ORDNANCE DEPARTMENT

ORDNANCE MANUAL.

THE

ORDNANCE MANUAL

FOR

THE USE OF THE OFFICERS

OF THE

UNITED STATES ARMY.

PHILADELPHIA:
J. B. LIPPINCOTT & CO.
1861.

A

WASHINGTON, D. C.
September 2, 1861.

GENERAL :—

I have the honor to report that I have completed the duty assigned me of preparing a new edition of the Ordnance Manual for publication. The manuscript is now ready for the printer.

Very respectfully, I am, General,
Your obedient servant,
T. T. S. LAIDLEY,
Bvt. Major, Capt. of Ordnance.

Brig. Gen. J. W. RIPLEY,
Chief of Ordnance.

WATERTOWN ARSENAL,
October 24, 1861.

Gen. J. W. RIPLEY,
Ordnance Office,
Washington, D. C.

SIR :—

The undersigned have the honor to report that, in obedience to your instructions of the 3d of September, 1861, they have examined the new edition of the Ordnance Manual, prepared by Brevet Major Laidley, and have made such alterations as to them appeared to be required.

A. B. DYER,
Capt. of Ordnance.
T. J. RODMAN,
Capt. of Ordnance.
T. T. S. LAIDLEY,
Bvt. Major, Capt. of Ordnance.

ORDNANCE DEPARTMENT,
Washington, Nov. 4, 1861.

Hon. S. CAMERON,
Secretary of War.

It is respectfully recommended that the revised edition of the Ordnance Manual be published for the use of the Army.

WILLIAM MAYNADIER,
Lt. Col. of Ordnance,
in charge of Bureau.

Approved, November 4, 1861.
THOMAS A. SCOTT,
Acting Secretary of War.

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ORDNANCE MANUAL.

CHAPTER FIRST.

ORDNANCE.

All ordnance for the *land service* is made by private contractors, under the direction of officers of the Ordnance Department. The kinds and calibres used are as follow :

Guns	Field	3-in. (rifled)	Wrought iron or steel	Model	1861.
		6-pounder	Bronze	"	1841.
		12 "	Bronze	"	1841.
		12 "	Bronze	"	1857.
	Siege and garrison	4.5-in. (rifled)	Cast iron	"	1861.
		12-pounder	Cast iron	"	1839.
		18 "	Cast iron	"	1839.
		24 "	Cast iron	"	1839.
	Sea-coast	32 "	Cast iron	"	1841.
		42 "	Cast iron	"	1841.
Columbiads		8-inch	Cast iron	"	1844.
		8 "	Cast iron	"	1861.
		10 "	Cast iron	"	1844.
		10 "	Cast iron	"	1861.
		15 "	Cast iron	"	1861.
Howitzers	Mountain	12-pounder	Bronze	"	1841.
	Field	12 "	Bronze	"	1841.
		24 "	Bronze	"	1844.
		32 "	Bronze	"	1844.
	Garrison and siege	24-pounder	Cast iron	"	1841.
		8-inch	Cast iron	"	1841.
		8 "	Cast iron	"	1861.
	Sea-coast	8 "	Cast iron	"	1841.
		10 "	Cast iron	"	1841.

Mortars	Siege	8-inch	Cast iron	Model 1841.
		8 "		" 1861.
		10 "		" 1841.
		10 "		" 1861.
	Sea-coast	10 "		" 1844.
		10 "		" 1861.
		13 "		" 1841.
		13 "		" 1861.
	Coehorn	24-pounder	Bronze	" 1841.

There are, in some of the forts, guns of an older model than the above. The 42-pounder gun, and the 8 and 10-inch sea-coast howitzers, are suppressed, by order of Feb. 9, 1861.

The forms of the several pieces of ordnance are shown in the plates 1, 2, 6, 7, 9, 10, 11, and 14.

Guns and howitzers take their denominations from the weights of their solid shot in round numbers, including the 42-pounder; larger pieces, rifle guns, and mortars, from the diameter of the bore.

DEFINITIONS.

Cascable.—The knob on the end of the breech of a gun; it is composed of the *knob* and the *neck;* sometimes the *fillet.*

Breech.—The mass of solid metal behind the bottom of the bore, extending to the cascable.

Base of the breech.—The rear surface of the breech.

Base-line.—A line traced around the gun in rear of the vent.

Base-ring.—A projecting band of metal adjoining the base of the breech and connected with the body of the gun by a concave moulding.

Reinforce.—The thickest part of the body of the gun, in front of the base ring or line: if there is more than one reinforce, that which is next to the base-ring is called the *first reinforce;* the other, the *second reinforce.*

Reinforce-band.—A band at the junction of the first and second reinforces.

Chase.—The conical part of the gun in front of the reinforce.

Astragal and *fillets.*—The moulding at the front end of the chase.

Chase-ring.—A band at the front end of the chase.

Neck.—The smallest part of the piece, in front of the chase.

Swell of the muzzle.—The largest part of the gun in front of the neck.

Muzzle-band.—A band which takes the place of the swell of the muzzle, in some guns.

Face of the piece.—The plane terminating the gun at the muzzle.

Trunnions.—Two cylinders near the centre of gravity of the gun, by which it is supported on its carriage. The axes of the trunnions are in a line perpendicular to the axis of the bore, and, in our guns, in the same plane with that axis.

Rimbase.—The shoulder at the base of the trunnion.

Bore.—All the part bored out, including the chamber, and the junction of the bore with the chamber.

Chamber.—The small part of some bores; it contains the charge of powder.

Gomer chamber.—A conical chamber which is joined to the cylinder of the bore by a portion of a spherical surface.

True windage.—The difference between the true diameters of the bore and of the ball.

Lock-piece.—A block of metal at the outer opening of the vent, to facilitate attaching a lock to the gun.

Natural line of sight.—A line drawn in a vertical plane through the axis of the piece, from the highest point of the base-ring to the highest point of the swell of the muzzle, or to the top of the sight, if there be one.

Natural angle of sight.—The angle which the natural line of sight makes with the axis of the piece.

Dispart.—The difference of the semi-diameters of the base-ring and the swell of the muzzle, or the muzzle-band. It is therefore the tangent of the natural angle of sight, to a radius equal to the distance from the rear of the base-ring to the highest point of the swell of the muzzle, the sight, or the front of the muzzle-band, as the case may be.

Preponderance.—The excess of weight of the part in rear of the trunnions over that in front: it is measured by the weight which the breech bears on a balance, the point of support resting at the rear of the base-ring, at the base-line, or at the bottom of the ratchet, the gun being suspended freely on the axis of the trunnions.

Handles.—Flat rings cast on some bronze pieces: they are placed with their centres over the centre of gravity of the piece.

Ear.—A lug of metal cast on some mortars: it is attached to a *clevis* by a bolt, and constitutes a handle.

NOMENCLATURE.

Guns of the Model of 1861.

Parts.—The *bore,* a cylinder terminated by a *semi-ellipsoid,* the *chamfer.* The *breech:* the *cascable,* the *knob,* the *neck.* The *body of the gun:* the *reinforce,* the *chase,* the *muzzle,* the *face,* the *trunnions,* the *rimbases.* For rifled guns, *vent-piece,* wrought copper, screwed in.

Mouldings.—None.

Columbiads.—Add to the above the *ratchet;* the *sight-piece.*

Mortars.—Omit the *cascable,* the *knob,* the *neck,* and add the *ratchet.* For the *sea-coast mortars,* add the *ear.*

The columbiads and mortars have their vents in planes parallel to the plane through the axis of the bore and perpendicular to the axis of the trunnions, and at a distance from it equal to one-half the radius of the bore. The vents are at right angles to the elements of the cylinder of the bore: the one on the right of the axis is not bored entirely through to the bore, by one inch. The vent of the siege and field pieces is at right angles to the axis, and in the vertical plane passing through it.

Guns of the Model of 1841 *and* 1844.

The same as for guns of model of 1861, with the following exceptions:

Parts.—The *bore* is terminated by a plane perpendicular to the axis, united with the sides (in profile) by an arc of a circle, the radius of which is one-fourth of the diameter of the bore at the bottom. The vent is in the vertical plane passing through the axis, and makes an angle of 80° with it. It enters the bore at a distance from the bottom equal to one-fourth the diameter of the bore.

Add the *second reinforce*, the *swell of the muzzle.*

Mouldings.—Add the *fillet of the cascable*, the *base-ring*, the *lock-piece*, the *chase-ring*, the *muzzle-mouldings*, *two echinus.* The *rimbases* are *cylindrical.*

Field Guns.—The same as above, except as follows: Omit the *second reinforce*, *lock-piece*, *chase-ring*, *two echinus*, and add *vent-piece*, wrought copper, screwed in, for bronze guns. The *astragal*, the *fillets*, the *lip*, the *fillet*, the *handles* for the 12-pounders.

Columbiads.—Same as guns of the model of 1841 and 1844, except as follows: *Bore*, add the *chamber* cylindrical, terminated by a *hemisphere;* the *junction of the bore* with *chamber* conical; add the *ratchet*, the *sight-piece;* omit the *lock-piece.*

Sea-Coast Howitzers.—Same as guns of model of 1844, except as follows: *Bore*, add the *chamber* cylindrical, the *junction of the bore* with *chamber* conical.

Mouldings.—Add the *reinforce-band.*

Siege Howitzers.—Same as sea-coast howitzers, except as follows: for the *first reinforce*, substitute the *recess;* the base of breech is the frustum of a cone; omit the *chase-ring*, the *swell of the muzzle;* add the *muzzle-band*, the *fillet.*

Field Howitzers.—Same as sea-coast howitzers, except as follows: *Base of breech*, a frustum of a cone; omit *lock-piece*, *reinforce-band*, *swell of muzzle;* add *muzzle-band*, *fillet*, *handles*, except for the 12-pounder, which has none; *vent-piece*, wrought copper, screwed in.

Mountain Howitzers.—Same as field 12-pounder, except for *reinforce* read *recess.*

Sea-Coast Mortars.—The *bore*, the *chamber* conical, terminated by a *hemisphere;* the *junction of the bore* with *chamber*, (in profile,) the arc of a circle. The *body of the mortar*, the *breech*, portion of a sphere; the *trunnions*, at the end of the breech; the *rimbases*, the *muzzle*, the *face*, the *muzzle-band*, the *ear*. *Vent* at right angles to the *axis* of the *bore*, in the vertical plane through it.

SIEGE MORTARS.—Same as the sea-coast, except the *chamber*, which is "Gomer," terminated at the bottom by a plane, the angles rounded by arcs of circles. Add *muzzle-fillet;* no *ear*.

Guns of the Model of 1839.

Same as those of 1841, except the *muzzle-mouldings*, which consist of an *echinus*, a *fillet*, and a *cavetto*.

Grooves of the Rifled Guns.

Number of grooves..	4½-inch gun	9
	3 " "	7
Width "	4½ " "	.97 inch.
	3 " "	.84 "
Depth "	4½ " "	.075 "
	3 " "	.075 "
Twist "	4½ " "	1 turn in 15 feet.
(uniform)	3 " "	1 " 10 "
Width of lands.......	4½ " "	.6 inch.
	3 " "	.5 "

TO DESIGNATE A PIECE OF ORDNANCE.

State the kind, the calibre, (in inches if it be foreign ordnance,) the material, the weight, the inspector's initials, the number, the country in which it was made, the date, the place of fabrication, the founder's name, the name inscribed on it, its condition for service, the kind of chamber, if any; whether it has a vent-piece, a lock-piece, handles; the ornaments, and any particular marks which may serve to identify it.

Principal Dimensions and Weights of Guns of pattern of 1861.

	COLUMBIADS.			RIFLED.		Siege Howitzer.	MORTARS.			
	Sea-Coast.			Siege.	Field.		Heavy.		Light.	
	15-in.	10-in.	8-in.	4½-in.	3-in.	8-in.	13-in.	10-in.	10-in.	8-in.
	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
Diameter of bore	15.	10.	8.	4.5	3.0	8.	13.	10.	10.	8.
True windage	0.13	0.13	0.13	.05	.05	.12	.13	.13	.13	.12
Length of bore	165.	120.	110.	120.	65.	46.5	35.	32.5	20.5	16.
Do. do. in diameters	11.	12.	13.75	26.66	21.66	5.81	2.69	3.25	2.05	2.0
Semi-axis of ellipse, bottom of bore	9.	7.5	6.	3.375	2.25	6.0	9.0	7.5	7.5	6.
Length from base-line to face of muzzle	170.	122.	111.5	121.	66.25	50.	33.	32.5	18.	14.
Whole length of piece	190.	136.66	119.475	133.	73.3	60.	54.5	47.5	28.	22.
Semi-diameter at base-line	23.65	15.63	12.5	7.8	4.71	8.75	21.5	15.	10.	8.
Semi-diameter at muzzle	12.5	8.1	6.6	4.5	3.0	7.5	21.5	15.	10.	8.
Distance between these semi-diameters	169.	121.	110.5	120.5	65.	49.25	32.0	31.5	17.	13.
Distance from face of muzzle to axis of trunnions	118.7	86.	78.75	78.35	41.415	26.09	24.45	22.8	13.	10.
Distance between rimbases	48.1	32.1	25.7	15.0	9.5	18.0	43.4	30.4	20.4	16.4
Length of trunnions	6.5	3.25	3.25	4.0	2.8	5.0	3.5	3.5	3.5	2.5
Diameter of trunnions	15.	10.	8.	5.3	3.67	5.82	15.	12.	12.	10.
Maximum diameter	48.	32.	25.6	16.	9.7	17.5	43.	30.	20.	16.
Distance of the max. diameter from the face of muzzle	155.	110.	102.	110.	60.					
Weight ... pounds	49,099	15,059	8,465	3,450	820	......	17,120	7,300	1,900	1,010
Preponderance ... pounds	1,200	519	350	300	40					

NOTE.—The vent is .2 inch in diameter, *in all* guns.

Principal Dimensions and Weights of Guns, Model 1839–1844.

	Iron.					Brass.		
	Sea-Coast.		Siege and Garrison.			Field.		
	42	32	24	18	12	12	12 1857.	6
	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
Diameter of the bore	7.	6.4	5.82	5.3	4.62	4.62	4.62	3.67
True windage	0.16	0.15	0.14	0.13	0.10	0.10	0.10	0.09
Length of bore	110.	107.6	108.	108.5	103.4	74.	63.6	57.5
Do. in diameters	**15.71**	**16.78**	**18.56**	**20.47**	**22.38**	**16.**	**13.76**	**15.67**
Length from rear of base-ring to face of muzzle	117.	114.	114.	114.	108.	78.	66.	60.
Whole length of the piece	129.	125.7	124.	123.25	116.	85.	72.15	65.6
Semi-diameter of the base-ring	12.2	11.7	10.7	9.875	8.7	6.5	5.5	5.15
Semi-diameter of the swell of the muzzle	8.4	7.7	7.793	6.935	5.932	5.17	4.25	4.125
Distance between these two semi-diameters	115.	112.	111.	111.6	105.8	76.3	65.	58.7
Natural angle of sight	....	....	1°30′	1°30′	1°30′	1°	1°6′	1°
Distance from rear of base-ring to rear of trunnions	43.2	42.2	43.	43.50	42.	30.7	25.4	23.25
Diameter of the base-ring	24.4	23.4	21.4	19.75	17.4	13.	11.	10.3
Distance between the rimbases	22.	20.7	18.	16.8	14.8	12.	11.5	9.5
Length of the trunnions	6.5	6.	5.	4.75	4.5	3.5	3.25	2.8
Diameter of the trunnions	7.	6.4	5.82	5.3	4.62	4.62	4.2	3.67
Distance from axis of trunnions to face of muzzle	70.3	68.6	68.09	67.85	63.69	44.99	38.5	34.91
Weight ... pounds	8,465	7.200	5,790	4,913	3,590	1,757	1,227	884
Preponderance ... pounds	600	695	395	305	270	108	123	47

Principal Dimensions and Weights of Columbiads and Howitzers, Model 1841.

