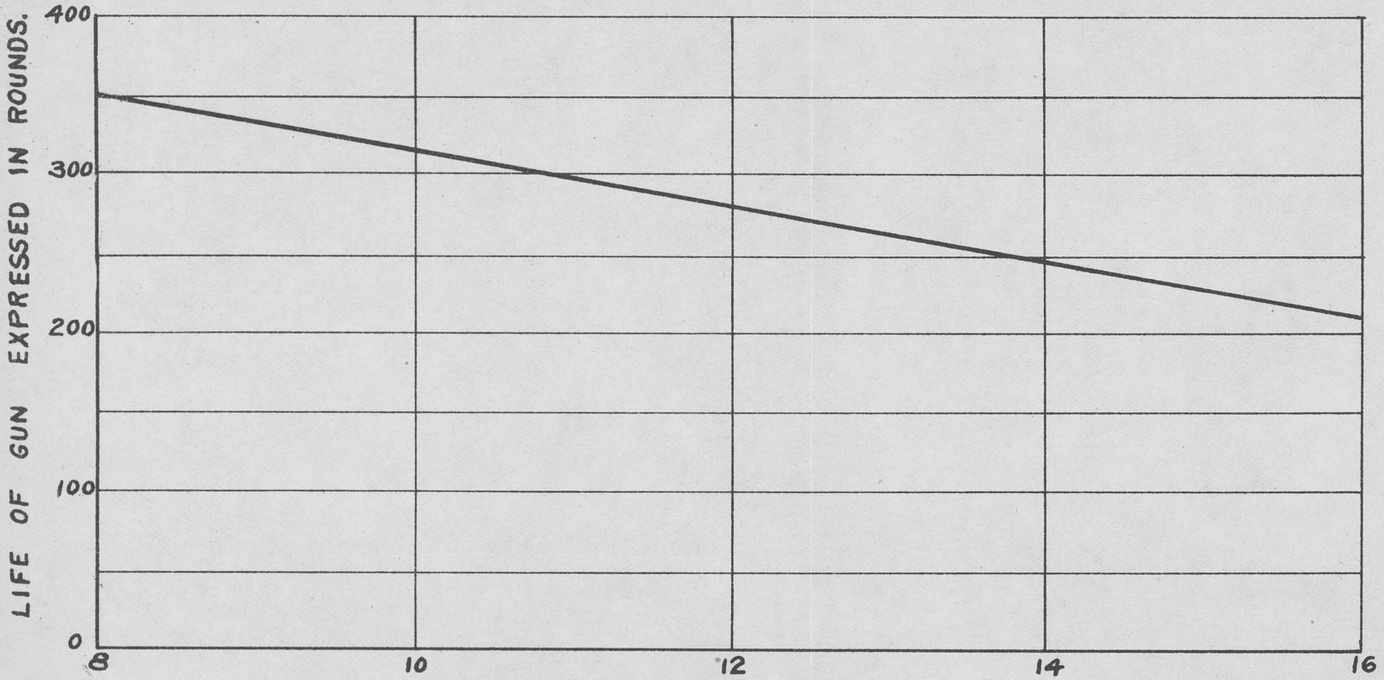


PLATE VIII.



MUZZLE VELOCITY FOR ALL GUNS 2150 FEET PER SECOND.

PLATE IX.

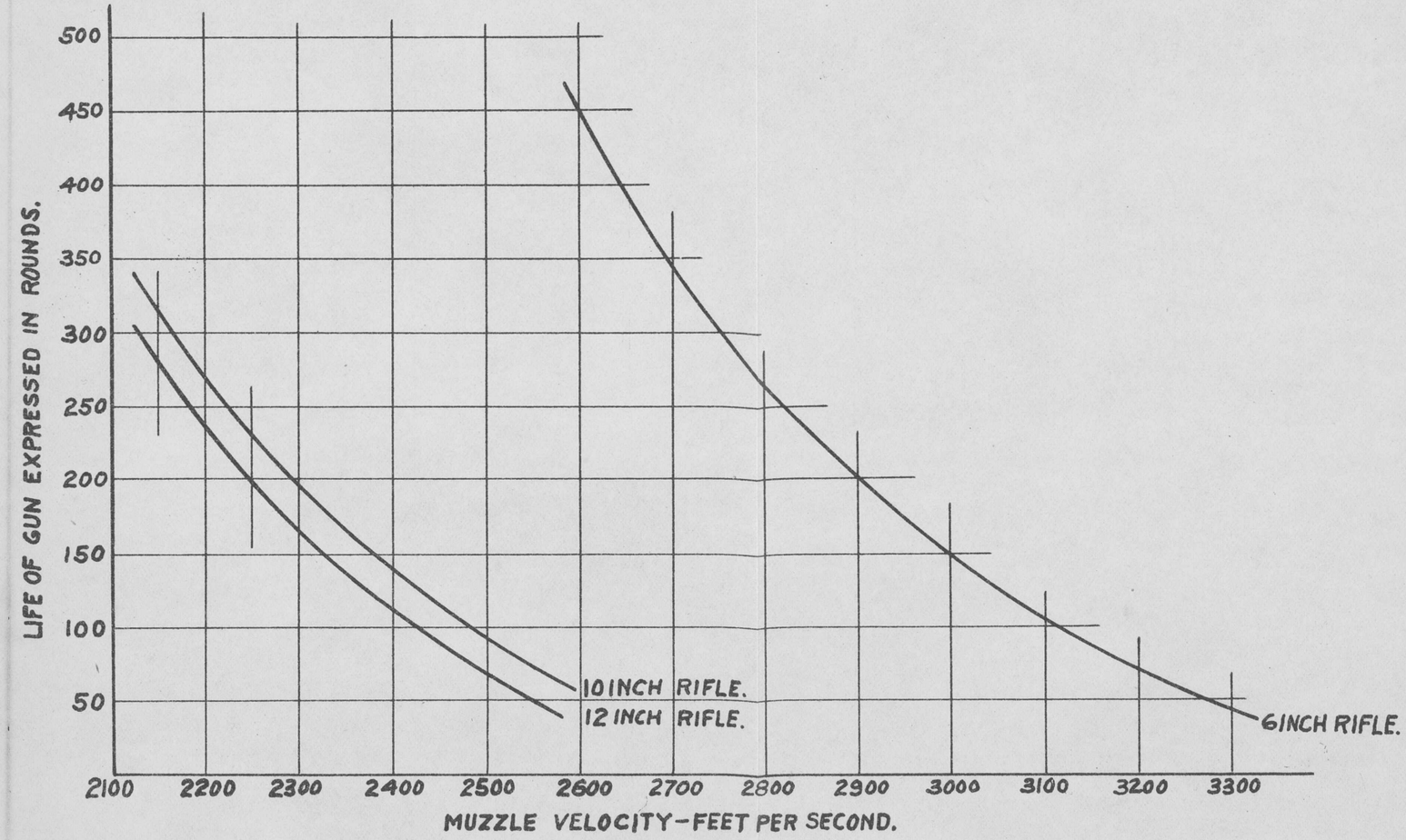
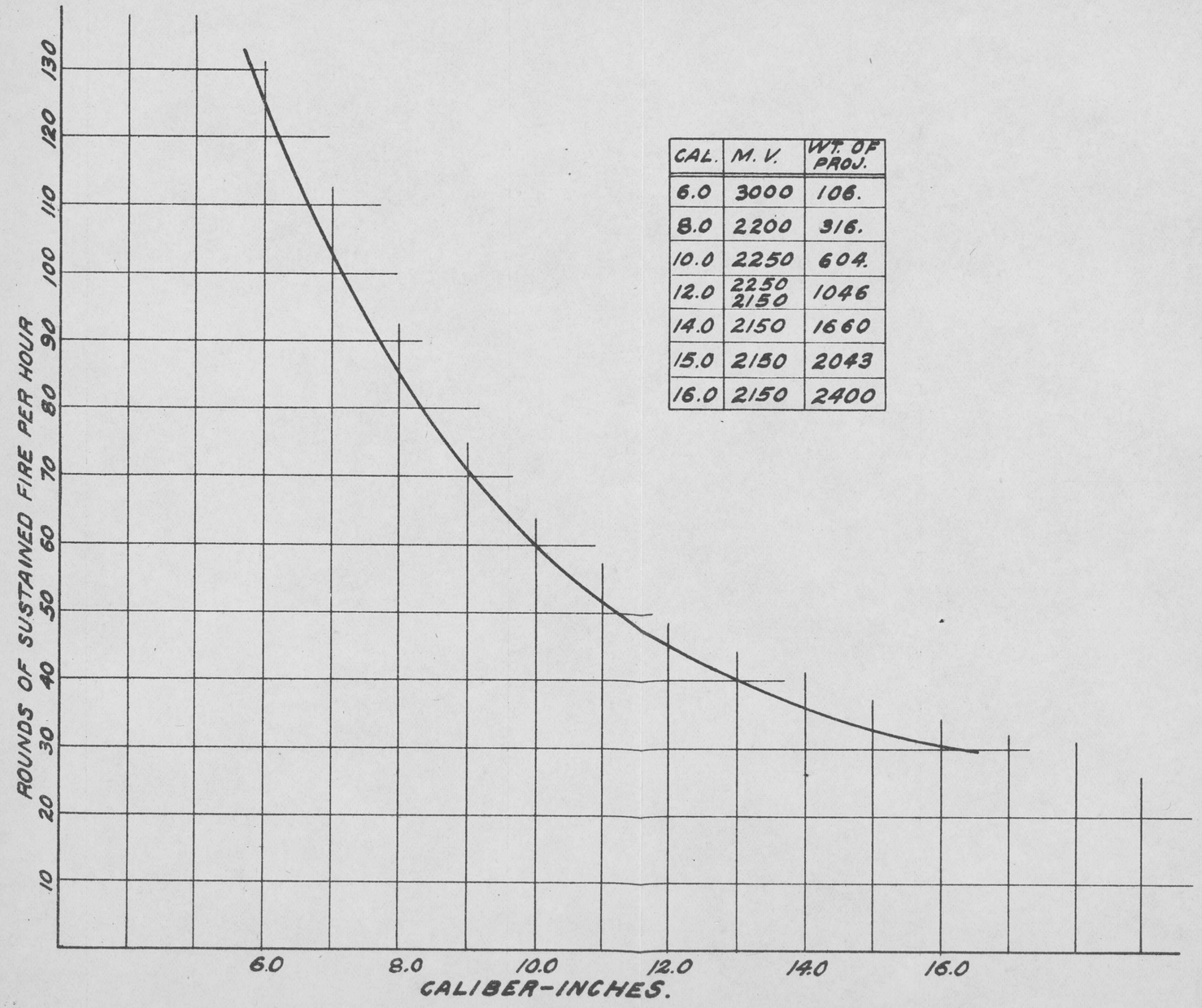