	COLUMBIADS.		HOWITZERS.							
	Shell guns.		IRON.				BRONZE.			
	Model 1844.		Sea-Coast.		Siege and Garrison.		Field.			Mountain.
	10-in.	8-in.	10-in.	8-in.	8-in.	24-pr.	32-pr.	24-pr.	12-pr.	12-pr.
	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
Diameter of the bore	10.	8.	10.	8.	8.	5.82	6.4	5.82	4.62	4.62
True windage	0.13	0.13	0.13	0.12	0.12	0.14	0.15	0.14	0.10	0.10
Length of bore, exclusive of chamber	99.00	100.	96.	85.5	38.5	53.25	64.	56.25	46.25	28.16
" " " " in diameters	**9.9**	**12.5**	**9.6**	**10.68**	**4.81**	**9.15**	**10.**	**9.66**	**10.**	**6.1**
Diameter of the chamber	8.	6.4	7.	6.4	4.62	4.62	4.62	4.62	3.67	3.34
Length of the chamber	12.	11.	9.5	7.5	8.	4.75	7.	4.75	4.25	2.75
Length from rear of base-ring to face of muzzle	120.	119.	112.	98.	52.	62.	75.	65.	53.	32.91
Whole length of the piece	126.	124.	124.25	109.	61.5	69.	82.	71.2	58.6	37.21
Semi-diameter of base-ring	16.	13.	13.25	11.10	9.125	6.9	6.9	6.	5.	3.8
Semi-diameter of swell of muzzle	10.75	8.5	10.125	8.25	8.225	5.85	5.6	4.875	4.1	3.45
Distance between these semi-diameters	117.5	117.	109.5	96.	51.5	61.8	74.75	64.8	52.85	32.91
Natural angle of sight	1° 21′	1° 23′	....	....	1°	1°	1°	1°	1°	0° 37′
Distance from rear of base-ring to rear of trunnions	41.5	41.5	41.	37.4	24.	24.69	30.7	27.5	23.25	15.
Diameter of base-ring	32.	26.	26.5	22.2	18.25	13.8	13.8	12.	10.	7.6
Distance between the rimbases	31.	25.	25.	20.7	18.	12.8	12.	11.5	9.5	6.9
Length of the trunnions	9.	6.5	7.5	6.	5.	3.25	3.5	3.25	2.8	2.25
Diameter of the trunnions	10.	8.	8.	6.4	5.82	4.62	4.62	4.2	3.67	2.7
Distance from axis of trunnions to face of muzzle	73.5	73.5	67.	57.4	25.09	35.	41.99	35.4	27.91	16.56
Weight ... pounds	15,400	9,240	9,500	5,740	2,614	1,476	1,920	1,318	788	220
Preponderance ... pounds	740	635	475	462	420	70	160	146	95	

Principal Dimensions and Weights of Mortars, Model 1841.

	Iron.				Bronze.
	Heavy.		Light.		Coehorn 24-pr.
	13-in.	10-in.	10-in.	8-in.	
	Inches.	Inches.	Inches.	Inches.	Inches.
Diameter of the bore	13.	10.	10.	8.	5.82
True windage	0.13	0.13	0.13	0.12	0.14
Length of the bore, exclusive of the chamber	26.	25.	15.	12.	8.82
" " " " " in diameters	**2.**	**2.5**	**1.5**	**1.5**	**1.51**
Diameter of the chamber. Superior (at the bottom of the shell in iron mortars)	9.5	7.15	7.6	6.08	3.
Diameter of the chamber. Inferior	7.25	5.64	5.	4.	2.
Length of the chamber	13.	10.	5.	4.	4.25
Whole length of the mortar	53.	46.	28.	22.5	16.32
Distance from face of muzzle to front of trunnions	41.	37.	20.	16.5	13.57
Distance between the rimbases	36.	27.5	20.5	16.25	7.5
Length of the trunnions	8.5	6.5	5.	4.	2.5
Diameter of the trunnions	12.	9.	8.	6.	2.75
Weight ... pounds	11,500	5,775	1,852	930	164

MATERIALS FOR ORDNANCE.

Bronze.

Bronze for cannon (commonly called *brass*) consists of 90 parts of copper and 10 of tin, allowing a variation of one part of tin, more or less. It is more fusible than copper, much less so than tin, more sonorous, harder, and less susceptible of oxidation, and much less ductile, than either of its components. When the mixture is well made, the metal is homogeneous: the fracture is of a uniform yellow color, with an even grain. The specific gravity of bronze is about 8.700, being greater than the mean of the specific gravities of copper and tin.

Pure copper is of a red color, inclining to yellow; it has a fine metallic lustre. The fracture of cast copper is even-grained; that of a forged bar exhibits a short, even, close grain, of a silky appearance; it is strong, very ductile, and very malleable. The greater the purity of copper, the more malleable it is, and the finer the grain. Specific gravity, from 8.600 to 9.000. The copper of commerce is impure, frequently containing oxygen, silver, iron, lead, tin, zinc, antimony, and arsenic. It should be rejected, for the manufacture of guns, if it contain sulphur in an appreciable quantity; more than one-thousandth of arsenic and antimony united; more than about three-thousandths of lead, iron, or oxygen; if it contain more than about five-thousandths of foreign substances altogether; or if, near these limits, it give bad results when subjected to the mechanical tests of hammering, rolling, and wire-drawing.

Pure tin is of a white color, a little darker than silver; it is very malleable, and susceptible of being rolled into thin sheets; it is not very ductile; it is soft, and, when, in rods or bars, is bent backwards and forwards, it gives a peculiar crackling sound, the distinctness of which is in proportion to the purity of the tin. Specific gravity, 7.290 to 7.320.

Tin for gun-metal should be rejected if, when run into elongated drops, it have not a smooth and reflecting surface, without any considerable sign of rough spots; if, when analyzed, it contain more than about one-thousandth of arsenic and antimony united; more than about three-thousandths of lead or iron; or more than four-thousandths of foreign substances.

All *bronze* ought to be rejected which contains sulpur in an appreciable amount; which contains more than about one-thousandth of arsenic and antimony united; more than about three-thousandths of lead, iron, or zinc; or, in all, more than about five-thousandths of foreign substances.

Notice should be taken of the appearance of the fracture of specimens: it sometimes gives indications sufficient to authorize the rejection of certain bronzes full of sulphur or oxides.

Analysis of bronze.

TIN.—Nitric acid dissolves the copper and converts the tin into an insoluble peroxide. Put into a small glass matrass 10 parts (say 100 grains) of bronze, in small particles, and 80 parts of very pure nitric acid, at 22° Beaumé's hydrometer, (specific gravity, 1,180;) heat it gradually to ebullition, and continue that heat until red vapors cease to come over. Let it settle; pour off the liquor, and add to the oxide of tin 20 parts of nitric acid; let it boil ten minutes; decant the liquor again, and repeat the same operation; dilute the first portion decanted with 2 or 3 times its volume of water, and pass it through a filter; do the same with the second and third portions. Then throw the oxide of tin on a double filter, the two parts of which are equal; wash the precipitate on the filter until the water that comes off no longer gives a blue color when heated with ammonia, and does not change the color of litmus-paper. Spread the filter on paper, and dry it perfectly in a stove or a sand-bath. Weigh it, adding the exterior filter to the weights, in order to ascertain the quantity of peroxide of tin which remains on the upper filter; 127 parts of peroxide give 100 parts of pure tin.

COPPER.—Collect the nitric acid solutions obtained in the process described above; evaporate them to dryness; calcine and weigh the black residuum; it is the oxide of copper; 100 grains of oxide of copper contains 79.82 grs. of copper. Or, dissolve, in a large matrass with a narrow neck, about 1.1 gr. of bronze in pure aqua regia, adding to it about 0.1 gr. of lead. Pour into the solution an excess of ammonia; then, keeping the liquid constantly boiling, pour into it from a graduated vessel a solution of monosulphuret of sodium, until the liquid becomes entirely colorless. From the volume of sulphuret used, the amount of copper in the liquid can be determined.

SULPHUR.—In boiling bronze in nitric acid or aqua regia, a part of the sulphur is converted into sulphuric acid, which remains in the solution: the rest collects on the surface in yellow globules. These globules are collected and weighed.

The sulphuric acid is precipitated as a sulphate of baryta by the chloride of barium, and is weighed after being washed and dried: 100 grains of the sulphate of baryta contains 13.797 grs. of sulphur.

Mechanical Tests.

Chemical analysis is not sufficient to give a correct estimate of the qualities of all bronzes. In other words, good bronzes according to the results of analysis may be very inferior, deficient in strength, on account of oxides interspersed between the molecules, or want of homogeneity.

Bronzes should be subjected to fusion in a close crucible; to hammering into thin plates, and to wire-drawing, both before and after fusion; if it improves in these particulars by the fusion, a comparison with the analysis will show whether the improvement is due to the volatilization of certain metals, or to the decomposition of oxides. The results obtained by hammering and wire-drawing should be compared with those made on bronze known to be of the best quality.

Cast Iron.

(*See also Chapter* 14.)

Iron for making cannon should be smelted with the greatest possible care, with charcoal, and a blast of a constant temperature of 125° to 300°, depending upon the ore used. All the materials which enter the smelting-furnace should be of the best and purest quality, should be kept dry, be supplied at regular intervals of time, be regularly and uniformly mixed together in the smelting-furnace, and, as far as practicable, rendered independent of the vicissitudes of the weather, that the greatest possible uniformity in the iron produced from day to day may be obtained.

The most important quality of gun-iron, after a medium strength of 25,000 to 30,000 pounds per square inch, is *uniformity*, without which no two guns can be made alike, or any idea formed of what kind of guns are being made.

The quality of iron in the pig is generally judged of by its strength, and by the appearance and feel of the freshly-fractured surface. It should be soft, yielding easily to the file or chisel; its fracture should present a rough, jagged surface, of uniform appearance, a dark gray color, a brilliant aspect, and crystals under medium size, angular, and sharp to the touch.

But iron for making guns requires to be still further tested before it can be known, even by the most practised eye and judgment, to possess all of the essential qualities of a good gun-iron. These qualities are tenacity, elasticity, extensibility, and incompressibility: that iron will be the best which has them all to the greatest degree, and the absence of any one will render the iron unfit for guns. The existence of these qualities is best determined by actual experiment on specimens cut from castings of the size of the gun to be made.

The density is indicative to some extent of the tenacity, elasticity, and incompressibility of the iron; but the density will increase after the tenacity and extensibility have reached their maximum.

When cast into cannon, iron should be above medium in hardness, but yielding readily to the file or chisel, and offering no great difficulty in turning and boring. Its color should be a bright, lively gray, showing incipient mottle in small guns, and becoming more marked as the size of the gun, and time of cooling, increase. The structure should be uniform, close and compact; crystals small, with acute angles, and sharp to the touch;

the fractured surface uneven, rough, and jagged, with many fragments strongly adhering.

Before making guns from an iron which has never been tried for this purpose, a sample-gun of the calibre of the gun to be made should first endure a satisfactory proof with service-charges.

The mean specific gravity of gun-iron is about 7.248, and the average tenacity about 30,000 per square inch.

Wrought Iron and Steel.

Experimental guns have been made of wrought iron and steel, giving satisfactory results, and an order has been given for guns, to be made of the former material. The superior strength of these materials, and the evenness, smoothness, and hardness of surface of which they are susceptible, render it probable that these are the materials of which our field rifle guns will soon be made, exclusively.

INSPECTION OF ORDNANCE.

Instruments.

1. *Star gauge.*—This is an instrument for measuring the diameter of the bore of a gun, at any part.

The head is of brass, with four steel sockets for the measuring-points. Two of the sockets are soldered fast into the head; the other two are movable. The movable sockets and points are pushed out by means of two inclined cylinders, which are fastened to a stem, forming a conical slider. This slider tapers 0.35 in. in a length of 2.2 in.; so that by pushing the slider the 35th part of this length (about .06 in.) the distance between the movable points is increased .01 in.

The slider is connected with a square steel rod, consisting of three parts, which are screwed together, according to the length of bore to be measured. This rod slides through a brass tube, which is also made in three pieces.

The tube is graduated, in inches and quarters, commencing at the measuring-points, so as to indicate the distance of the latter from the muzzle of the gun.

The handle is of wood, attached to a brass cylinder, or socket, through which the sliding-rod passes. In the tube of the handle there is a slit, on the side of which a scale is marked, to indicate the movements of the measuring-points. Each joint of the long tube has a mark, made on a small plate of silver, which shows the place of the zero on the scale when the measuring-points are adjusted to the true diameter of the bore. In this position the handle is fixed on the sliding-rod by means of a screw clamp.

A *ring gauge*, for each calibre, is used for adjusting the instrument for use.

A *rest*, in the form of a T, is placed in the mouth of the gun, to keep the instrument in the axis of the bore. This rest has three slides, which can be adjusted to the different sizes of bore; the upright branch is movable, for convenience of packing.

The star gauge, its points and rest, are packed in one box, and the ring gauges in another.

2. The *cylinder-staff.*—This is a round staff, made of mahogany, or other hard wood. It is in two parts, which are joined together by brass sockets and screws; each part has also a brass socket and screw at the outer end, to receive the *cylinder-gauge*, *guide-plate*, and *measuring-point*. The staff is graduated, in inches and tenths, on a strip of brass let into it, on one side. These graduations are arranged to read the distances from the extremity of the measuring-point, when it is screwed on the staff.

The cylinder-staff is supported, at the muzzle of the piece, by a *half-tompion* of wood, having in the centre a groove of the size of the staff. The *rest* for the star gauge may be used also for this purpose.

3. The *cylinder-gauge* is a hollow cylinder of wrought or cast iron, turned to the exact minimum (or true) diameter of the bore. The length of the cylinder is equal to its diameter. It has cross-heads, at right angles to each other: one with a smooth hole of the same diameter as the cylinder-staff; the other tapped for the screw of the staff socket. Weight for 8 in., 27 lbs.; for 10 in., 40 lbs.

4. The *guide-plate* is a circular iron plate 0.2 inch thick, and of the minimum diameter of the bore; it has a hole in the centre, with a thread by which it is screwed to the cylinder-staff; it serves to direct the measuring-point to the centre of the bottom of the bore.

5. The *measuring-point* is screwed on the end of the cylinder-staff, over the guide-plate, to measure the depth of the bore; it is of iron, cylindrical in shape, so far as it screws on the end of the staff, and tapering down to the diameter of 0.75 inch.

6. The *trunnion-gauge* is an iron ring of the diameter of the trunnions, which must pass over them and fit closely. The exterior diameter of this gauge serves to verify that of the rimbases.

7. The *trunnion-square* is a double square of wood, the distance between whose branches is the same as that between the rimbases of the gun; in the centre is a pointed sliding plate, with a thumb-screw to fasten it; the lower edges of the branches, which are shod with iron, are in the same plane, parallel to the upper edge of the connecting piece, so that when the square is placed with its branches resting on the trunnions, the upper edge of the connecting piece is parallel to their axis. Each branch has also an iron plate projecting perpendicularly from one side to rest on the top of the trunnions. It is used to ascertain the position of the trunnions in relation to the axis of the bore and to each other.

8. The *trunnion-rule*, for measuring the distance from the rear of the base-ring to the rear of the trunnions.

9. *Callipers*, to measure diameters.

10. A *standard scale*, for verifying other instruments.

11. A wooden *rule*, to measure exterior lengths.

12. The *vent-gauges* are two pointed pieces of steel wire, 0.005 in. greater and less than the true diameter of the vent.

13. The *vent-searcher* is a hooked steel wire, about half the diameter of the vent.

14. A *rammer-head*, shaped to the form of the bottom of the bore, and furnished with a staff, is used to ascertain the interior position of the vent.

15. A *mirror; sperm candles; beeswax.*

16. *Rammer, sponge,* and *priming-wire.*

17. *Figure* and *letter stamps*, to affix the required marks.

Inspection of Ordnance.

Cannon presented for inspection and proof are placed on skids for the convenience of turning and moving them easily. They are first examined carefully on the exterior, to ascertain whether there be any flaws or cracks in the metal, whether they be finished as prescribed, and to judge, as well as practicable, of the quality of the metal. They must not be covered with paint, lacker, or any other composition. If it be ascertained that an attempt has been made to conceal any flaws or cavities by plugging, or filling them with cement or any substance, the gun is rejected without further examination. After this preliminary examination, the inspector proceeds to verify the dimensions of the piece. The *interior of the bore* is first examined by reflecting the sun's rays into it from the mirror; or, if the sun be obscured, by a lighted candle or a lamp placed on the end of a rod and inserted into the bore. The *cylinder-gauge*, screwed on the staff, is then pushed gently to the bottom of the cylindrical part of the bore and withdrawn; it must go to the bottom, or the bore is too small.