LIFE OF GUN EXPRESSED IN ROUNDS.
500
450
400
350
300
250
200
150
100
50
2100
2200
2300
2400
2500
2600
2700
2800
2900
3000
3100
3200
3300
MUZZLE VELOCITY—FEET PER SECOND.
10 INCH RIFLE.
12 INCH RIFLE.
6 INCH RIFLE.

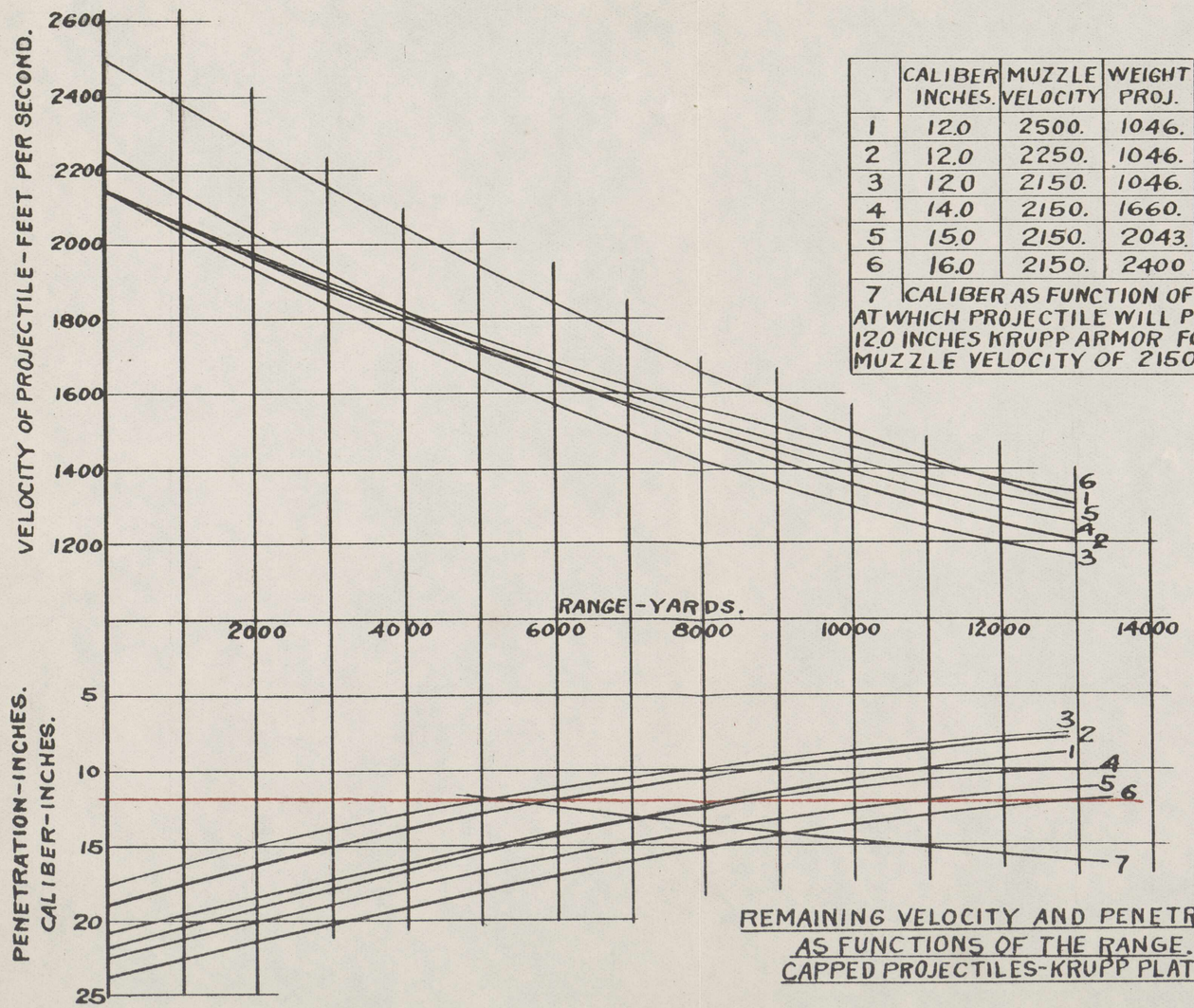
PLATE X.



CAL.	M. V.	WT. OF PROJ.
6.0	3000	106.
8.0	2200	316.
10.0	2250	604.
12.0	2250 2150	1046
14.0	2150	1660
15.0	2150	2043
16.0	2150	2400

	CALIBER INCHES.	MUZZLE VELOCITY	WEIGHT PROJ.
1	12.0	2500.	1046.
2	12.0	2250.	1046.
3	12.0	2150.	1046.
4	14.0	2150.	1660.
5	15.0	2150.	2043.
6	16.0	2150.	2400

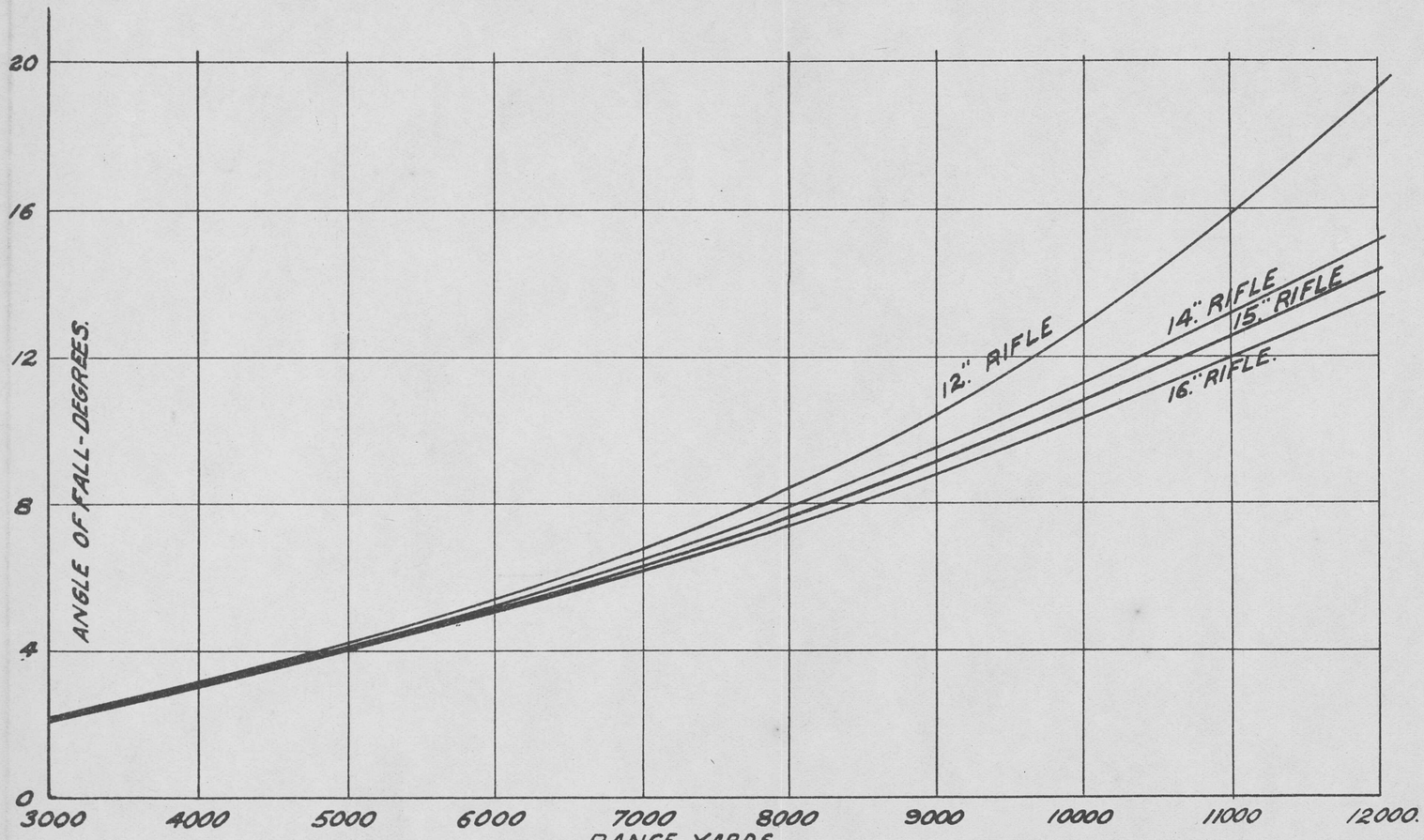
7 CALIBER AS FUNCTION OF RANGE AT WHICH PROJECTILE WILL PENETRATE 12.0 INCHES KRUPP ARMOR FOR A MUZZLE VELOCITY OF 2150 f/s.



REMAINING VELOCITY AND PENETRATION AS FUNCTIONS OF THE RANGE. CAPPED PROJECTILES-KRUPP PLATE.

PLATE XII.

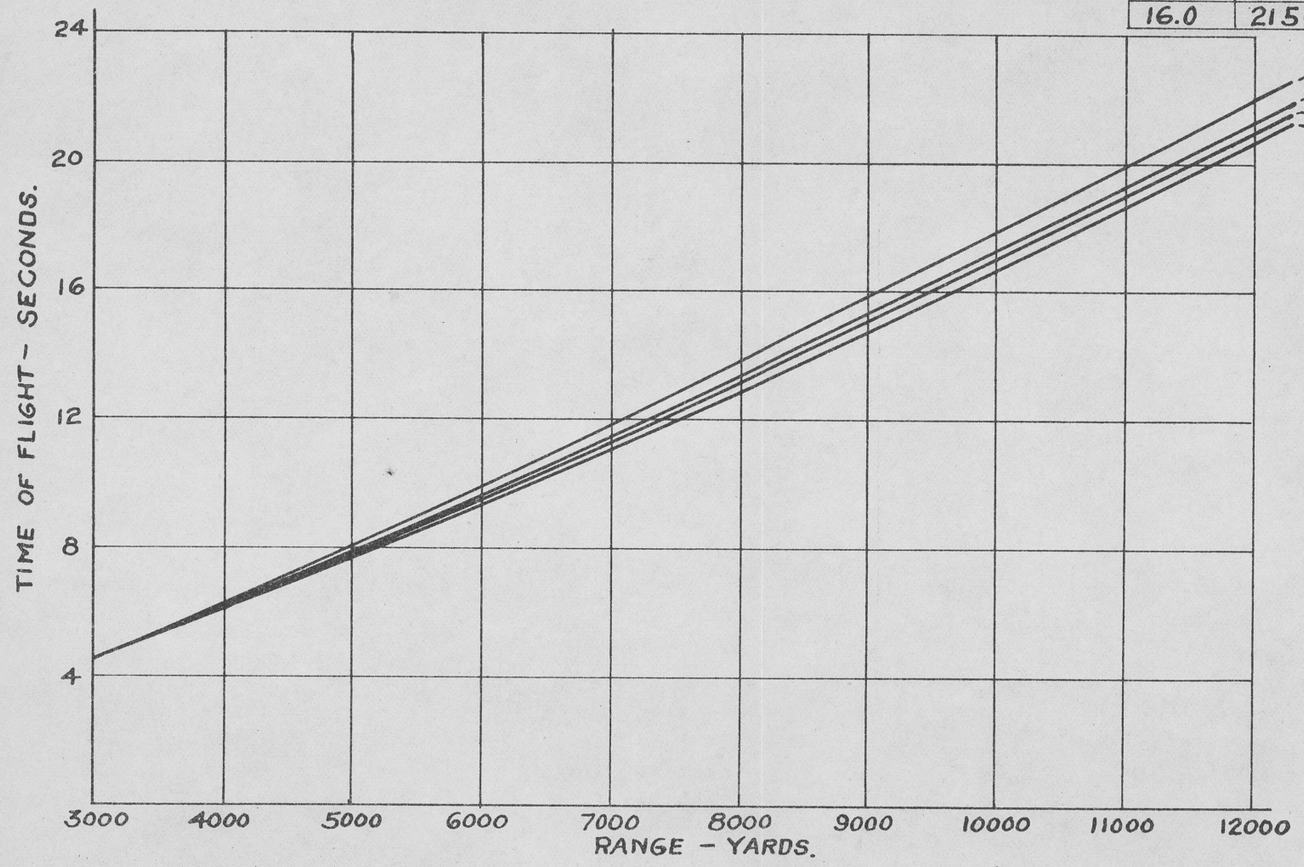
CALIBER INCHES	MUZZLE VELOCITY	WEIGHT PROJ.
12.	2150	1046
14.	2150	1660
15.	2150	2043
16.	2150	2400