The *bore of the piece* is then measured with the star gauge. The measurements should be made at intervals of ¼ inch in the part of the bore occupied by the shot; at intervals of 1 inch in the rest of the bore in rear of the trunnions, and of about 1 calibre from the trunnions to the muzzle.

The *position of the trunnions*, with regard to the axis of the bore and to each other, is next ascertained.

To verify the position of the axis of the trunnions.—Set the trunnion-square on the trunnions, and see that the lower edges of its branches touch them throughout their whole length; push the slide down till it touches the surface of the piece, and secure it in that position by the thumb-screw; turn the gun over, and apply the trunnion-square to the opposite side, and if, when the point of the slide touches the surface of the piece, the lower edges of the branches rest on the trunnions, the axis of the trunnions is in the same plane with the axis of the bore; if they do not touch the trunnions, their axis is above the axis of the bore by half the space between; and if the edges touch the trunnions, and the point of the slide does not touch the surface of the piece, their axis is below the axis of the bore. If the *alignment of the trunnions* be accurate, the edges of the trunnion-square will fit on them when applied to different parts of their surface; their diameter and cylindrical form, and the diameter of the rimbases, are verified with the trunnion-gauge.

To ascertain the length of the bore.—Screw the *guide-plate* and *measuring-point* on the cylinder-staff, and push them to the bottom of the bore; place a *half-tompion* in the muzzle, and rest the staff in its groove; apply a *straight-edge* to the face of the muzzle, and read the length of the bore on the staff. The *exterior lengths* are measured by the *rule*, or by a *profile*, the accuracy of which is first verified. The *exterior diameters* are measured with the *callipers* and *graduated rule*. The *position of the interior orifice of the vent* is found from the mark made on the *rammer-head* by the *vent-gauge* inserted in the vent, while the rammer-head is held against the bottom of the bore: two impressions are taken. The position of the exterior orifice of the vent is also verified. The *vent* is examined with *gauges*, and with the *vent-searcher*, to ascertain if there are any cavities in it.

All *bronze* ordnance should be bored under size from .04 to .05 inch, and after proof reamed out to the exact calibre. *Whitish spots* show a separation of the tin from the copper, and, if extensive, should condemn the piece. A *great variation from the true weight*, which the dimensions do not account for, shows a defect in the alloy.

In *mortars*, the dimensions of the *chambers*, and the *form of the breech*, may be verified with *patterns* made of plate iron.

After the *powder proof*, the bore is washed and wiped clean, and the bore and vent are again examined, and the bore re-measured. The results of each of the measurements and examinations are noted on the inspection report against the number of the gun.

A proper discretion must be exercised in the inspection of ordnance; such slight imperfections as do not injure a piece for service may be disregarded, whilst the instructions should be strictly enforced with regard to defects which may impair its utility.

Variations allowed in the Dimensions of Ordnance.

		Field.	Garrison, etc.
		Inches.	Inches.
In the bore	More than the prescribed diameter	0.02	0 03
	Less than the prescribed diameter	.00	.00
In exterior diameters.	Where turned, more or less	.04	.05
	Where not turned. more	.10	.20
	Where not turned. less	.05	.05
In the length.	Of the bore, more or less	.10	.20
	From rear of base-line to face of muzzle, more or less	.10	.25
	Of the breech, including cascable, more or less	.15	.20
	Of the base-ring, more or less	.05	.05
	Of the reinforce, more or less	.10	.20
	Of the chase, including the muzzle, more or less	.10	.15
	From rear of trunnions to base-line, more or less, in different pieces	.10	.20
In the position of the axis of the trunnions.	above the axis of the bore	.00	.00
	below the axis of the bore	.20	.20
In the length of the trunnions,	more	.10	.10
	less	.05	.05
Diameter of trunnions, less		.03	.04
In the distance between the rimbases, less		.05	.05
In the same gun, no variation is allowed in the position or in the alignment of the trunnions.			
In the vent	Diameter... more	.005	.005
	Diameter... less	.00	.00
	Position of exterior orifice, more or less.	.05	.05
	Position of interior orifice, more or less.	.20	.20
Depth of cavities.	In the bore or vent	.00	.00
	On the exterior surface	.20	.25
	On the trunnions, within one inch of the rimbases	.10	.10
	On the trunnions elsewhere	.20	.25

The whole exterior surfaces of guns, except mortars, are turned in the athe, or dressed smooth in the parts which cannot be turned.

PROOF OF ORDNANCE.

Gunpowder for proving ordnance should be of the best quality, giving not less than the standard initial velocity; it should be proved immediately before being used, unless it shall have been proved within one year previously, and there be no reason to suspect that it has become deteriorated.

The *cartridge-bags* are made of cotton or paper, the full diameter of the bore or chamber. They are filled by weight; and, if not filled at the place where the guns are proved, each bag should be enveloped in a paper cylinder and cap, marked with the weight of powder and its proof qualities.

The *shot* must be smooth, free from seams and other inequalities that might injure the bore of the piece, and they must be of the true diameter given in the tables.

Guns and *howitzers* are laid with the muzzle resting on a block of wood and the breech on the ground, or on a thick plank, giving the bore a small elevation.

Bronze pieces are mounted on appropriate carriages or beds.

Mortars are mounted on strong wooden frames or iron beds, at an elevation of 45°, supported by the trunnions.

In proving iron ordnance, after pricking the cartridge, prime with powder, or a tube, and place over the vent a piece of port-fire, set in clay or putty, long enough to permit the man who fires it to reach a place of safety before the charge explodes.

Each piece shall be fired three rounds with the following

Proof-charges.

15-inch columbiad	50 lbs. of powder and	1 shell.	
10 " "	18 " " "	1 shot.	
8 " "	12 " " "	1 "	
32-pounder gun	9 " " "	1 "	
24 " "	8 " " "	1 "	
18 " "	6 " " "	1 "	
12 " "	4 " " "	1 "	
8-inch siege howitzer	4 " " "	1 "	
24-pounder howitzer (iron)	3 " " "	1 shot, strapped.	
All field guns (bronze)	⅓ weight of shot.	1 " "	
32-pounder howitzer "	3.25 lbs. of powder and	1 " "	
24 " " "	2.5 " " "	1 " "	
12 " " "	1.25 " " "	1 " "	
12 " " mountain (bronze)	0.5 " " "	1 " "	
Coehorn mortar (bronze)	0.5 " " "	1 shell.	
13-inch S. C. mortar (iron)	20 " " "	1 "	Filled with sand.
10 " " " "	10 " " "	1 "	Filled with sand.
10 " " Light	5 " " "	1 "	Filled with sand.
8 " " Light	2.5 " " "	1 "	Filled with sand.
4½ " rifled siege gun	4.5 " " "	1 shot of 36 lbs.	
3 " " field "	1.5 " " "	1 " of 11 lbs.	

Should any of the guns proved at one time fail to sustain the above proof, the remainder shall be rejected, if made of the same metal treated in the same manner.

The bore, vent, and the exterior surface of every piece which is approved should be well covered with sperm oil immediately after the inspection.

MARKS.

All guns are required to be weighed and to be marked, as follows,—viz.: the *number of the gun, the initials of the inspector's name, and that of the foundry, the year of fabrication,* and the *weight of the piece in pounds* on the face of the piece, in a circle concentric with the bore, in letters and figures at least one inch long; the numbers in a separate series for each kind and calibre at each foundry; the foundry-number, in small figures, on the end of the right rimbase, above the trunnion; the letters U. S., in large characters, on the upper surface of the piece, in rear, but near the trunnions.

The highest point of metal at the base-line and at the muzzle, when the axis of the trunnions is horizontal, should be marked, with a fine line cut into the metal, whilst the piece is in the trunnion-lathe.

Guns rejected on inspection are marked X C, on the face of the muzzle; if condemned for erroneous dimensions which cannot be remedied, add X D; if by powder proof, X P.

INJURIES CAUSED BY SERVICE.

Bronze guns are little subject to external injury, except from the bending of the trunnions, sometimes, after long service, or heavy charges.

Internal injuries are caused by the action of the gases developed in the combustion of the powder, or by the action of the shot in passing out of the bore. These effects generally increase with the calibre of the piece.

Of the first kind, the principal one is the cutting away of the metal of the upper surface of the bore over the seat of the shot.

Those of the second kind are: *The lodgment of the shot,* a compression of the metal on the lower side of the bore, at the seat of the shot, caused by the pressure of the gas in escaping over the top of the shot. There is a corresponding *burr* in front of the lodgment, and the motion thereby given to the shot causes it to strike alternately on the top and bottom of the bore, producing other *enlargements,* generally *three* in number; it is chiefly from this cause that bronze guns become unserviceable. *Scratches* caused by the fragments of a broken shot, or the roughness of an imperfect one.

The durability of bronze guns may be much increased by careful use, and by the precautions of *increasing the length of the cartridge,* or that of the *sabot,* or using *a wad over the cartridge,* in order to change the place of the shot; by *wrapping the shot in woollen or other cloth,* or *in paper,* so as to diminish the windage and the bounding of the shot in the bore. In field *guns,* both bronze and iron, the paper cap which is taken off from the cartridge should always be put over the shot.

Iron guns are subject to the above defects in a less degree than bronze, except the corrosion of the metal. The principal cause of injury to iron guns is the *rusting* of the metal, producing a roughness and enlargement of the bore.

The service to which an iron gun has been subjected may generally be determined by the appearance of the vent. After about 500 rounds the vent becomes enlarged to .3 inch, and should not be longer used.

In rifled guns the wear of the vent is about twice as great as in smooth-bored guns.

Replacing Vents.—In field and rifled pieces, the vent-piece is taken out and a new one is screwed in. In other guns, the vent is filled up by pouring in melted zinc, the vent being closed on the interior by means of clay placed on the head of a rammer and pressed against the upper surface of the bore, and a new vent is bored, at a distance of two or three inches from the first.

Spiking and unspiking guns, and rendering them unserviceable.

To spike a piece, or to render it unserviceable.—Drive into the vent a jagged and hardened steel spike with a soft point, or a nail without a head; break it off flush with the outer surface and clinch the point inside by means of the rammer. Wedge a shot in the bottom of the bore by wrapping it with felt, or by means of iron wedges, using the rammer or a bar of iron to drive them in; a wooden wedge would be easily burnt by means of a charcoal fire lighted with the aid of a bellows. Cause shells to burst in the bore of bronze guns, or fire broken shot from them with high charges. Fill a piece with sand over the charge to burst it. Fire a piece against another, muzzle to muzzle, or the muzzle of one to the chase of the other. Light a fire under the chase of a bronze gun, and strike on it with a sledge to bend it. Break off the trunnions of iron guns; or burst them by firing them with heavy charges and full of shot, at a high elevation.

When guns are to be spiked temporarily, and are likely to be retaken, a *spring spike* is used, having a shoulder to prevent its being too easily extracted.

To unspike a piece.—If the spike is not screwed in or clinched, and the bore is not impeded, put in a charge of powder of $\frac{1}{3}$ the weight of the shot, and ram junk wads over it with a handspike, laying on the bottom of the bore a strip of wood with a groove on the under side containing a strand of quick-match by which fire is communicated to the charge; in a bronze gun, take out some of the metal at the upper orifice of the vent, and pour sulphuric acid into the groove for some hours before firing. If this method, several times repeated, is not successful, unscrew the vent-piece, if it be a bronze gun, and if an iron one, drill out the spike, or drill a new vent.

To drive out a shot wedged in the bore.—Unscrew the vent-piece, if there be one, and drive in wedges so as to start the shot forward, then ram it back again in order to seize the wedge with a hook; or pour in powder and fire it, after replacing the vent-piece. In the last resort, bore a hole in the bottom of the breech, drive out the shot, and stop the hole with a screw.

To use a piece which has been spiked.—Insert one end of a piece of quick-match in the cartridge, allowing the other to project out of the muzzle of the gun. Apply the fire to the quick-match, and get out of the way.

When quick-match of sufficient length is not at hand, insert one end in the cartridge, the other projecting in front of the shot, and, after ramming the cartridge home, throw two or three pinches of powder into the bore. Place another piece of match in the muzzle, the end projecting out. The piece may be fired in this way without danger. Quick-match in the cartridge may be dispensed with by piercing three or four holes in the cartridge-bag. In this manner the gun may be fired with great rapidity.

PRESERVATION OF ORDNANCE.

Cannon should be placed together, according to kind and calibre, on skids of stone, iron, or wood, laid on hard ground, well rammed and covered with a layer of cinders, or of some other material to prevent vegetation.

Guns and long howitzers.—The pieces should rest on the skids in front of the base-ring and in rear of the astragal; the axis inclined at an angle of 4 or 5 degrees with the horizon, the muzzle lowest; the trunnions touching each other; or, if space be wanting for that arrangement, the trunnion of one piece may rest on the adjoining piece, so that the axis of the trunnions is inclined about 45° with a horizontal line; the muzzle closed with a tompion or a plug of dry wood, well saturated with oil or grease; the vent down, stopped with a greased wooden plug, or with putty or tallow. If circumstances require it, the pieces may be piled in two tiers, with skidding placed between them, exactly over those which rest on the ground; the muzzles of both tiers in the same direction and their axes preserving the same inclination.

Short howitzers and mortars.—On thick planks, standing on their muzzles, the trunnions touching, the vents stopped.

Iron ordnance should be covered on the exterior with a lacker impervious to water, (see Chap. VII.;) the bore and the vent should be greased with a mixture of *oil* and *tallow*, or of *tallow* and *beeswax* melted together and boiled to expel the water. The lacker should be renewed as often as required, and the grease at least once every year.

The lacker and grease should be applied in hot weather.

The cannon should be frequently inspected, to see that moisture does not collect in the bore.

CHAPTER SECOND.

SHOT AND SHELLS.

NOMENCLATURE, DIMENSIONS, WEIGHTS.

Shot, shells, grape and canister shot take the name of the gun or howitzer in which they are used. The size of grape and canister shot is so regulated that a certain number shall chamber in the bore.

The *ears* of a shell are holes for the points of the shell-hooks, 0.5 inch in diameter, bored on opposite sides of the fuze-hole, their axes perpendicular to the axis of the fuze-hole. The metal is cut out above them at the distance indicated in the table, in a direction perpendicular to the axes of the holes, which must remain 0.25 inch deep, with a thickness of 0.25 inch of metal above them, at the thinnest part.

Shot.

	13-in.	12-in.	10-in.	8-in.	42	32	24	18	12	9	6	4	3	1
Diameter, in.	12.87	11.87	9.87	7.88	6.84	6.25	5.68	5.17	4.52	4.10	3.58	3.12	2.84	1.96
Weight, lbs.	282.84	222	127.6	65	42.5	32.4	24.3	18.3	12.25	9.14	6.1	4.07	3.05	1

Shells.

	For Columbiads and S.C. Howitzers.		For Mortars.			For Guns and Howitzers.				
	10-in.	8-in.	13-in.	10-in.	8-in.	42	32	24	18	12
	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
Diameter	9.87	7.88	12.87	9.87.	7.88	6.84	6.25	5.68	6.17	4.62
Thickness of sides and bottom. True	2.	1.5	2.5	1.6	1.25	1.2	1.	0.9	0.9	0.7
Thickness of sides and bottom. Greatest	2.1	1.68	2.65	1.7	1.33	1.25	1.05	0.95	0.94	0.74
Thickness of sides and bottom. Least	1.9	1.42	2.35	1.5	1.17	1.15	0.95	0.85	0.86	0.66
Thickness at fuze-hole	3.	2.25	2.5	1.6	1.25	1.8	1.35	1.35	1.35	1.05
Diameter of fuze-hole. Exterior	1.45	1.338	1.8	1.75	1.3	1.	0.9	0.9	0.9	0.9
Diameter of fuze-hole. Interior	1.	1.	1.247	1.51	1.113	0.73	0.698	0.698	0.698	0.743
Distance between ears	6.	5.	7.	6.	5.					
Weight.....lbs.	101.67	49.75	218	88.42	44.12	31.3	22.5	16.8	13.45	8.34

The 8-inch mortar-shell is used for the siege howitzer. The 15-inch shell is 14.85 in. diameter. It has two ears at the extremities of the diameter at right angles to the axis of the fuze-hole. Thickness of shell, 2.5 inch.