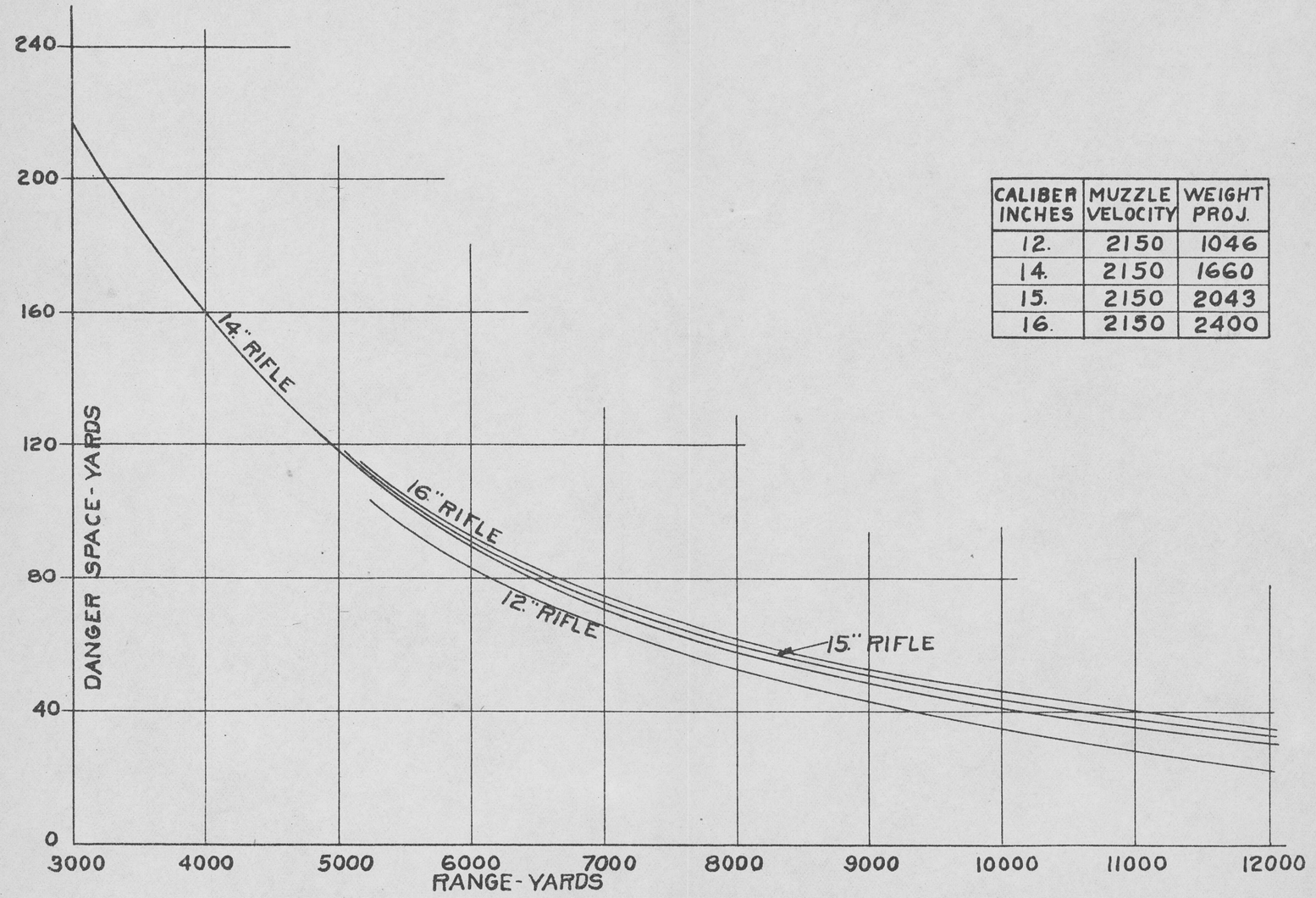
ANGLE OF FALL AS A FUNCTION OF RANGE.

PLATE XIII.

CALIBER INCHES	MUZZLE VELOCITY	WT. OF PROJECTILE
12.0	2150	1046
14.0	2150	1660
15.0	2150	2043
16.0	2150	2400



TIME OF FLIGHT
AS A FUNCTION OF RANGE.