Spherical case shot.

	8-in.	42	32	24	18	12	6
	In.	In.	In.	In.	In.	In.	In.
Diameter	7.88	6.84	6.25	5.68	5.17	4.52	3.58
Thickness of metal at the sides. True	0.7	0.65	0.60	0.55	0.5	0.45	0.36
Thickness of metal at the sides. Greatest	0.725	0.675	0.625	0.575	0.525	0.475	0.385
Thickness of metal at the sides. Least	0.675	0.625	0.575	0.525	0.475	0.425	0.335
Thickness of metal at the fuze-hole	1.5	1.25	1.25	1.1	1.1	0.9	0.9
Depth of recess for fuze	.4	.4	.4	.4	.4	.4	.4
Diameter of fuze-hole. Exterior	1.62	1.62	1.62	1.62	1.62	1.62	1.62
Diameter of fuze-hole. Interior	.75	.75	.75	.75	.75	.75	.75
Mean weight ...lbs.	30.36	20.73	16.12	12.32	9.27	6.22	3.22

The thickness of metal at the fuze-hole is supposed to be measured in the axis of the fuze-hole between the spherical surfaces of the shell and of the reinforce.

Spherical case shot of the old pattern *may* be used with the Bormann fuzes.

The fuze-holes of shells and spherical case shot for the fuze-plug taper 0.15 inch to 1 inch.

Diameter of gauges for Shot and Shells.

	13-in.	12-in.	10-in.	8-in.	42	32	24	18	12	9	6	4	3	1
	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
Large	12.90	11.90	9.90	*7.90	6.86	6.27	5.70	5.18	4.53	4.12	3.60	3.14	2.86	1.96
Small, new	12.84	11.84	9.84	7.85	6.81	6.22	5.65	5.13	4.49	4.08	3.56	3.10	2.82	1.92
Small, old	12.80		9.80	7.80	6.76	6.18	5.61	5.10	4.46	4.05	3.54		2.80	

* The gauges for 8-inch *solid shot* are 7.85 and 7.80 in. respectively.

For the manner of using these gauges, see page 38.

Case Shot for Rifled Guns.

Dimensions.	4½-in.		3-in.		Remarks.
	Iron.	Soft Metal.	Iron.	Soft Metal.	
Diameter ...in.	4.43	4.45	2.93	2.95	Thickness at end of cup, .25 inch.
Length ...in.	8.2	1.5	6.7	1.5	Depth of cup. .5 in.
Thickness of metal at sides ...in.	.625	.15	.4	.15	Diameter of fuze-hole, 1 inch.
" " " " bottom ...in.	.7	.1	.5	.1	
" " " " fuze-hole ...in.	2.	... .	2.	....	

The soft metal (lead 8, antimony 1) is attached most securely by casting it on a tin cup set up in a die of the proper size, and pouring the iron into the cup placed in the bottom of the mould.

Grenades.

Six-pounder spherical case shot may be used for *hand grenades,* and shells of any calibre for *rampart grenades.*

Grape-Shot.

	8-in.	42	32	24	18	12
	In.	In.	In.	In.	In.	In.
Diameter of large gauge......	3.60	3.17	2.90	2.64	2.40	2.06
Diameter of small gauge......	3.54	3.13	2.86	2.60	2.36	2.02
Mean weight................lbs.	6.1	4.2	3.15	2.4	1.8	1.14

Canister-Shot.

	NATURE OF ORDNANCE.								
	42-pdr. gun.	32-pdr. gun.	24-pdr. gun & 8-in. siege howitzer.	18-pdr. gun.	12 pdr. gun and 32-pdr. howitzer.	24-pdr. howitzer.	6-pdr. gun.	12-pdr. howitzer. Field.	12-pdr. howitzer. Mountain.
	In.	In.	In.	In.	In.	In.	In.	In.	In.
Diameter of large gauge....	2.26	2.06	1.87	1.70	1.49	1.35	1.17	1.08	.69
Diameter of small gauge...	2.22	2.02	1.84	1.67	1.46	1.32	1.14	1.05	Musket ball.
Mean weight..............lbs.	1.5	1.14	0.86	0.64	0.43	0.32	0.21	0.16	

Lead Balls.

DIAMETERS OF LEAD BALLS FROM 1 TO 32 TO THE POUND.

No. of balls to 1 lb.	Diameter.	No. of balls to 1 lb.	Diameter.	No. of balls to 1 lb.	Diameter.	No. of balls to 1 lb.	Diameter.
	In.		In.		In.		In.
1	1.670	9	0.803	17	0.650	25	0.571
2	1.326	10	.775	18	.638	26	.564
3	1.157	11	.751	19	.626	27	.557
4	1.051	12	.730	20	.615	28	.550
5	.977	13	.710	21	.605	29	.544
6	.919	14	.693	22	.596	30	.537
7	.873	15	.676	23	.587	31	.531
8	.835	16	.663	24	.579	32	.526

For the mode of fabrication of lead balls, see Chapter X.

DIAMETERS OF CAST-IRON BALLS FROM ¼ POUND TO 50 POUNDS WEIGHT.

Weight.	Diameter.	Weight.	Diameter.	Weight.	Diameter.	Weight.	Diameter.
Lbs. oz.	In.	Lbs.	In.	Lbs.	In.	Lbs.	In.
0 4	1.231	9	4.065	23	5.531	37	6.512
6	1.403	10	4.211	24	5.639	38	6.570
8	1.551	11	4.346	25	5.714	39	6.627
10	1.665	12	4.474	26	5.789	40	6.684
12	1.701	13	4.595	27	5.862	41	6.738
14	1.865	14	4.710	28	5.930	42	6.793
1	1.954	15	4.819	29	6.004	43	6.846
2	2.462	16	4.924	30	6.068	44	6.898
3	2.819	17	5.025	31	6.140	45	6.951
4	3.104	18	5.121	32	6.205	46	7.002
5	3.341	19	5.215	33	6.268	47	7.052
6	3.551	20	5.304	34	6.330	48	7.101
7	3.738	21	5.392	35	6.392	49	7.145
8	3.908	22	5.476	36	6.442	50	7.198

The specific gravity of shot is 7,000: shells, 7.1.

To find the weight of a cast-iron shot or shell:

Multiply the cube of the diameter of the shot in inches by .13268, and the difference of the cubes of the exterior and interior diameters of the shell, by 0.13458 for the weight in pounds.

For lead balls, the multiplier is 0.2142 for a density of 11.301.

To find the diameter of a cast-iron shot of a given weight:

Divide the weight in pounds by 0.134, and the cube root of the quotient will be the diameter in inches.

To find the quantity of powder which a shell will contain:

Multiply the cube of the interior diameter of the shell in inches by 0.01744, for the weight of powder in pounds.

General Directions in the Fabrication of Shot and Shells.

All shot and shells, except canister-shot for mountain howitzers, are made of cast iron. It should be gray or mottled iron, of good quality. (See Chap. XIV. *Cast Iron.*) They must be cast in sand, and not in iron moulds: the shot from the latter are generally not spherical in form, nor uniform in size; they are also full of cavities, and are cracked by being heated.

Spherical case shot must be made with peculiar care, of the best quality of iron, in order that they may not be liable to break in the gun.

Grape and canister shot should be made of a soft, gray iron: it ought to be very fluid. They are made smooth, and polished by rolling in a barrel for that purpose.

A sample bar 1.5 inch square and 8 inches long, with a head 4 inches long, is cast, on end, from the same metal that shot and shells are made of, to be tested as to its strength and the character of the metal.

INSPECTION OF SHOT AND SHELLS.

Shot.

Inspecting instruments.—One *large* and one *small gauge* and one *cylinder gauge* for each calibre: the cylinder-gauge has the same diameter as the large gauge; it is made of cast iron, and is 5 calibres long. The gauges should be verified from time to time, and when they have become .008 larger than their true diameter, they should no longer be used. One *hammer*, weighing half a pound, and having a flat face and a conical point. *Steel punches.*

One searcher, of steel wire No. 20, with a handle.

The shot should be inspected before they become rusty; after being well cleaned, each shot is placed on a table and examined by the eye to see that its surface is smooth, that the metal is sound and free from seams, flaws, and blisters. If cavities or small holes appear on the surface, strike the point of the hammer or punch into them and ascertain their depth with the searcher; if the depth of the cavity exceed 0.2 inch, the shot is rejected; and also if it appear that an attempt has been made to conceal such defects by filling up the holes with nails, cement, &c.

The shot must pass in every direction through the large gauge, and not at all through the small one; the founder should endeavor to bring the shot up as near as possible to the *large gauge* or to the *true diameter.*

After having been thus examined, the shot are passed through the *cylinder-gauge*, which is placed at an inclination of about 2 inches between the two ends and supported on blocks of wood in such a manner as to be easily turned from time to time, to prevent its being worn in furrows. Shot which *slide* or *stick* in the cylinder are rejected; the latter must be pushed out from the lower end with a wooden rammer.

Shot are proved by dropping them from a height of 20 feet on a block of iron, or rolling them down an inclined plane of that height, against another shot at the bottom of the plane.

The average weight of the shot is deduced from that of three parcels of 20 to 50 each, taken indiscriminately from the pile: some of those which appear to be the smallest should be also weighed, and they are rejected if they fall short of the weight expressed by their calibre more than one *thirty-second* part. They almost invariably exceed that weight.

Grape and Canister Shot.

The dimensions are verified by means of a large and a small gauge attached to the same handle. The surface of the shot should be smooth and free from seams.

Shells and Hollow Shot.

INSPECTING INSTRUMENTS.—A *large* and *small gauge* for each calibre, and a *cylinder-gauge* for shells of 8 inches and under.

Callipers for measuring the thickness of the metal at the sides of the shell.

Callipers to measure the thickness at the bottom of the shell.

Gauges for the dimensions of the fuze-hole, and for the thickness of metal at the fuze-hole.

A pair of hand-bellows; a wooden plug to fit the fuze-hole, and bored through to receive the muzzle of the bellows.

A hammer; a searcher; a cold chisel; steel punches.

The surface of the shell and its exterior dimensions are examined as in the case of shot, particular attention being paid to the hemisphere opposite the fuze-hole. Cavities and imperfections in casting are generally found about 30° from the top of the shell, when in the position in which it was cast. Shells should be rejected for rough casting, projecting seams, sand-flaws, a collection of dross, cavities or honey-combs of more than two-tenths of an inch in depth, whatever their diameter, or a number of small holes giving the projectile a spongy appearance.

The shell is next struck with the hammer, to judge by the sound whether it be free from cracks; the position and dimensions of the ears are verified; the thickness of metal is then measured at several points on the great circle perpendicular to the axis of the fuze-hole, and at the bottom, and at the fuze-hole. The diameter of the fuze-hole, which should be accurately reamed, is then verified, and the soundness of the metal about the inside of the hole is ascertained by inserting the finger.

The shell is now placed on a trivet in a tub containing water deep enough to cover it nearly to the fuze-hole; the bellows and plug are inserted into the fuze-hole and the air forced into the shell; if there be any holes in the shell, the air will rise in bubbles through the water. This test also gives another indication of the soundness of the metal, as the parts containing cavities will dry more slowly than the other parts.

The mean weight of shells is ascertained in the same manner as that of shot.

Shot and shells rejected in the inspection are marked with a X, made with the cold chisel; on shot near the gate, and on shells near the fuze-hole.

PRESERVATION AND PILING OF BALLS.

Balls should be carefully lackered as soon as possible after they are received. The *new 8-inch solid shot* are painted *red*, to distinguish them from the old, which will not answer for hot-shot firing. *All spherical case shot* are also painted red. Other projectiles are lackered *black*. For the composition of lacker and the manner of applying it, see Chap. VII.

When it becomes necessary to renew the lacker, the old lacker should be removed by rolling or scraping the balls, which should never be heated for that purpose.

Balls are piled according to kind and calibre, under cover if practicable, in a place where there is a free circulation of air, to facilitate which the piles should be made narrow if the locality permits; the width of the bottom tier may be from 12 to 14 balls, according to the calibre.

Prepare the ground for the base of the pile by raising it above the surrounding ground so as to throw off the water; level it, ram it well, and cover it with a layer of screened sand. Make the bottom of the pile with a tier of unserviceable balls buried about two-thirds of their diameter in the sand; this base may be made permanent: clean the base well and form the pile, putting the fuze-holes of shells downwards, in the *intervals*, and not resting on the shells below. Each pile is marked with the number of serviceable balls it contains.

The base may be made of bricks, concrete, stone, or with borders and braces of iron. Good and imperfect balls should not be used in the same base; and, to avoid confusion, the unserviceable should be left unpainted, or painted of a different color from the serviceable.

Grape and canister shot should be oiled or lackered, put in piles, or in strong boxes, on the ground-floor, or in dry cellars,—each parcel marked with its kind, calibre, and number.

To find the number of balls in a pile.

Multiply the sum of the three parallel edges by one-third of the number of balls in a triangular face.

In a square pile, one of the parallel edges contains but one ball; in a triangular pile, two of the edges have but one ball in each.

The number of balls in a triangular face is $\frac{n(n+1)}{2}$; n being the number in the bottom row.

The sum of the three parallel edges in a triangular pile is $n+2$; in a square pile, $2n+1$; in an oblong pile, $3N+2n-2$; N being the length of the top row, and n the width of the bottom tier: or, $3m-n+1$; m being the length and n the width of the bottom tier.

If a pile consist of two piles joined at a right angle, calculate the contents of one as a common oblong pile, and of the other as a pile of which the three parallel edges are equal.

To find the length of a pile which shall hold a given number of balls, the width of the base being fixed.

$A =$ the number of balls to be piled.

$n =$ the number in the width of the base of the pile.

$m =$ the number of balls in the length of the base of the pile; then $m = \frac{6A + n(n+1)(n+1)}{3n(n+1)}$.

In the following Table of the number of balls in a pile, the second line shows the number in a triangular pile, the base of which is the corresponding number in the first line

The other numbers show the contents of square and oblong piles; the length and width of the base being in the upper line and in the left-hand column respectively.

Table of the Number of Balls in a Pile.

	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Tri.	4	10	20	35	56	84	120	165	220	286	364	455	560	680	816	969	1140	1330	1540	1771
2	5																			
3	8	14																		
4	11	20	30																	
5	14	26	40	55																
6	17	32	50	70	91															
7	20	38	60	85	112	140														
8	23	44	70	100	133	168	204													
9	26	50	80	115	154	196	240	285												
10	29	56	90	130	175	224	276	330	385											
11	32	62	100	145	196	252	312	375	440	506										
12	35	68	110	160	217	280	348	420	495	572	650									
13	38	74	120	175	238	308	384	465	550	638	728	819								
14	41	80	130	190	259	336	420	510	605	704	806	910	1015							
15	44	86	140	205	280	364	456	555	660	770	884	1001	1120	1240						
16	47	92	150	220	301	392	492	600	715	836	962	1092	1225	1360	1496					
17	50	98	160	235	322	420	528	645	770	902	1040	1183	1330	1480	1632	1785				
18	53	104	170	250	343	448	564	690	825	968	1118	1274	1435	1600	1768	1938	2109			
19	56	110	180	265	364	476	600	735	880	1034	1196	1365	1540	1720	1904	2091	2280	2470		
20	59	116	190	280	385	504	636	780	935	1100	1274	1456	1645	1840	2040	2244	2451	2660	2870	

Table of Oblong Piles.—Continued.