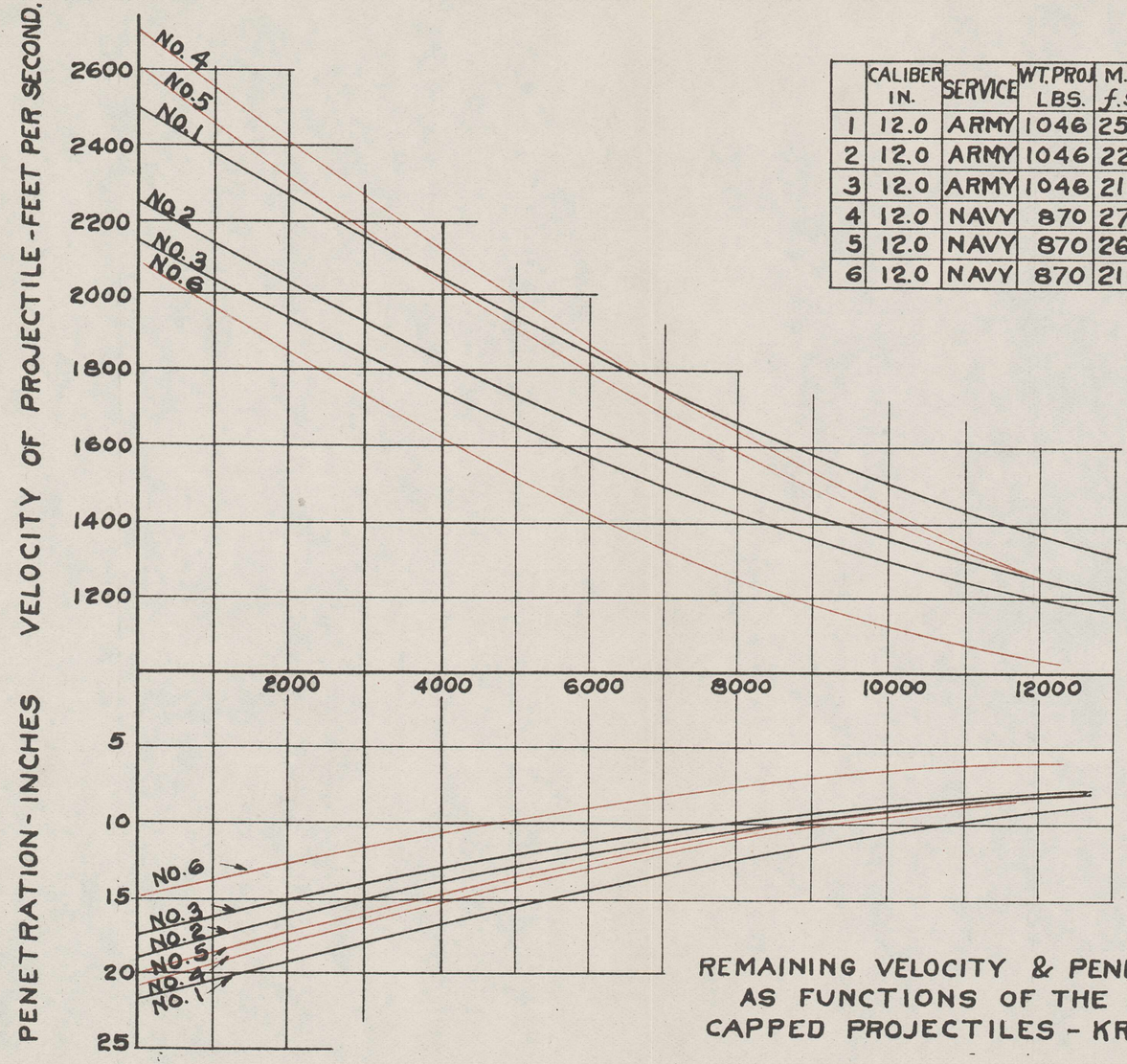


DANGER SPACE AS A FUNCTION OF RANGE.

CALIBER INCHES	MUZZLE VELOCITY	WEIGHT PROJ.
12.	2150	1046
14.	2150	1660
15.	2150	2043
16.	2150	2400

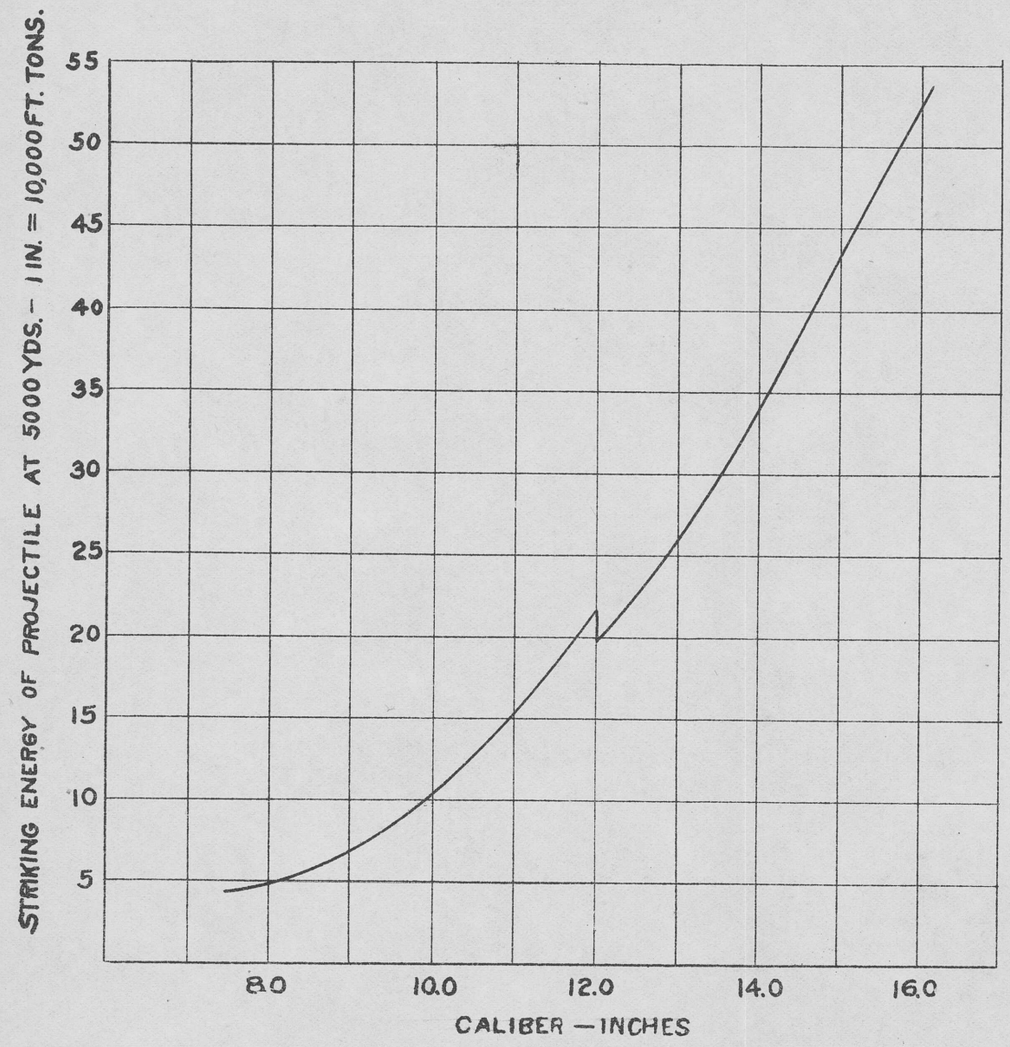
PLATE XV.