	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
21	62	122	200	295	406	532	672	825	990	1166	1352	1547	1750	1960	2176	2397	2622	2850	3080	3311
22	65	128	210	310	427	560	708	870	1045	1232	1430	1638	1855	2080	2312	2550	2793	3040	3290	3542
23	68	134	220	325	448	588	744	915	1100	1298	1508	1729	1960	2200	2448	2703	2964	3230	3500	3773
24	71	140	230	340	469	616	780	960	1155	1364	1586	1820	2065	2320	2584	2856	3135	3420	3710	4004
25	74	146	240	355	490	644	816	1005	1210	1430	1664	1911	2170	2440	2720	3009	3306	3610	3920	4235
26	77	152	250	370	511	672	852	1050	1265	1496	1742	2002	2275	2560	2856	3162	3477	3800	4130	4466
27	80	158	260	385	532	700	888	1095	1320	1562	1820	2093	2380	2680	2992	3315	3648	3990	4340	4697
28	83	164	270	400	553	728	924	1140	1375	1628	1898	2184	2485	2800	3128	3468	3819	4180	4550	4928
29	86	170	280	415	574	756	960	1185	1430	1694	1976	2275	2590	2920	3264	3621	3990	4370	4760	5159
30	89	176	290	430	595	784	996	1230	1485	1760	2054	2366	2695	3040	3400	3774	4161	4560	4970	5390
31	92	182	300	445	616	812	1032	1275	1540	1826	2132	2457	2800	3160	3536	3927	4332	4750	5180	5621
32	95	188	310	460	637	840	1068	1320	1595	1892	2210	2548	2905	3280	3672	4080	4503	4940	5390	5852
33	98	194	320	475	658	868	1104	1365	1650	1958	2288	2639	3010	3400	3808	4233	4674	5130	5600	6083
34	101	200	330	490	679	896	1140	1410	1705	2024	2366	2730	3115	3520	3944	4386	4845	5320	5810	6314
35	104	206	340	505	700	924	1176	1455	1760	2090	2444	2821	3220	3640	4080	4539	5016	5510	6020	6545
36	107	212	350	520	721	952	1212	1500	1815	2156	2522	2912	3325	3760	4216	4692	5187	5700	6230	6776
37	110	218	360	535	742	980	1248	1545	1870	2222	2600	3003	3430	3880	4352	4845	5358	5890	6440	7007
38	113	224	370	550	763	1008	1284	1590	1925	2288	2678	3094	3535	4000	4488	4998	5529	6080	6650	7238
39	116	230	380	565	784	1036	1320	1635	1980	2354	2756	3185	3640	4120	4624	5151	5700	6270	6860	7469
40	119	236	390	580	805	1064	1356	1680	2035	2420	2834	3276	3745	4240	4760	5304	5871	6460	7070	7700

CHAPTER THIRD.

ARTILLERY CARRIAGES.

NOMENCLATURE.

The nomenclature and the tables of weights and dimensions given in this chapter apply to the latest patterns adopted.

The parts are enumerated generally in the order in which they are put together.

The wheels are designated by numbers referring to special description given after the carriages.

The axle-trees, washers, linch-pins, nave-boxes, bolts, nuts, &c., are designated by letters and numbers which refer to the forms and dimensions laid down in the tables.

Field Gun Carriages. (Plate 2.)

There are four gun-carriages for field service, viz.:

One for the 6-pounder gun and 12-pounder howitzer.

One for the 24-pounder howitzer.

One for the 12-pounder gun, model 1857.

One for the 12-pounder gun and the 32-pounder howitzer.

The parts of these carriages are all similar, differing only in their dimensions. The parts which are common to all are marked with an asterisk (*).

The carriages for the 24-pounder howitzer and 12-pounder gun, 1857, differ chiefly in the length of the cheeks, and the position of the elevating-screw.

Wood.—1 *stock* in two pieces, assembled with 2 *dowels;* 2 *cheeks;* 1 *axle-body.*

Iron.—*2 trail-handles, fastened by 2 *bolts* No. 3 A, and 2 *nuts.*

1 *lock-chain,* (page 70;) 1 *lock-chain bolt* A; 1 *washer;* 1 *nut.*

1 *lunette* for the trail: the under side of the front part of the circumference is plated with steel.

1 *trail-plate,* plate-iron No. 6, fixed to the lunette by 2 *rivets* No. 3 B. The lunette is fastened to the stock by 6 *nails* No. 2 C, and the trail-plate by 6 *nails* No. 2 C, and both by the pointing-ring bolts.

1 *large pointing-ring and plate:* the plate is fastened to the trail by 2 *bolts* No. 3 H, and 2 *nuts,* octagonal.

1 *small pointing-ring;* 2 *bolts* No. 3 H, and 2 *nuts,* octagonal.

*2 *wheel-guard plates,* fastened to the sides of the stock by 10 *nails* No. 2 C.

*2 *prolonge-hooks,* fastened on the top of the stock by 8 *nails* No. 2 C.

1 *stop* for rammer-head, fastened to the under side of the stock by 4 *nails* No. 1 C.

*1 *ear-plate* for worm, fastened to the under side of stock by 2 *nails* No 2 C.

*1 *ear-plate key and chain* of 5 links No. 1, and 2 *rings* No. 1 B, attached to the stock by 1 *eye-pin* No. 1.

2 *chains and hasps* for sponges and rammers, united to 1 *eye-plate*, which is fastened to the under side of stock by 2 *screws* No. 20, 3 in.

*2 *turnbuckles*, (brass,) riveted to the studs of 2 *stud-plates*, which are fastened to the sides of the stock by 4 *nails* No. 2 C.

2 *trunnion-plates*, fastened to the cheeks by 6 *cheek-bolts* A, 4 *washers*, 6 *nuts;* by 2 *chin-bolts*, 2 *bevel washers*, 2 *nuts;* by 2 *key-bolts*, 2 *nuts*, and by 28 *nails* (16 No. 2 D and 12 No. 2 C) for the 12-pounder carriage, and by 20 *nails* (12 No. 2 D and 8 No. 2 C) for the others.

2 *cap-squares;* 2 *eye-pins* No. 1, riveted into the cap-squares; 2 *cap-square chains*, each consisting of 5 links No. 2 and 2 rings No. 2 B.

2 *eye-pins* No. 2, screwed into the outside of the cheeks; 2 *cap-square keys;* 2 *key-chains*, each 5 *links* No. 1 and 2 *rings* No. 1 B; 2 *eye-pins* No. 1 for key-chains, screwed into the outside of the cheeks.

* 2 *D-rings* for handspikes, fastened near the head of the cheeks by 4 *staples*.

6 *rondelles*, (cast iron,) placed between the cheeks and stock.

3 *assembling-bolts*, for the cheeks and stock; 3 *washers;* 3 *nuts*, 1 of them octagonal.

*1 *washer-hook* for lock-chain, under the head of middle assembling-bolt on the right cheek.

2 *washer-hooks* for handspikes, held by the rear assembling-bolt.

1 *axle-tree* No. 1. (See page 68.)

2 *understraps:* the front ends hold the implement-hooks.

1 *axle-strap* has an eye for the sponge-bucket, 3 *bolts* No. 4 B, 3 *nuts:* 1 *bevel washer* for the 6-pounder.

2 *axle-bands* on the end of the axle-body, fastened by 6 *nails* No. 1 C.

*1 *box for elevating-screw*, (brass;) 2 *bolts* No. 3 C; 2 *washers;* 2 *nuts*.

*1 *elevating-screw*.

*2 *shoulder-washers* No. 1, shrunk on the axle-tree; *2 *linch-washers* No. 1; *2 *linch-pins* No. 1.

2 *wheels:* No. 1 for the 6-pounder; No. 2 for the other carriages. (See page 68.)

Limber.

The same limber is used for all the field carriages, including caisson, forge, and battery-wagon.

Wood.—1 *axle-body;* 2 *hounds;* 1 *fork;* 1 *splinter-bar;* 4 *foot-board brackets;* 2 *foot-boards;* 1 *pole;* 1 *pole-prop*.

Iron.—8 *screws* for foot-board brackets No. 16; 20 *nails* for foot-boards No. 1 C.

4 *rivets* No. 2 B, 4 *burrs*, one at each end of the hound.

4 *washer-plates* for stay-pins, let in and fastened on upper and under side of hounds by 8 *nails* No. 1 C.

1 *axle-tree* No. 1, (see page 68;) 2 *shoulder-washers* No. 1; 2 *linch-washers* No. 1; 2 *linch-pins* No. 1.

1 *pintle-hook:* the inside of the cylindrical part is plated with steel; 3 *bolts* No. 4 C; 2 *washers;* 3 *nuts* No. 4.

1 *stay-plate* for ammunition-chest, fastened on the under side of the fork with 2 *nails* No. 2 C, and held by the pintle-hook bolt.

1 *pintle-key*, attached to the rear of the axle-body by 1 *key-chain* of 8 *links* No. 3, and 2 *rings* No. 2 A, and 1 *eye-pin* No. 3.

1 *tar-bucket hook*, fastened to the front of the axle-body by 2 *nails* No. 1 C.

2 *bolts* No. 3 E; 2 *washers;* 2 *nuts* No. 3, to connect the axle-body and hounds.

2 *under-straps;* 4 *bolts* No. 3 B; 4 *nuts.*

2 *axle-bands*, shrunk on the ends of the axle-body, and fastened by 6 *nails* No. 1 C.

2 *end-bands* for splinter-bar, having 2 *trace-hooks*, fastened by 4 *rivets* No. 2, (wire;) 2 *bolts* No. 3 D for hounds and splinter-bar; 4 *washers;* 2 *nuts*

1 *eye-plate* for pole-prop socket, let in the under side of splinter-bar.

2 *middle-bands* for splinter-bar, having 2 *trace-hooks.*

1 *fork-strap.*

2 *bolts* No. 3 D for splinter-bar and fork; 2 *nuts* No. 3.

1 *pole-prop socket*, hooked in the eye-plate; 1 *rivet* No. 2.

1 *pole-prop ferrule;* 1 *rivet* No. 2.

2 *stay-pins* for ammunition-chest; 2 *keys;* 2 *key-chains*, 5 *links* No. 1 and 2 *rings* No. 1 B; 2 *eye-pins* No. 1.

1 *rivet* No. 3 B and 1 *burr*, for large end of the pole; 1 *pole-bolt* No. 3 D; 2 *washers;* 1 *nut.*

1 *pole-pad bolt.*

1 *pole-yoke*, composed of 1 *muff;* 1 *collar*, in 2 parts; 2 *branches;* 2 *sliding-rings;* 2 *bolts* No. 3 for collar; 1 *washer* for muff; 1 *key.*

2 *wheels* No. 1.

Leather.—1 *pole-prop strap*, with 1 *buckle* No. 10, held by 3 *screws* 1 inch, No. 12.

1 Ammunition-Chest.

Caisson. (Plate 3.)

Wood.—1 *middle rail;* 2 *side rails;* 1 *cross-bar*, framed into the rails; 1 *bolster* for front foot-board; 1 *front foot-board;* 1 *rear foot-board;* 1 *axle-body;* 1 *stock.*

Iron.—1 *middle assembling-bar*, fastened to the rails by 2 *bolts* No. 3 A; 2 *washers;* 2 *nuts.*

1 *carriage-hook*, let in on the under side of the middle rail.

1 *rear assembling-bar*, fastened to the side rails by 2 *bolts* No. 3 D; 2 *washers;* 2 *nuts.*

1 *bridle* for rear of middle rail, fastened to sides by 4 *nails* No. 1 C.

1 *spare-wheel axle*, consists of 1 *body;* 1 *washer;* 2 *ribs*, fastened to the body by 3 *rivets;* 1 *chain and toggle;* 2 *stays;* 2 *nuts.*

1 *stay-bolt* No. 3 D; 1 *foot-bolt* No. 3 D; 1 *nut.*

4 *foot-board bolts* No. 3 D; 2 *washers;* 4 *nuts;* 2 *nails* No. 1 C, fastening the front foot-board to the side rails; 6 *nails* No. 1 C for the rear foot-board.

2 *lock-chain bridles*, fastened under the front end of the side rails by the four foot-board bolts.

2 *lock-chains*, (see page 70.)

2 *lock-chain hooks*, fastened to the outside of the side rails by 4 *nails* No. 1 C.

1 *axle-tree* No. 1; 2 *shoulder-washers* No. 1; 2 *linch-washers* No. 1; 2 *linch-pins* No. 1.

2 *understraps;* 4 *bolts* No. 3 B; 4 *nuts.*

2 *axle-bands*, fastened on the ends of the axle-body by 6 *nails* No. 1 C.

2 *rivets* and 2 *burrs* No. 3 B for the stock.

1 *lunetts:* the lower side of the eye is plated with steel. The plates are fastened to the stock by 2 *bolts* No. 3 D; 2 *nuts;* 12 *nails* No. 2 C.

1 *key-plate for spare pole*, fastened to the under side of the lunette by the front lunette-bolt; 1 *key* for the same, attached to the left side of the stock by 1 *key-chain* of 11 *links* No. 1 and 2 *rings* No. 1 A, and 1 *eye-pin* No. 1.

2 *wheel-guard plates*, fastened to the stock by 10 *nails* No. 2 C.

1 *stock-stirrup*, held by 2 *bolts* No. 3 D, which pass through the front foot-board; 2 *washers;* 2 *nuts.*

1 *axle-strap*, fastened to the middle rail by 3 *bolts*—one, No. 3 D, and two, No. 3 B; 3 *nuts.*

1 *spare pole-ring*, held by the axle-strap, in rear of the axle-tree.

4 *stay-pins*, like those for the limber, except in length; 8 *washer-plates* for same, let in the top and bottom of side rails, and fastened by 16 *nails* No. 1 C; 4 *keys* for stay-pins; 4 *chains;* 4 *eye-pins*, the same as for the limber.

1 *ring-bolt* for spare handspike, on the right side of the middle rail; 2 *washers;* 1 *nut.*

1 *key-plate for spare handspike*, fastened on the right side of the middle rail by 2 *nails* No. 1 C; 1 *key;* 1 *key-chain;* 1 *eye-pin*, same as those for ammunition-chest stay-pins.

1 *key-plate for the shovel-handle*, fastened on the inside of the right side

rails by 2 *nails* No. 1 C; 1 *key;* 1 *key-chain;* 1 *eye-pin,* the same as for spare handspike.

2 *staples* for tool-handles, driven into the top of the axle-body.

2 *wheels* No. 1.

LEATHER.—1 *pole-prop strap,* with 1 *buckle* No. 10, held by 3 *screws,* 1-inch, No. 12.

2 *ammunition-chests,* like the one on the limber. (See page 53.)

Travelling Forge. (Plate 4.)

BODY AND BELLOWS-HOUSE.

WOOD.—2 *side rails;* 1 *front cross-bar,* fastened to the side rails by 2 *wooden pins;* 2 *middle cross-bars,* fastened to the side rails by 6 *wooden pins;* 1 *rear cross-bar,* fastened to the side rails by 2 *wooden pins;* 1 *middle rail,* the ends fastened to the middle cross-bar by 4 *screws* No. 14; 1 *axle-body;* 1 *stock.*

4 *floor-boards,* fastened to the middle cross-bars by 16 *screws* No. 14.

4 *corner-studs,* joined by tenons to the side rails, and fastened by 8 *pins.*

1 *front end-board,* mortised into front studs, and fastened by 2 *pins.*

2 *side studs,* fastened to side rails and plates with tenons and 4 *pins.*

2 *plates,* framed on the upper ends of the studs.

1 *front end-stud,* mortised into the front end-boards.

2 *end-boards* for roof, fastened to the plates and corner-studs by 6 *screws* No. 12 and 4 *screws* No. 14.

2 *roof-bows,* fastened to the plates by 4 *screws* No. 14.

2 *side linings* for iron room, fastened to the studs by 12 *nails,* 8-penny.

1 *rear end* for iron room, dovetailed into the side linings.

2 *groove-cleats* for cover of iron room, fastened to the studs by 6 *screws* No. 14.

1 *sliding cover* for iron room, consists of 6 *boards,* fastened to 2 *battens* by 36 *nails,* (wrought.)

2 *braces* for the bellows-arms, framed into, and fastened to, the corner side studs by 6 *screws* No. 14.

1 *cap for coal-box,* let in and fastened to the rear end-board of roof by 5 *screws* No. 14.

10 *boards* for sides of bellows-house, fit into rabbets in the corner-studs, side rails, and plates, to which they are fastened by 4-penny nails.

7 *boards for the roof,* fastened to the roof-bows and end-board by 4-penny cut nails.

1 *prop* for the stock, like the pole-prop for the limber.

1 *bellows-pole,* (hickory, oak, or ash.)

IRON.—1 *axle-tree,* the same as for the 6-pounder gun-carriage.

2 *axle-bands,* fastened on the ends of the axle-body by 6 *nails* No. 1 C.

2 *under-straps,* fastened to the side rails by 4 *bolts* No. 3 D, 4 *washers,* and 4 *nuts.*

2 *rivets*, 2 *burrs* for the front end of stock.

1 *lunette*, like that for the caisson, except the size of the rear hole, and 1 additional bolt-hole; 1 *middle bolt* No. 3 D; 1 *prop-bolt* No. 3; 1 *vice-bolt* No. 3; 3 *nuts;* 12 *nails* No. 2 C.

1 *pole-prop socket;* 1 *ferrule.*

1 *stock-stirrup*, fastened to the front cross-bar by 2 *bolts* No. 3 B; 2 *nuts.*

1 *bolt* No. 3 B for the middle cross-bar and stock; 1 *washer;* 1 *nut.*

1 *axle-strap*, fastened to the middle rail by 2 *bolts* No. 3 B; 2 *nuts.*

2 *wheel-guard plates*, like those for the caisson, fastened by 10 *nails* No. 2 C.

2 *stud-plates* for coal-box, let in the rear corner-studs, and fastened by 2 *screws* No. 16 and 2 *rivets* No. 2 B.

2 *keys;* 2 *key-chains*, 4 *links* No. 1 and 2 *rings* No. 1 B; 2 *eye-pins* No. 1, screwed into the two rear corner-studs.

2 *lock-chain hooks*, fastened to the side rails by 4 *nails* No. 1 C.

1 *bellows-pole hook*, like the lock-chain hook, fastened on the right of the front corner-stud by 2 *nails* No. 1 C.

1 *staple* for bellows-pole, driven into the rear corner-stud, to carry the bellows-pole when travelling.

2 *front stay-plates* for bellows-arms, fastened to the braces by 6 *screws* No. 14.

2 *rear stay-plates* for bellows-arms, fastened to the braces by 4 *bolts* No. 1 D; 4 *thumb-nuts.*

1 *front* for bellows-house, (sheet iron No. 24,) fastened to the front studs and roof-boards with 12-*oz. tacks*, (iron.)

1 *sheet-iron cover* for cross-bar, (sheet iron No. 24,) fastened to the cross-bar with 12-*oz. iron tacks.*

1 *guard* for stock, (sheet iron No. 24,) bent over the top, and fastened on the sides of the stock by 18 *iron tacks*, (12-oz.)

1 *stay and stud* for bellows-pole, fastened to the front roof-board and to the front middle cross-bar by 4 *screws* No. 14.

1 *cover* for roof, (sheet copper No. 24,) fastened to the edge of the roof-boards by 315 *copper tacks*, (12-oz.)

1 *fireplace*: consists of 1 *back plate*, made of 2 pieces; 2 *side plates;* 1 *front plate*, placed parallel to the back plate; 1 *bottom plate*, resting on flanges formed by the 2 side plates and the back and front plates. The upper back plate is No. 11, the others No. 8. The plates are riveted together where they lap by 59 *rivets*, (0.3 inch.)

1 *air-back*, (cast iron:) consists of 1 *box* and *back plate*, joined air-tight by 4 *bolts* No. 2 E: the air-back is fastened to the back plate of the fire-place by 5 *bolts* No. 2 E; 5 *nuts*, octagonal.

1 *hook* for forge-bucket, like the lock-chain hook, riveted to the back of the fireplace by 2 *rivets* No. 2.

3 *plates* for side rails and cross-bar, bent down on the inside of the rails and cross-bar, and riveted to the sides and front of the fireplace: the plates are fastened to the side rails and cross-bar by 10 *bolts* No. 2 D; 8 *washers* and 10 *nuts*.

2 *lock-chain bridles*, like that for the caisson, except size of the holes, fastened by the 4 front bolts in the side-rails.

2 *lock-chains*. (See page 70.)

1 *brace* for fireplace, fastened to the back of the fireplace and the front end board of roof by 2 *rivets* No. 2; 2 *rivets* No. 2 B.

1 *bellows-pole strap*, fastened to the pole by 2 *rivets* No. 2 and 3 *screws* No. 14.

1 *bellows-pole chain:* 2 *links*, one of which is fastened in the hook.

2 *wheels* No. 1.

Bellows.

Wood.—3 *bellows-planks*, each made of 2 pieces joined by a tongue of hard wood.

2 *cross-heads*, fastened to the middle plank by 12 *screws* No. 20.

2 *ribs:* each consists of 2 *sides*, 1 *end*, 1 *cross-bar*, glued and fastened by 16 *clout-nails*.

2 *valves;* 2 *battens*, fastened by 16 *nails*.

4 *cleats* for the bellows-arms, fastened to the middle plank by 16 *screws* No. 14.

Iron.—6 *butt-hinges*, (wrought iron,) let into the upper and lower bellows-planks and cross-heads, and fastened by 36 *screws* No. 14.

2 *arms*, fastened to the middle plank by 4 *rivets* No. 2 B and 8 *screws* No. 14.

1 *hook*, fastened to the lower plank by 3 *rivets* No. 2 B and 4 *screws* No. 14.

1 *windpipe:* consists of 1 *elbow* (brass) screwed into the wind-hole of the bellows; 1 *collar*, (brass,) screwed to the elbow; 1 *joint-pipe*, (brass;) 1 *bent pipe*, (sheet copper No. 18,) riveted and soldered to the joint-pipe.

Leather.—4 *hinges* for the ribs.

2 *hinges* for the valves, (bag-leather or deer-skin with the hair on.)

2 *valve-straps*.

392 *copper tacks* for hinges.

1 *bellows-leather* for the sides, fastened to the edges of the planks with *bellows-nails*, and to the ribs with *clout-nails*.

617 *bellows-nails*: *safes* to go under the heads of the nails.

To put the bellows in its place: Remove the coal-box from the back of the bellows-house; take out the two stay-plates at the lower ends of the rabbets in the braces; put the projecting ends of the upper bellows-arm in the rabbets, and slide them up until the ends of the lower arm come into their places; put on the stay-plates, and fasten them down with the thumb-nuts. Screw the brass elbow-pipe into its place, through the hole in the sheet-iron front of the bellows-house; put in the copper pipe, and screw up the collar which connects it with the elbow-pipe.

Coal-box.

Wood.—2 *sides*, 2 *ends*, and 1 *bottom*, rabbeted together and fastened with 50 *cut-nails*, (6-penny.)

1 *top-piece*, fastened by 7 *screws* No. 14.

1 *lid;* 2 *clamps*, framed on each end.

Iron.—4 *corner-plates*, (sheet iron No. 13,) fastened by 60 *screws* No. 12.

2 *end-straps*, fastened to the ends of the box by 2 *rivets* and 4 *screws*.

2 *handles*, fastened inside of the box by 2 *washers* and 2 *nuts*.

1 *stud-plate* for turnbuckle, fastened to the front of the box; 2 *rivets* No. 2 B.

1 *turnbuckle*, (brass,) riveted on the stud.

1 *hasp and strap*, fastened on the inside of the lid by 1 *rivet* No. 2 B and 3 *screws* No. 14.

1 *cover*, (sheet copper No. 24,) in 2 pieces, fastened on the top of the box and lid by 185 *copper tacks*, (12-oz.)

2 *hinges*, fastened on the outside of the copper covering by 4 *rivets* No. 2 B and 16 *screws* No. 14.

Battery-Wagon. (Plate 5.)

The battery-wagon carries tools, spare parts of carriages, spare harness, and other stores required for the service of the battery in the field and for repairs.

WAGON-BODY.

Wood.—2 *lower side-rails;* 5 *cross-bars*, fastened to the side-rails with tenons and 10 *wooden pins;* 3 *floor-boards*, fastened to the cross-bars by 36 *nails* No. 1 C; 1 *axle-body;* 2 *upper side rails;* 2 *sides;* 2 *ends;* 1 *stock;* 2 *cleats*, 1 *bottom*, and 1 *side* for till; the cleats are fastened to the ends of the body by 6 *screws* No. 14; the side is fastened to the edge of the bottom by 11 *cut-nails*, (8-penny;) 1 *forage-rack*, composed of 2 *sides* and 3 *bars*, fastened to the sides by 6 *wooden pins*.

Iron.—2 *rivets*, No. 3 B; 2 *burrs*, through the rear end of the lower rails.

8 *side-studs*, fastened to the sides by 14 *rivets* No. 3 D.

2 *chains*, for the forage-rack, each consisting of 1 *ring*, 32 *links*, and 1 *hook* welded in an eye in the rear studs.

1 *spare stock-hook*, fastened to the rear stud, on the right side, by the assembling-bolt and groove-bolt.

1 *button* for spare stock, fastened by the middle groove-bolt.

1 *spare stock-stirrup*, fastened to the front stud by the two lower groove-bolts.

4 *grooves* for wagon-ends, (sheet iron No. 7,) fastened to the sides by 12 *bolts* No. 1 C; 12 *nuts*.

2 *assembling-bolts* for lower side rails, pass through the end cross-bars; 2 *nuts*.

3 *bolts* for middle side studs; 3 *washers;* 3 *nuts*.

1 *turnbuckle-bolt;* 1 *turnbuckle*, (brass,) riveted on the head of the bolt; 1 *washer;* 1 *nut*.

1 *hook* for cover-prop; 1 *burr:* passes through top of forward middle stud.

1 *eye-pin* for cover-hasp; 1 *burr:* passes through the top of the rear middle stud.

2 *stays* for the upper rails, fastened by 4 *screws* No. 14.

2 *end-studs*, fastened to the ends of the body by 6 *rivets;* 1 *bolt* No. 3 B; 1 *nut* for the front stud, and 1 *nut* and 1 *washer* for the rear stud.

1 *mortise-plate*, fastened to the front of axle-body by 8 *screws* No. 14.

1 *axle-tree* like that for 6-pounder carriage; 2 *shoulder-washers;* 2 *linch-washers;* 2 *linch-pins*.

2 *understraps;* 4 *bolts* No. 4 B; 4 *nuts*.

1 *bolt* for front end of right side rail; 2 *washers;* 1 *nut*.

2 *lock-chain bridles*, like those of the caisson, at the front end of the side rails; 2 *bolts* No. 3 D and No. 3 B; 1 *washer;* 2 *nuts;* 2 *lock-chains*. (See page 70.)

2 *lock-chain hooks*, fastened to the side rails by 4 *nails* No. 1 C.

2 *rivets* No. 3 B; 2 *burrs* for front end of stock.

1 *lunette*, like that for caisson; 2 *bolts* No. 3 D; 2 *nuts;* 12 *nails* No. 2 C.

2 *wheel-guard plates*, like those of the caisson, fastened by 10 *nails* No. 2 C.

1 *stock-stirrup;* 2 *bolts* No. 4 B; 2 *nuts*.

2 *bolts* No. 4 B for stock and cross-bar; 2 *nuts;* 2 *washers*.

2 *washer-plates* for side rails, fastened by 4 *screws* No. 14.

2 *forage-rack bands*, fastened to the rack by 2 *rivets* No. 2 and 22 *screws* No. 14.

4 *washer-plates* for forage-rack, sides fastened by 4 *rivets* No. 2 D.

2 *forage-rack bolts* No. 4; 2 *washers;* 2 *nuts*.

2 *wheels* No. 1.

WAGON-COVER.

WOOD.—2 *side rails;* 2 *end rails*, dovetailed into the side rails; 2 *end-studs*, fastened to the end rails by 4 *wooden pins*, and to the end-boards by 4 *rivets*.

2 *end-boards,* fastened to the side and end rails by 8 *screws* No. 12, and to the end stud by 6 *screws* No. 12; 1 *ridge-pole;* 9 *cover-boards,* fastened to the end-boards by 36 *nails,* (4-penny,) and to the end-bows by 36 *rivets* No. 1 H, and to the middle-bows by 36 *screws* No. 12.

Iron.—4 *corner-squares,* fastened on the inside of the frame by 16 *screws* No. 14.

2 *end-bows.*

4 *joint-bolts* for cover-frame, pass through the rails and end-bows; 4 *nuts* No. 1.

2 *middle-bows,* fastened in mortises in the rails by 4 *rivets* No. 3 B.

2 *plates and staples* for cover-prop and hasp, fastened to the left cover-rail by 2 *rivets* No. 3 B and 2 *screws* No. 12; 1 *cover-prop,* fastened in the front staple; 1 *hasp,* fastened in the rear staple.

3 *hinges,* fastened to the rail by 6 *rivets* No. 3 B, and to the body-rail by 6 *bolts* No. 1 B; 6 *nuts.*

The roof is covered with strong linen canvas, which is fastened by 264 *copper nails,* (12-oz.,) with strips of *leather* under their heads.

Ammunition-Chest.

The same ammunition-chest is adapted to the limbers of the different field gun-carriages and to their caissons. The interior divisions vary with the different kinds of ammunition. (See Chap. XI.)

Wood.—2 *ends,* 2 *sides,* dovetailed and fastened by 16 *cut nails,* (8-penny;) 1 *principal partition;* 1 *bottom,* fastened by 18 *cut nails* (8-penny) and 4 *screws* No. 16.

1 *cover,* consisting of 1 *frame* of 4 pieces, 1 *panel,* and 1 *lining* fastened by 60 *copper tacks.*

Iron.—4 *corner-plates* for ends and sides—2 *corner-plates* for ends and bottoms—1 *corner-plate* for side and bottom—sheet iron No. 13, fastened by 96 *screws* No. 12.

1 *assembling-bolt* No. 2; 1 *turnbuckle,* (brass,) attached to the assembling-bolt.

1 *washer-plate* for assembling-bolt, fastened by 2 *screws* No. 12.

1 *back stay,* fastened to the back and bottom by 6 *screws* No. 14.

2 *front stays,* fastened to the front and bottom by 4 *rivets* No. 2 B and 8 *screws* No. 14.

2 *hinges,* 4 *rivets* No. 2 B, 20 *screws* No. 14; 2 *hinge-plates,* fastened on the back edge of the cover by 4 *screws* No. 14.

1 *hasp,* fastened to the cover by 1 *rivet* No. 2 B and 5 *screws* No. 14; 1 *hasp-plate;* 2 *screws* No. 14.

2 *handles;* 8 *rivets* No. 3 B.

14 *copper washers,* (sheet copper No. 24,) to cover heads of rivets; 56 *copper tacks.*

1 *cover*, (sheet copper No. 24,) fastened to the edges of the wooden cover by 216 *copper tacks.*

2 *leather straps* for the tarpaulin, 5 inches long, with 2 *buckles* No. 6, fastened to the edges of the cover of the limber-chest by 4 *screws* No. 14.

2 *leather straps* for the tarpaulin, 29 inches long, fastened to the hasp side of the cover of the limber-chest by 4 *screws* No. 14; 4 *copper washers.*

Limber-Chest for the Travelling Forge and Battery-Wagon.

This chest differs from the ammunition-chest in the following points, viz.: It has no principal partition; and, instead of the assembling-bolt, with the washer-plate and turnbuckle, it has a *hasp-staple and plate,* fastened by 2 *rivets.* The *back stay* is fastened by 1 *rivet* and 6 *screws.* The heads of the rivets are not covered with copper washers.

For the interior arrangement of the chest see Chapter XI.

Prairie Carriage for the 12-pounder Mountain Howitzer.

WOOD.—1 *stock* in 2 pieces, put together with 2 *dowels.* The stock is hollowed out on top at the head, leaving the sides to project and form the cheeks. 1 *axle-body.*

IRON.—2 *assembling-bolts* No. 4 D; 2 *washers;* 2 *washer-hooks* for the front bolt; 2 *nuts.*

2 *trail-handles;* 2 *bolts* No. 2 A; 2 *nuts.*

1 *lunette:* the under part of the ring is plated with steel; 1 *trail-plate* (plate iron No. 8) is riveted to the lunette by 2 *rivets* No. 2 B. The lunette is fastened to the stock by 6 *nails* No. 2 C, and the trail-plate by 6 *nails* No. 1 C, and both by the *pointing-ring bolts.*

1 *large pointing-ring and plate:* the plate is fastened to the stock by 2 *bolts* No. 2 H; 2 *nuts,* octagonal.