	CALIBER IN.	SERVICE	WT. PROJ. LBS.	M.V. f.s.
1	12.0	ARMY	1046	2500
2	12.0	ARMY	1046	2250
3	12.0	ARMY	1046	2150
4	12.0	NAVY	870	2700
5	12.0	NAVY	870	2600
6	12.0	NAVY	870	2100



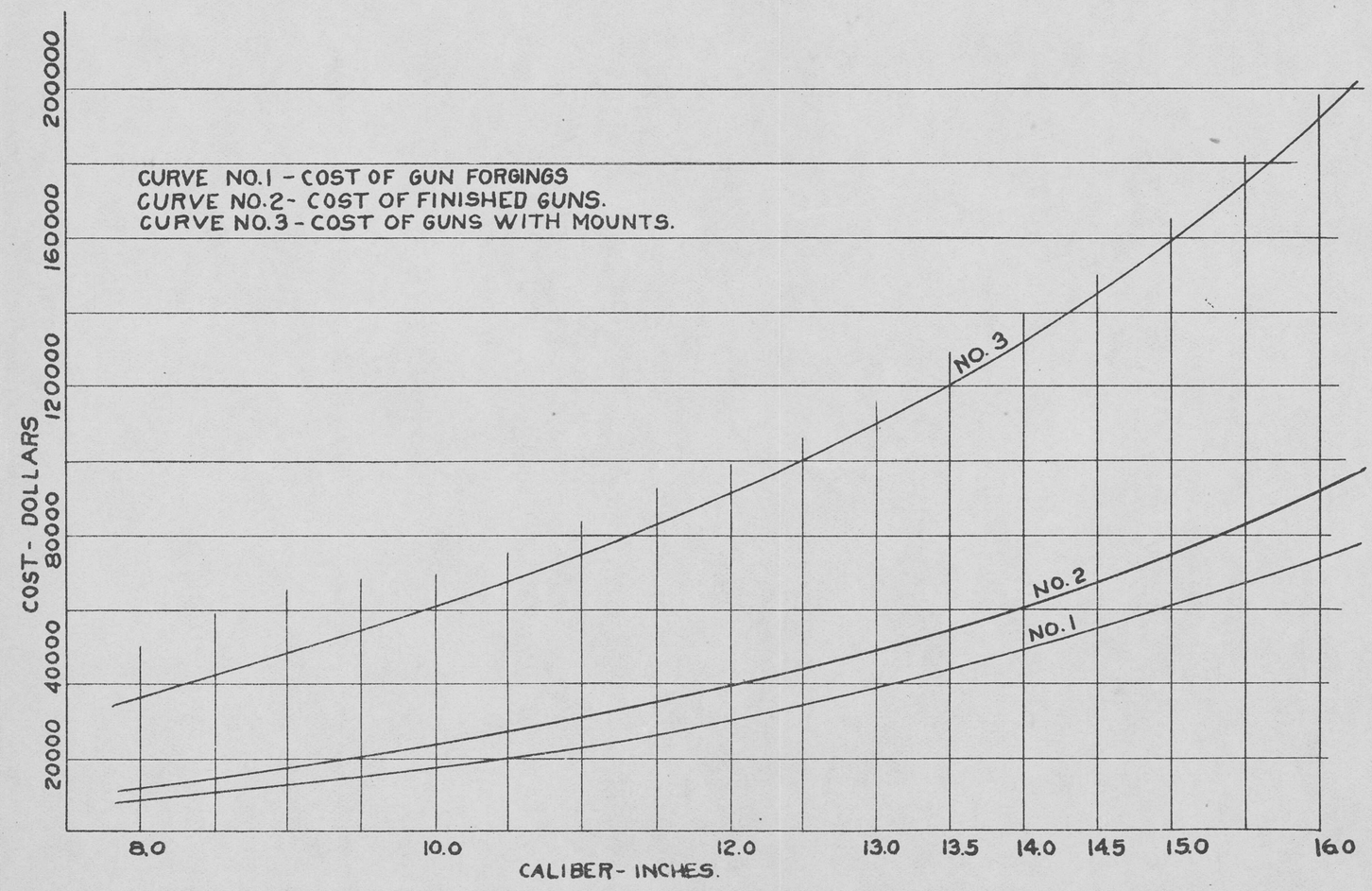
REMAINING VELOCITY & PENETRATION
AS FUNCTIONS OF THE RANGE.
CAPPED PROJECTILES - KRUPP PLATE

PLATE XVI.



CAL.	MUZZLE VELOCITY	WT. OF PROJECTILE
8.0	2200	316
10.0	2250	604
12.0	{2250 / 2150}	1046
14.0	2150	1660
15.0	2150	2043
16.0	2150	2400

PLATE XVII.


CURVE NO.1 - COST OF GUN FORGINGS
CURVE NO.2 - COST OF FINISHED GUNS.
CURVE NO.3 - COST OF GUNS WITH MOUNTS.
NO.3
NO.2
NO.1
COST - DOLLARS
200000
160000
120000
80000
40000
20000
8.0
10.0
12.0
13.0
13.5
14.0
14.5
15.0
16.0
CALIBER - INCHES.

APPENDIX II.

THE LIMIT OF THE ACCURACY-LIFE OF THE MUSKET.

Prepared by Maj. W. S. PEIRCE, Ordnance Department, U. S. Army.

The value of a musket as a weapon depends first of all upon the degree of probability with which it can be relied upon to hit with its projectile, when properly aimed, a desired target. As the probability of hitting grows less, the value of the musket decreases and finally disappears. This range of action may be called the "life" of the musket, and that portion of it from the beginning up to the point when the musket becomes too inaccurate for good target work is, for the purposes of this article, considered the accuracy life of the musket.

It is, of course, evident that the immediate causes of inaccuracy in a musket are those conditions which produce changes either in the form of the projectile or in its normal velocity of rotation during its progress through the bore. A loss merely in the velocity of translation, provided a corresponding rotational velocity is maintained, does not, within limits, decrease the accuracy, since it may be compensated for by giving greater elevation. It is equally evident that the projectile can be affected only by changes in the form and dimensions of the bore, and therefore inaccuracy must be due finally to the agencies at work to produce such changes.

These agencies are the erosive action of the powder gases and the friction of the projectile or its band on the lands and grooves of the rifling. Of these two the former exerts by far the greater influence, and upon the rate at which it proceeds depends almost entirely the accuracy life of the musket. It follows, therefore, that any effort to prolong materially this life must be directed toward reducing the rate of erosion.

This factor in the life of a musket has recently assumed a greater importance because of the tendency to increase the velocity of the projectile in order to increase the power of the musket, and thus obtain the advantages of a larger caliber. But increased velocities, the projectile remaining unchanged, mean higher pressures, and these, in turn, mean greater rapidity of erosion and a consequent shortening of the life of the musket. Moreover, it is found that the rate of erosion increases so rapidly in proportion to the increase in pressure that the gain in the power of the musket so obtained is not sufficient to offset the sacrifice in its useful life. It results, then, that the higher velocity must be abandoned, unless some means of decreasing the rate of erosion can be discovered.

Examination of the bores of muskets which have been fired a large number of times shows that the erosive action of the powder gases attacks the bore originally in the immediate vicinity of the seat of the projectile and that its effect in all stages is most pronounced at that point. This is because the gas can escape past the projectile until the latter has moved forward far enough to seal the bore, and it is this rush of gas under pressure which produces erosion. Erosion therefore takes place mainly in rear of the sealing point and progresses along the bore only as this point advances. In guns using fixed ammunition it does not affect the chamber in rear of the front edge of the cartridge case, since the case protects that portion, but immediately in front of that point its effect is most marked. In all muskets the bore becomes guttered and is washed away progressively, so that the distance the projectile must pass over before it takes the rifling is continually increasing.

In its passage through this eroded portion the projectile is not properly centered in the bore, and as this distance increases the velocity acquired by the projectile when it strikes the rifling increases. The result is that the projectile may enter the rifling obliquely, which in a small arm tends to deform it unsymmetrically, and has, in addition, a velocity that in a larger gun may be too great to permit the band to communicate to it the proper rotation. Neither of these conditions is corrected by its passage through the remainder of the bore, and either is sufficient to impair the regularity and accuracy of its subsequent flight.