1 *small pointing-ring;* 2 *bolts* No. 2 H; 2 *nuts,* octagonal.

2 *prolonge-hooks,* fastened over the middle line of the stock by 8 *nails* No. 1 C.

1 *key* for handspike; 1 *chain;* 1 *eye-pin.*

2 *wheel-guard plates,* fastened to the stock by 10 *nails* No. 1 C.

2 *trunnion-plates,* fastened to the stock by 2 *chin-bolts* and 2 *key-bolts* No. 4 A, 2 *trunnion-plate bolts* No. 4 D; 6 *nuts;* 6 *nails* No. 2 C.

2 *cap-squares;* 2 *eye-pins,* riveted to the cap-squares; 2 *chains,* 5 links, No. 1.

2 *eye-pins,* screwed into the sides of the stock; 2 *cap-square keys;* 2 *chains,* 3 links, No. 1; 2 *eye-pins,* screwed into the sides of the stock.

2 *implement-hooks,* screwed into the top of the axle-body.

2 *implement-hooks,* screwed into the sides of the stock near the trail.

1 *axle-tree* No. 3; 2 *shoulder-washers;* 2 *linch-washers;* 2 *linch-pins.*

2 *under-straps,* fastened by the chin and key bolts.

1 *sponge-bucket hook:* passes through the axle-body from the front; 1 *washer;* 1 *nut.*

2 *axle-bands,* put on the axle-body *hot,* and fastened by 6 *nails* No. 1 C.

1 *box for elevating-screw,* (cast brass;) 2 *bolts* No. 2 C; 2 *washers;* 2 *nuts.*

1 *elevating-screw.*

Limber.

Wood.—1 *axle-body*; 2 *hounds;* 1 *fork;* 1 *splinter-bar;* 4 *foot-board brackets;* 2 *foot-boards;* 1 *pole;* 1 *pole-prop.*

Iron.—4 *screws* No. 16; 4 *screws* No. 14 for brackets; 20 *nails* for foot-board; 4 *rivets* No. 2 B; 4 *burrs* for ends of hounds.

1 *axle-tree* No. 3; 2 *shoulder-washers;* 2 *linch-washers;* 2 *linch-pins.*

1 *pintle-hook;* 3 *bolts* No. 2 C; 3 *washers;* 3 *nuts;* 1 *pintle-key;* 1 *chain,* 9 *links* No. 2 and 2 *rings* No. 1 A; 1 *eye-pin* No. 1, fastened to the rear of the axle-body.

1 *tar-bucket hook,* fastened by 2 *nails* No. 1 C.

2 *bolts* No. 2 E to connect the axle-body and hounds; 2 *washers;* 2 *nuts.*

2 *under-straps;* 4 *bolts* No. 2 B; 4 *nuts.*

2 *axle-bands;* 6 *nails* No. 1 C.

2 *end-bands* for splinter-bar; 2 *trace-hooks;* 4 *rivets* No. 2 *wire.*

2 *middle-bands* for splinter bar; 2 *trace-hooks*; 2 *bolts* No. 2 D; 2 *nuts.*

1 *fork-strap:* supports the tongue, and is held by the bolts of the middle bands.

2 *bolts* No. 2 D for splinter-bars and hounds; 4 *washers;* 2 *nuts.*

1 *pole-prop socket;* 1 *ferrule;* 1 *pole-prop stud* driven into the splinter-bar.

1 *eye-pin,* riveted; 1 *burr.*

4 *stay-pins;* 4 *nails* No. 1 C; 4 *keys*; 4 *chains* of 5 *links* No. 1 and 2 *rings* No. 1 A, each.

4 *eye-pins* No. 1; 1 *stay-plate;* 4 *screws.*

1 *rivet* in large end of pole; 1 *pole-bolt* No. 2 D; 2 *washers;* 1 *nut.*

1 *ferrule;* 1 *buckle,* fastened on the small end of the pole by 1 *rivet.*

1 *pole-yoke,* composed of 1 *muff,* 1 *collar* in two parts, 2 *branches,* 2 *sliding-rings;* 2 *bolts* for collar; 1 *washer* for muff; 1 *key.*

1 *pole-prop strap,* (leather,) fastened to the splinter-bar by 3 *screws* No. 12; 1 buckle No. 10.

2 *ammunition-chests;* 2 *wheels* No. 3.

Ammunition-Chests.

Wood.—2 *ends;* 2 *sides,* dovetailed and glued to the ends.

1 *bottom,* rabbeted into the sides and ends, and fastened with 30 *cut nails,* (6-penny.)

1 *cover,* made of 1 *panel* and 2 *end-clamps,* mortised, glued, and fastened with 4 *pins.*

4 *bolsters;* 8 *cleats,* fastened—the first to the bottom, the second to the sides on the inside—by 48 *copper nails,* (4-penny.)

IRON.—1 *brace,* fastened on the inside to the back by 1 *screw,* and to the front by the stud-plate rivet.

1 *turnbuckle,* (brass;) 1 *stud;* 1 *stud-plate,* fastened to the front by 1 *rivet* No. 2 B and 1 *screw* No. 9.

4 *corner-plates,* (sheet iron No. 17;) 40 *screws* No. 9.

1 *back-stay;* 1 *front-stay;* 6 *screws* No. 9; 3 *rivets* No. 2 B.

2 *hinges,* fastened to the under side of the cover by 8 *screws* No. 12, and to the back and bottom by 9 *screws* No. 12 and 2 *rivets* No. 2 B.

2 *handles,* fastened to the bottom and end by 1 *rivet* and 4 *screws* No. 12.

1 *hasp:* the strap let into the under side of the cover, and fastened with 5 *screws* No. 12 and 1 *rivet* No. 2 B.

1 *canvas cover,* secured to the edges of wooden cover by 12 *copper tacks.*

1 *tarpaulin* to cover the carriage.

Prairie Ammunition-Cart.

This is a two-wheeled cart, with shafts, carrying four ammunition-chests and one implement-chest like those used for the mountain howitzer ammunition.

The chests are held in place by stays and a bar fastened with a spring catch behind, so that they may be easily detached.

The wheels are like those of the gun-carriage, and have the same track.

The shafts have hooks at their front ends for the purpose of attaching another horse if necessary, though one horse is sufficient for the ordinary draught.

Gun-Carriage for the Mountain Howitzer. (Plate 6.)

The gun-carriage is adapted to transportation on a pack-mule; but for occasional draught, when the roads permit, it is furnished with a thill, which is used with the same saddle that carries the pack.

WOOD.—1 *stock* in 2 pieces, put together with 2 *dowels.* The stock is hollowed out on top, forming the cheek from the sides of the stock.

1 *axle-tree,* in 2 pieces bolted and riveted together with an iron skean between.

IRON.—3 *assembling-bolts* No. 4 D for the stock; 2 *washer-hooks* for the front bolt; 4 *washers;* 3 *nuts.*

2 *trunnion-plates;* 2 *chin-bolts* No. 4; 2 *key-bolts* No. 4; 2 *trunnion-plate bolts* No. 4 D; 6 *nails* No. 1 C.

2 *cap-squares;* 2 *eye-pins,* riveted to the cap-squares; 2 *chains,* 5 *links* No. 1 and 2 *rings* No. 1 B, each; 2 *keys;* 2 *key-chains,* 3 *links* No. 1, 2 *rings* No. 1 B; 4 *eye-pins* No. 1, screwed into the sides of the stock.

2 *handspike-hooks,* screwed into the sides of the stock near the head.

2 *staples* for handspike-straps.

1 *lunette,* fastened to the stock by 6 *nails* No. 2 C.

1 *trail-plate,* fastened to the stock by 6 *nails* No. 1 C, and to the lunette-plate by 2 *rivets* No. 3 C.

1 *handspike-staple,* driven into the stock through holes in the trail-plate.

2 *friction-plates* for shaft; 4 *nails* No. 1 C.

1 *box for elevating-screw;* 2 *bolts* No. 1 C; 2 *washers;* 2 *nuts;* 1 *elevating-screw.*

1 *axle-skean;* 1 *bolt* No. 2 D; 2 *washers;* 1 *nut;* 2 *rivets* No. 3 B; 4 *burrs.*

2 *ferrules,* fastened to the end of the axle-tree by 2 *rivets* No. 2; 2 *linch-pins.*

2 *axle-bands,* put on hot; 4 *nails* No. 1 C.

2 *under-straps,* fastened by the chin, key, and trunnion-plate bolts.

2 *wheels* No. 4.

SHAFTS.

WOOD.—2 *shafts;* 1 *cross-bar,* joined to the shafts by tenon and mortise.

IRON.—1 *cross-bar plate,* fastened to the shafts by 2 *bolts* No. 2 D, 4 *rivets* No. 2 B, 4 *screws* No. 14, and 2 *nuts;* and to the cross-bar by 7 *screws* No. 14.

1 *supporting-bar;* 1 *key;* 1 *chain* of 8 *links* No. 1, 2 *rings* No. 1 A, 1 *eye-pin* No. 1, riveted to the cross-bar plate.

2 *staples* for the shafts; 4 *burrs* for same.

In attaching the shafts to the gun-carriage, the supporting-bar is laid on the trail-plate, near the handspike-staple, and the knee in rear of the lunette rests on the cross-bar plate, the holes for the key in these two pieces corresponding with each other.

Ammunition-Chests.

WOOD.—2 *ends;* 2 *sides,* dovetailed and glued to the ends; 1 *bottom,* let into the sides and ends and nailed; 1 *cover,* made of 1 *panel* and 2 *clamps,* joined by tenons, glued and fastened with pins; 2 *brackets* for handles, fastened with 4 *screws* No. 12 and 4 *screws* No. 14; 16 *cleats,* glued and fastened by 8 *screws* No. 7; 48 *nails,* (3-penny.)

IRON.—1 *brace,* fastened on the inside to the back by 1 *screw* No. 12, to the front by the stud-plate rivet.

1 *turnbuckle,* (brass;) 1 *stud;* 1 *stud-plate,* let into the front and fastened by 1 *rivet* No. 2 and 1 *screw* No. 9.

4 *corner-plates,* (sheet iron No. 18;) 40 *screws* No. 7.

2 *hinges,* let into the under side of the cover, and pass under the bottom; 26 *screws* No. 9.

2 *lashing-chains,* 4 *links* each; 1 bridle, held by 4 *rivets* No. 2 B passing through the hinge-strap.

1 *hasp,* let into the under side of the cover; 4 *screws* No. 9.

1 *covering* of stout linen, painted; 1 *leather strip;* 160 *copper tacks.*

2 *handles* of 1-*inch rope.*

Portable Forge.

IRON.—1 *frame,* made of 3 pieces, welded together.

1 *fireplace,* (sheet iron No. 13,) composed of 1 *bottom,* bent into a hollow form and riveted to the frame; 1 *back plate,* in 2 pieces, the lower piece bent under the bottom and riveted to it; the 2 plates are joined by 2 *brass hinges,* which are riveted to each plate by 4 *screws.*

1 *border,* bent round the back and riveted to it and to the frame.

2 *reinforces* to the back plate, riveted to the edges of both pieces.

1 *air-back,* (sheet iron No. 7,) made into a convex shape when hot: is riveted to the upper back plate.

1 *button;* 1 *stud,* riveted to the outside of the upper back plate: is used to fasten down the back plate in packing.

1 *iron pipe,* attached to the rear of the lower back plate by means of 1 *bridle,* which is fastened by 2 *bolts;* 2 *nuts.*

1 *front leg,* forked; 2 *eye-pieces,* riveted to the sides of the frame: the leg is joined to the eye-pieces by 2 *bolts;* 2 *nuts.*

2 *rear legs;* 1 *cross-bar,* fastened to the rear legs by 2 *nuts;* 2 *bolts,* to join the rear legs to the frame.

1 *bellows-handle*: a bent bar of iron with a *wooden head* is fastened to the handle-fork by 1 *rivet;* 1 *sliding-catch;* 1 *thumb-screw* on the lower end.

1 *handle-fork* fits in a square hole in the cross-bar.

BELLOWS.

WOOD.—The same parts as the bellows for the field forge.

IRON.—1 *nozzle,* (sheet iron,) inserted into the cross-head.

1 *journal-rod,* fastened to the middle plank.

1 *top-plate,* fastened to the upper plank by 9 *screws.*

1 *handle,* attached to the plate by 3 *staples* riveted under the plate.

1 *bellows-weight,* (lead, 1 pound weight,) fastened on the inside of the lower plank.

1 *bellows-leather,* fastened by *bellows nails.*

Tool-Chests.

Two chests are used to pack the forge and smiths' tools. They are alike except in their interior divisions and the socket-plates, which are attached only to the forge-chest. For contents see Chapter XI.

WOOD.—2 *ends;* 2 *sides,* dovetailed and glued to the ends; 1 *bottom,* let into the ends and sides, and fastened by 32 *nails,* (6-penny;) 1 *cover,* made of 1 *panel* and 2 *end-clamps,* mortised, glued, and fastened by 4 *pins.*

IRON.—4 *corner-plates*, (sheet iron No. 18;) 18 *screws* No. 7.

2 *handles*, turned under the bottom of chest, and fastened by 2 *rivets* and 8 *screws*.

2 *hinges*, fastened to the inside of the cover with 2 *rivets* and 6 *screws*, and to the bottom and back with 6 *rivets* and 22 *screws*; 2 *bridles* for lashing chains, held by the hinge-rivets.

1 *hasp*, let into the inside of the cover; 4 *screws*.

1 *hasp-staple and plate:* the staple is riveted to the plate, which is fastened to the chest by 2 *rivets*.

3 *socket-plates*, with holes in them to receive the legs of the frame, fastened to the back of the forge-chest by 12 *screws*.

1 *linen covering*, like that of the ammunition-chest.

SIEGE CARRIAGES.

Gun-Carriage. (Plate 7.)

There are three gun-carriages for siege artillery, viz.:

One for the 12-pounder gun;

One for the 18-pounder gun;

One for the 24-pounder gun and the 8-inch howitzer.

These carriages are constructed in the same manner, differing only in their dimensions.

When the 8-inch howitzer is mounted on the 24-pounder carriage, a *quoin* is used, instead of the elevating-screw, the howitzer being too short to rest on the screw.

WOOD.—1 *stock* in 2 pieces, put together with 2 *dowels; 2 cheeks; 1 axle-body;* 1 *breech-bolster*.

IRON.—1 *assembling-bolt* for the stock No. 7 A; 2 *washers;* 1 *nut*.

1 *manœuvring-bolt* No. 7; 2 *collars;* 4 *washers;* 2 *nuts* No. 5.

6 *rondelles*, (cast iron;) 2 *assembling-bolts* No. 7 A; 4 *washers;* 2 *nuts*.

1 *assembling eye-bolt* for the lock-chain, No. 9: the ring of the lock-chain is welded in the eye of the bolt, which is on the left side of the carriage; 1 *washer* No. 9; 1 *washer* and 1 *nut* No. 7.

1 *lock-chain*, (see page 70;) 1 *shoe;* 1 *key* for the shoe, to keep the wheel from slipping off.

2 *trunnion-plates;* 2 *chin-bolts* No. 7; 2 *bevel-washers;* 2 *nuts;* 2 *key-bolts* No. 7; 2 *nuts;* 4 *cheek-bolts* No. 7 A; 4 *washers;* 4 *nuts*.

2 *trunnion-plate bolts* No. 3 E; 2 *nuts;* 2 *travelling-trunnion bolts;* 2 *washers;* 2 *nuts*.

2 *cap-squares;* 2 *cap-square chains*, 6 *links* No. 3 and 2 *rings* No. 2 A, each; 4 *eye-pins* No. 3,—2 riveted into the cap-squares and 2 screwed into the sides of the cheeks; 2 *cap-square keys;* 2 *key-chains*, each 5 *links* No. 2 and 2 *rings* No. 2 B; 2 *eye-pins* No. 2 for key-chains.

1 *axle-tree* No. 5; 2 *shoulder-washers;* 2 *linch-washers;* 2 *linch-pins.*

2 *under-straps,* held by the eye, chin, and trunnion-plate bolts.

1 *axle-strap,* held by 2 *bolts* No. 5 B, connecting the stock and axle-body; 2 *nuts.*

2 *axle-bands,* put on hot, and fastened to the axle-body by 8 *nails* No. 1 C.