Erosion is induced by both the temperature and pressure resulting from the combustion of the charge. The action is, perhaps, slightly chemical, but to a much greater extent physical, in its effects, and may be compared to that of a sand blast. Such chemical action as there may be is undoubtedly due to the effects of the high temperature attained upon the surface of the bore, but the main effect of the temperature is to soften the metal, and thus increase the physical action of the blast. The importance, therefore, of keeping the maximum temperature as low as possible is evident, and for some time has been recognized by powder makers. At present, however, there is no indication that any further material gain can be made in this direction. If, therefore, it is possible to reduce the rate of erosion, it seems evident that under present conditions it can be done only by obtaining a steel which in itself shall better resist this action or by changes in the dimensions or form of the bore, by which the volume and effect of the escaping gas may at first be reduced to a minimum. It is obvious that the latter condition will reduce the rate of erosion, if at all, only in its earlier stages, for as soon as the surface has been cut and the clearance for escaping gases increased the original advantage is entirely lost. With a better resisting steel, however, it may be expected that the rate should be proportionately slower at all stages and that the resulting increase in length of life of the musket would be material.

The adoption of a muzzle velocity of 2,300 feet per second for the United States magazine rifle, model of 1903, with the 220-grain bullet gave a most powerful small arm. But during the extensive firings made to determine the proper graduations for the sight, the drift, and effect of wind upon the bullet, it was discovered that the life of the musket for accurate target shooting was between 1,100 and 1,500 rounds.

This should not be construed to mean that the musket becomes useless or is not a serviceable military weapon after 1,500 rounds. It is sufficiently accurate up to from 4,500 to 5,000 rounds to be considered serviceable for field use. Target practice, however, is a most essential part of the training of a soldier, and in order to be of value and excite interest the error of the arm itself must not be so great as to produce irregular scores. An accuracy life of 1,500 rounds can not be considered satisfactory, for the reason that in time of peace the use of the musket is practically limited to the target range and the replacement of arms after such short life would involve too great an expense.

To determine, therefore, whether it is possible to prolong the accuracy life of the barrel without changing its ballistic qualities, a series of experiments were undertaken at the Springfield Armory during the previous year. It was considered that the most promising hope of improvement lay in the direction of obtaining a steel for the barrel having a higher resistance to erosion than the simple carbon steel heretofore used, but as some time was required to procure different samples of such steel, the first experiments were made with barrels of the regular steel in which the form and number of the grooves were changed. Two different forms of rifling were tried, one in which the cross section of the bore at any point was an ellipse, the inclination of the major axis varying so as to give the desired twist, and the other consisting of eight lands and grooves of equal width. It was thought that the smooth, unbroken surface of the elliptical bore, offering no starting point for erosion, would resist the action of the gases more uniformly than a barrel rifled in the ordinary manner, in which the grooves afford convenient channels for the gas and their angles, points most easily attacked. The eight-grooved barrel was tested principally to see whether it gave any improvement in accuracy over the service rifling, as was claimed by some makers, and not with any expectation that it would be longer lived.

In this test two muskets with elliptical rifling, one having an 8-inch twist and the other a 10-inch twist, and one with eight grooves were fired in comparison with a service musket.

At the beginning and after 1,000, 2,000, 2,500, 2,700, and 3,500 rounds, respectively, each musket was fired for accuracy, taking 5 targets of 10 shots each, except that after 2,500 rounds further firing with the eight-grooved musket was discontinued on account of its marked inferiority to the others at that point.

The results of these firings showed that the elliptical 8-inch twist was the most accurate of the four muskets fired at the start and retained this position generally throughout the test. The elliptical 10-inch was the lowest in accuracy at the beginning, but lost less than the others as the test progressed and finished practically even with the service musket. At least part of the good showing of the elliptical 8-inch must, however, be attributed to its more rapid twist, since previous firings had shown that the service rifling with an 8-inch twist gave greater accuracy than the same form with 10-inch twist. These firings, though not sufficient to be conclusive, do not indicate that much would be gained from the use of elliptical rifling.

The next series of experiments were made with the object of determining if it were possible to obtain a better resisting steel for the barrel. For this purpose a number of manufacturers were invited to furnish samples of special steels, and in addition several barrels of the

regular steel were subjected to a hardening treatment and tested with the others, to ascertain whether such treatment was beneficial or not.

Eight different samples were submitted by manufacturers, from each of which one barrel was made and tested. Such information as could be obtained from the manufacturers concerning the composition and qualities of these samples is given below.

H. & R.—This was called by the makers "Bohler Styrian steel," and was stated to be a tungsten (wolf-ranium) crucible cast steel. It was also said to be the steel used by Germany and other European powers for the infantry musket and machine gun. Its physical qualities were given as follows: Tensile strength, 107,250 to 128,700; elastic limit, not less than 71,500; elongation, not less than 12 per cent.

A chemical analysis of this sample gave the following:

Combined carbon	0.614	Sulphur	0.025
Manganese	.570	Phosphorus	.028
Silicon	.383	Tungsten	.890

Cl.—This sample was said to contain a small percentage of chromium. The results of physical tests before and after annealing were as follows:

	Tensile strength.	Elastic limit.	Elongation.	Contraction.
			Per cent.	*Per cent.*
Before	132,400	72,800	16	49.7
After	114,800	56,400	19.7	49.7

No chemical analysis was made.

M.—This steel was a plain nickel steel, containing, according to the makers, the following proportions of carbon and nickel: Carbon, 0.358; nickel, 3.480.

The value claimed for this steel depends upon a special treatment given by the makers after the last heating to which it is to be subjected. For that purpose the barrels after rolling at the armory were returned to the manufacturers for treatment. The physical results after such treatment were reported by the makers as follows, the specimen being taken from the muzzle end:

Tensile strength		120,000
Elastic limit		104,500
Elongation	per cent.	21
Contraction	do	62.5

P. & W.—This sample, though submitted through an American firm, was of Spanish manufacture. No information as to its physical qualities was given and no tests were made to determine them, for lack of sufficient metal. A chemical analysis showed the composition to be as follows:

Carbon	0.500
Manganese	.787
Silicon	.600
Sulphur	.045
Phosphorus	.045

Cp.—No information concerning the physical qualities of this steel or its chemical composition was given by the makers, and to avoid delaying the firing trials no tests were made at the armory.

H B.—This firm submitted three samples of German steel called "Bismarck, No. 1," "Bismarck, No. 2," and "A." No information

as to the composition or qualities of any of the samples was given and no tests to determine them were made.

Springfield Armory.—Three barrels, marked "A," "C," and "D," were made from the regular stock, which is a simple carbon steel. After drilling, these barrels were hardened, as follows:

"A" was heated to 575° C. and cooled by pouring oil through the bore from the breech end.
"C" heated to 600° C. and cooled in same manner.
"D" heated to 625° C. and cooled in same manner.

The manufacture of the barrels from these different samples was carefully watched in all stages and notes made of all difficulties encountered. Without going into particulars, it may be stated generally that more or less trouble was encountered on account of hardness in the drilling and machining of all the samples except the H. & R. and the three H B. The excepted samples were found to machine about as easily as the regular stock. A number of drills were broken and all tools used required frequent grinding, so that the time required for the various machine operations was from three to four times greater than with the regular stock. This fact, together with the breakage of tools, would materially increase the cost of the use of these steels and was given its proper weight in the consideration of the results of the tests.

These barrels were fired for velocity and accuracy at the beginning and after 3,500 rounds. In addition to this, they were fired for accuracy after 1,000, 2,000, and 2,500 rounds. The accuracy firings consisted in each case except the Springfield Armory barrels of five targets of ten shots each at ranges of 500 and 1,000 yards, one shot being fired from each musket in succession in order to obtain as far as possible uniform weather conditions. The test of the Springfield barrels was begun before the receipt of the others and they were fired only at a range of 1,000 yards. Assuming as a measure of the loss in accuracy of each barrel at the end of the test the ratio of its mean absolute deviation after 3,500 rounds to its original mean absolute deviation, the order of merit indicated by the results obtained is as follows:

1. Cp.
2. H B, Bismarck, No. 1.
3. H. & R.
4. Cl.
5. H B, "A."
6. H B, Bismarck, No. 2.
7. P. & W.
8. M.

The Springfield barrels are not rated, because they were not fired at 500 yards. The results obtained from them at 1,000 yards, however, indicated that "A" and "C" were inferior to all the others and that "D" was about the same as H B, "A."

Arranging the same barrels in the order of their loss in velocity, we have:

1. Cp.
2. Cl.
3. M.
4. H. & R. and P. & W.
6. H B, Bismarck, No. 2.
7. H B, Bismarck, No. 1
8. H B, "A."

Averaging these two classifications, the final order of efficiency of the eight barrels is as follows:

1. Cp.
2. Cl.
3. H. & R.
4. H B, Bismarck, No. 1.
5. P. & W.
6. M.
7. H B, Bismarck, No. 2.
8. H B, "A."

All the barrels fired were sectioned longitudinally at the conclusion of the tests and the condition of the bores carefully compared. It was found that the Cp barrel showed the least erosion, that the Cl and H. & R. were next and about equal, and that in the M and Springfield barrels the erosion was the greatest. The remaining barrels formed an intermediate group in which the differences were too slight to warrant a more definite classification. It was also found that the erosion was confined practically to the immediate vicinity of the bullet seat and was inappreciable throughout the main portion of the bore.

It will be seen that the barrel which came out first in order of efficiency, Cp, also showed the least erosion, and that the same relation existed also in the cases of the second and third barrels. Similarly the group in which the erosion was most marked was composed generally of those barrels which showed the greatest loss in efficiency. While this relation can not be traced accurately throughout the list, the coincidence is so general that it may safely be said that the loss in efficiency or accuracy of a musket barrel is directly proportional to the amount of erosion occurring about the bullet seat.

These tests also prove that certain grades of steel show a greater resistance to erosion than others. That this quality does not depend upon simple hardness, as measured by a file test, is shown by the results in the M and the Springfield barrels, which were among the hardest of those used. The composition of the Cp barrel, which gave the best results, is not known, but the barrels that came out second and third contained, respectively, chromium and tungsten and presumably owe their good qualities in some degree to the presence of these metals.

Both the Cp and Cl samples, however, were very difficult to machine. For this reason and the fact that they were not greatly the superior of the H. & R. sample, which gave no trouble in manufacture, the latter was considered best suited for regular use.

A further series of firings were decided upon to determine whether or not decreasing the area through which gas can escape before the bullet seals the bore would lessen the rate of erosion, and consequently prolong the accuracy life of the barrel. For these firings three barrels were first made in which the diameter of the neck of the chamber was reduced so that it fitted closely the maximum cartridge at that point. In two of the barrels the neck of the chamber was connected with the bullet slope by a square shoulder corresponding to the front edge of the cartridge case, and in the remaining barrel by a 60° slope. In one of the square shoulder barrels the clearance around the bullet was also reduced to a minimum.

These three barrels were fired up to 4,000 rounds each in comparison with two barrels of the regular dimensions. The velocity of each was taken at the beginning, after 3,500 rounds, and after 4,000, and targets at 1,000 yards at the same intervals. The lands and grooves were also star-gauged at the beginning and at the end of the test. At the conclusion of the firing the barrels were sectioned to permit examination of the bores.

The results of these firings showed that the two barrels in which the neck of the chamber, but not the bullet slope, had been reduced lost more in accuracy and velocity after 4,000 rounds than did the service barrels, and they were found to be eroded fully as much. The barrel

in which the clearance around the bullet was also reduced showed much less erosion and loss of accuracy. It was noted that all three barrels with special chambers gave originally, using ammunition of the same date, velocities ranging from 20 to 54 feet per second greater than the regular barrels gave. After 4,000 rounds, however, it was found that velocities from the special barrels had fallen about 25 feet per second below those from the regular barrels.

The results obtained with the barrel having a reduced clearance about the neck of the cartridge and the bullet were so promising that three more barrels were made, differing from the former only in having the neck of the chamber connected with the bullet slope by a 60° slope instead of a square shoulder. This change was made as no advantage was found to result from the use of the square shoulder, and it was feared that the shoulder would permit the accumulation of residue, which might interfere with the seating of the cartridge.

These three barrels were subjected to the same tests as the preceding lot. They not only failed to confirm the good results obtained before, but showed no improvement over the regular service barrel. So far, therefore, as a conclusion can be drawn from such a limited number of barrels, it appears that decreasing the clearance around the bullet increases the pressure in a new barrel, but does not for the same cartridge appreciably decrease either the amount of erosion or its rate as measured by the loss in accuracy after 4,000 rounds.

The increase in pressure had of course been anticipated, but that such increase would counterbalance so completely the decreased volume of escaping gas as to keep the rate of erosion practically constant was not expected. If the powder charge were reduced so that the original pressure was the same as obtained in the service barrel with the standard cartridge, it is probable that the rate of erosion would be decreased somewhat, but there is little promise that the gain would be material.

The results of all the experiments described above may be summarized as follows:

(*a*) The loss in accuracy of a musket is proportionate to the amount of erosion occurring near the bullet seat. Inferentially, the rate at which the accuracy decreases is proportional to the rate at which the erosion progresses.

(*b*) Variations in the form and dimensions of the rifling have little or no effect upon the accuracy life of the barrel.

(*c*) Certain grades of steel show a greater resistance to erosion than others. It is apparently possible to obtain a steel now which offers no difficulty in working and which will give a longer life for the barrel than the grade heretofore used.

(*d*) For a given cartridge changes in the diameters of the neck of the chamber and the bullet slope do not affect the rate of erosion of the barrel.

It appears then that, without any change in the ammunition, the only direction in which we can look for any material improvement in the length of the accuracy life of the musket is in the use of a special steel of greater erosion resistancy, and presumably the same is true for larger calibers.

The improvement that could be obtained in this way, however, from all present indications is small compared with that resulting from even

a comparatively slight reduction in the pressure. The experiments outlined herein were all made with ammunition giving 2,300 feet per second muzzle velocity with a maximum permissible pressure of 51,000 pounds per square inch. While these were in progress, other firings were made with ammunition giving a muzzle velocity of 2,200 feet per second with a maximum permissible pressure of 49,000 pounds per square inch, which showed that with the lower velocity and pressure the accuracy life of the barrel was practically doubled.

The recent decision, based upon this result, to reduce the velocity to 2,200 feet per second, removes to a great extent the unsatisfactory conditions which existed when these experiments were begun and for which a remedy was so urgently required.

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