1 *lock-chain hook,* passes through the axle-body on the right side; 2 *washers;* 1 *nut.*

1 *hook* for the shoe, screwed into the right side of the cheek.

1 *cheek-plate,* to protect the cheek from the friction of the shoe in travelling.

1 *box* for the elevating-screw, (brass;) 2 *bolts* No. 4 C; 2 *washers;* 2 *nuts.*

1 *elevating-screw;* 4 *handles,* screwed into the head of screw.

1 *strap-staple,* driven into the middle of the stock on the under side.

2 *wheel-guard plates,* fastened to the stock by 12 *nails* No. 2 C.

1 *lunette,* reinforced at the pintle-hole by 1 *rondelle,* fastened to the upper side of the lunette-plate by 3 *rivets* No. 3 C; 2 *bolts* No. 4 C; 2 *washers;* 2 *nuts.*

1 *trail-plate,* reinforced by 1 *guard-plate* fastened to the trail-plate by 6 *rivets* No. 3 C; 29 *nails* No. 3 C.

2 *bolster-bolts* No. 4 B, the heads hollowed out; 2 *washers;* 2 *nuts.*

2 *wheels* No. 5.

Limber.

Wood.—1 *fork;* 2 *hounds;* 1 *splinter-bar;* 1 *pole;* 1 *leading-bar.*

Iron.—1 *fork-bolt* No. 4 D; 2 *washers;* 1 *nut.*

1 *axle-tree* No. 5; 2 *shoulder-washers;* 2 *linch-washers;* 2 *linch-pins.*

1 *pintle-plate,* fastened to the fork by 7 *nails* No. 3 C and by 2 of the axle-strap bolts.

1 *sweep-bar:* the ends are fastened to the hounds by 2 *bolts* No. 4 C; 2 *washers;* 2 *nuts.*

1 *axle-strap,* fastened to the fork by 6 *bolts,*—4 No. 4 C and 2 No. 4 D. Two pass through the pintle-plate, two through the sweep-bar, and two through the fork. 2 *washers;* 6 *nuts.*

1 *lashing-chain* of 4 *rings* and 1 *hook:* the first ring is welded into the eye of the axle-strap.

2 *under-straps,* fastening the hounds to the axle-tree; 2 *bolts* No. 4 D; 2 *bolts* No. 4 C; 2 *washers;* 4 *nuts.*

1 *pintle,* fitted accurately in the mortises of the pintle-plate and fork; 1 *nut.*

2 *end-bands;* 2 *trace-hooks,* put on the end of the splinter-bar with 4 *rivets* No. 2.

2 *middle bands;* 2 *trace-hooks,* fastened by the bolts connecting the splinter-bar and fork.

1 *bridle* for the front end of the fork, fastened by the bolts connecting the fork and splinter-bar.

2 *bolts* No. 4 D for the splinter-bar and fork; 2 *nuts*.

2 *bolts* for the splinter-bar and hounds, No. 4 D; 4 *washers*; 2 *nuts*.

1 *bridle* for the middle of the fork, fastened to the fork by 4 *nails* No. 2 C.

1 *rivet* for the rear end of the pole; 1 *burr*.

1 *eye-plate* for the front end of the pole; 2 *bolts* No. 2 D; 3 *washers*; 2 *nuts*.

2 *pole-chains*, each 9 *links* No. 6, 1 *∞-link*, and 1 *ring*, welded into a hole in the eye-plate.

1 *ferrule* for the end of the pole.

1 *pole-clasp*, fastened by the eye-plate bolt and 1 *bolt* No. 2, hexagonal head.

2 *bolts* for the pole and fork, No. 4 D; 4 *washers*; 2 *nuts*.

1 *middle band* for the leading-bar, fastened by 2 *rivets* No. 2; 1 *hook*; 1 *double trace-hook*.

2 *end-bands* and *trace-hooks* for leading-bar, like those for the splinter-bar; 2 *rivets* No. 2.

2 *wheels* No. 5.

Mortar-Wagon.

This wagon is designed for the transportation of siege mortars and their beds, or of guns, or large shot and shells.

The limber and the wheels are the same as those of the gun-carriage.

Wood.—2 *middle rails*; 1 *front transom*, fastened between the middle rails by 2 *dowels*; 1 *middle transom* between the middle rails; 1 *rear transom* between the middle rails; 2 *side rails*; 1 *rear cross-bar*, let into the middle and side rails; 6 *middle cross-bars* between the middle and side rails, and let into both; 2 *front cross-bars*, let into the middle and side rails; 2 *bottom planks*, fastened to the middle cross-bars by 12 *nails* No. 2; 1 *axle-body*; 1 *windlass*; 1 *muzzle-bolster*; 6 *stakes*; 2 *handspikes* for working the windlass. When used for carrying balls, 1 *frame*, made of 4 planks dovetailed together and strengthened by iron corner-plates.

Iron.—1 *assembling-bar*, passes through the middle rails into the side rails.

2 *handspike-hooks*, fastened to the outside of the middle rails by 4 *nails* No. 2 C.

1 *assembling-bolt* No. 4 A; 2 *washers*; 1 *nut*.

1 *eye-plate* for the lashing-chain, placed between the middle rails.

2 *bolts* No. 4 A for the front ends of the middle rails; 4 *washers*; 2 *nuts*.

2 *manœuvring-staples*, driven into the under side of the middle rails.

2 *cross-bar plates*, fastened to the front and rear cross-bars by 12 *bolts* No. 4 C; 9 *washers*; 12 *nuts*.

1 *lock-chain and shoe,*—1 *key;* 1 *bridle,* fastened under the left side rail; 1 *bolt* No. 4 B; 1 *nut,*—like those on the gun-carriage.

1 *trail-plate,* fastened under the front end of the middle rails by 11 *nails* No. 3 C.

1 *lunette;* 1 *reinforce,* fastened to the lunette by 4 *rivets* No. 3 C; 1 *bridle;* 3 *bolts* No. 4 C; 3 *nuts.*

2 *wheel-guard plates,* fastened to the middle rails by 12 *nails* No. 2 C.

1 *axle-tree* No. 5.

2 *under-straps,* fastened to the side rails by 4 *bolts* No. 4 B; 4 *nuts.*

2 *axle-straps,* fastened to the middle rails by 4 *bolts* No. 4 B; 4 *nuts.*

1 *breech-hurter,* let into the middle rails and fastened by 4 *nails* No. 2 C.

6 *stake-sockets,* bolted on the outside of the side rails by 10 *bolts* No. 3 D; 10 *washers;* 10 *nuts.*

2 *lock-chain hooks* take the place of 2 stake-socket bolts on the left side; 2 *washers;* 2 *nuts.*

1 *tar-bucket hook,* fastened on the outside of the left side rail by 2 *nails* No. 1 C.

4 *roller-plates,* fastened on the square part of the windlass by 32 *nails* No. 1 C.

4 *roller-bands,* let into the ends of the roller and fastened by 6 *nails* No. 1 C.

2 *journal-boxes,* (brass,) let into the ends of the windlass.

2 *journals* for the windlass, riveted at one end into 2 *journal-plates,* which are fastened to the inside of the rails by 4 *bolts* No. 3 C; 4 *nuts.*

2 *circular journal-plates,* fastened by the bolts last mentioned and by 4 *nails* No. 1 C.

2 *roller-hooks,* driven into the windlass 5.5 inches from the middle.

2 *handspike-straps,* fastened to the small end of the handspike by 2 *rivets* No. 2.

2 *shoulder-washers* for the axle-tree, 2 *linch-washers,* 2 *linch-pins,* 2 *wheels* No. 5,	like those for the gun-carriage.

GARRISON AND SEA-COAST CARRIAGES.

The garrison and sea-coast carriages are all made of *wrought iron.* They are of four different kinds, viz.:

1. The Barbette, front pintle, carriage.
2. The Barbette, centre pintle, carriage.
3. The Casemate carriage.
4. The Flank-Casemate carriage.

Each carriage is composed of a *chassis* and *top carriage.*

The inclination of the chassis-rails is the same in all the carriages,—3°. The trough-beam braces, transoms, and angle-iron sub-braces vary only in length, the flank-casemate carriage excepted. The thickness of the cheek-plates is the same in all. The barbette rails differ both in length and depth from the casemate, which are also different from the flank-casemate.

BARBETTE-CARRIAGES.

Barbette-carriages are divided into *front pintle* carriages and *centre pintle* carriages. The top carriage is the same for both kinds.

Of the front pintle class there are three carriages which are similar to each other: one for the 10-inch columbiad, one for the 8-inch columbiad and 42-pounder gun, and one for the 32 and 24 pounder guns: the latter two differ only in the lengths of the transoms and axle-trees.

Of the centre pintle class, there are two carriages: one for the 10-inch columbiad, and one for the 8-inch columbiad.

Top Carriage.

The parts marked with an asterisk (*) are common to all carriages.

2 *cheek-plates.*

2 *front braces*—2 *middle braces*—2 *rear braces,* fastened to the cheek-plates each by 4 *bolts* No. 4 E and 4 *nuts.*

2 *front sub-braces,* fastened to the cheek-plates by 4 *bolts* No. 4 E and 4 *nuts.*

2 *rear sub-braces,* fastened to the cheek-plates by 6 *bolts* No. 4 E and 6 *nuts.*

2 *shoes,* each fastened to the front brace by 1 *bolt* No. 4 E and 1 *nut,* to the rear brace by 1 *bolt* No. 4 E and 1 *nut,* to the front sub-brace by 2 *bolts* No. 4 H and 2 *nuts,* and to the rear sub-brace by 3 *bolts* No. 4 H and 3 *nuts.*

2 *trunnion-plates,* fastened to the front braces by 2 *bolts* No. 4 E and 2 *nuts,* and to the rear brace by 2 *bolts* No. 4 E and 2 *nuts.*

*2 *axle-boxes,* (brass,) held in place by *2 *axle-box washers,* (cast iron,) fastened to the cheek-plates each by 4 *bolts* No. 4 E and 4 *nuts.*

*1 *handspike-fulcrum,* fastened to the *left* rear brace by 2 *rivets* No. 5 C.
*2 *arc-supports,* fastened to the *right* rear brace by 2 *bolts* No. 1 D and 2 *rivets* No. 3 D.

*1 *lanyard roller,* brass, fastened to the right rear-brace by 1 *nut,* .375 in.

2 *transoms,* fastened to the front brace by the 4 bolts which hold the braces to the cheek-plate.

1 *rear transom,* composed of 2 *pieces,* 5-inch trough-beams, with pieces welded in the ends, each piece fastened to the cheek-plates by 4 *bolts* No. 4 E and 4 *nuts.*

2 *brace-transoms,* fastened to the middle brace by the 4 bolts which hold the braces to the cheek-plates.

2 *diagonal braces,* fastened to the shoes by 4 bolts which hold the shoes and sub-braces, and to each other by 1 *bolt* No. 4 E and 1 *nut.*

1 *axle-tree;* *2 *linch-pins;* *2 *truck-wheels.*

1 *elevating-bed,* fastened to the rear transom by 4 *bolts* No. 4 E and 4 *nuts;* 1 *elevating-screw;* *1 *elevating-screw box,* (brass) fastened to the rear transom

by 4 *bolts* No. 4 E and 4 *nuts;* *1 *bevel-wheel and nut,* fitting on elevating-screw; *1 *brass pinion,* mounted on *1 *elevating-screw arbor;* *1 *arbor-box,* (brass,) fastened to the cheek-plate by 2 *bolts* No. 1 E and 2 *nuts,* .375 inch, (hexagonal;) *1 *arbor-handle;* *1 *nut,* .375 inch; 1 *pawl;* 1 *pawl-port;* 1 *elevating-arc,* (brass.)

The carriages for the 42-pounder and smaller guns have no elevating-bed, pawl, or pawl-port. The rear transom is made of a single piece of 5-inch trough-beam. The 8-inch carriage answers for the 42-pounder gun by adding 2 trunnion-plates, removing the elevating-bed, and adding a longer elevating-screw. The 32-pounder carriage answers for smaller guns by the addition of trunnion-plates.

Chassis.—Front pintle.

2 *rails,* (I-shape.) 15 inches deep.

1 *hurter-bar,* fastened to the rails by 4 *bolts* No. 4 E and 4 *nuts.*

2 *counter-hurters,* fastened to the rails by 8 *rivets* No. 5 D, countersunk on top.

1 *front transom,* composed of 1 *transom-plate* and 2 *cast-iron transom-bolsters:* the transom is fastened to the rails by 16 *bolts* No. 4 E, which pass through the bolsters and keep them in place; 16 *nuts;* 4 *bevel-washers.*

3 *transoms,* fastened to the rails by 12 *bolts* No. 4 E and 12 *nuts*—2 of them have hook heads.

2 *diagonal braces,* fastened to the front transom by 4 *bolts* No. 4 H and 4 *nuts,* and to the rails by 4 *bolts* No. 4 E and 4 *nuts.*

2 *side steps,* fastened to the rails by 4 *bolts* No. 4 E and 4 *nuts.*

2 *rear steps,* fastened to the rear transom by 4 *bolts* No. 4 E and 4 *nuts.*

2 *rear traverse wheel-forks,* fastened to the rails by 16 *bolts* No. 4 E, 16 *nuts;* 2 *traverse-wheels;* 2 *traverse-wheel bolts* 1.75 inch, 2 *nuts.*

4 *implement-hooks,* fastened to the rails by 4 *nuts* No. 4; 1 *key* in the pintle.

WOOD.—15 *planks,* 6 inches wide, 1½ inches thick, placed across the chassis, on the lower flange.

NOTE.—The ends of the front transom must have a firm support on an iron friction-bar resting on the masonry around the pintle; and the transom must be held down, and be prevented from rising off the pintle, by a key passing through it or by a nut screwed on the top.

Chassis.—Centre pintle.

2 *rails,* I-shaped.

1 *hurter-bar,* fastened to the rails by 4 *bolts* No. 4 E; 4 *nuts.*

2 *counter-hurters,* fastened to the rails by 8 *rivets* No. 5 D, countersunk on top.

4 *transoms,* fastened to the rails by 16 *bolts* No. 4 E,—6 of them have hook heads; 16 *nuts.*

1 *middle transom,* fastened to the rails by 16 *bolts* No. 4 E; 16 *nuts:* this transom is composed of 1 *transom-plate* and 2 *transom-bolsters,* fastened

together by 16 *bolts* No. 4 H; 16 *nuts:* the transom-bolster is made of 2 pieces, fastened together by 4 *rivets* No. 4 D.

4 *diagonal braces*, fastened to the middle transom by 8 *bolts* No. 4 H, (8 *nuts*,) and to the lower flange of the rail by 8 *bolts* No. 4 E; 8 *nuts*.

2 *transom and rail braces*, fastened to the rails by 2 *bolts* No. 4 E, 2 *nuts*, and to the bolster of the middle transom by 2 *bolts* No. 4 E; 2 *nuts*.

2 *front traverse-wheel forks* and 2 *rear traverse-wheel forks*, fastened to the rails by 32 *bolts* No. 4 E; 32 *nuts;* 2 *front traverse-wheels*, (cast iron;) 2 *rear traverse-wheels*, (cast iron;) 2 *front traverse-wheel bolts*, (2-inch;) 2 *nuts;* 2 *rear traverse-wheel bolts*, (1.75 inch;) 2 *nuts*.

2 *implement hooks*, fastened to rails by 2 *bolts*, No. 4.

WOOD.—15 *planks*, 6 inches wide, 1.5 inch thick, placed across the chassis, resting on the lower flange.

The rails of the centre-pintle carriages for the platforms *now laid* are 9 inches in depth; for new platforms, not yet laid, the depth of rails will be 15 inches. The pintle-plate of new platforms is to be raised 2½ inches, which will obviate the necessity of bolsters to the middle transoms: simple wedges will replace them.

IMPLEMENTS.—2 *manœuvring-bars;* 2 *pinch-bars;* 2 *offset-wrenches;* 1 *manœuvring-handspike*.

1 *pointing-bar* for columbiads.

CASEMATE-CARRIAGES.

There are two carriages, one for the 8-inch and 42-pounder guns, the other for the 32 and 24 pounders.

Top Carriage.

2 *cheek-plates*.

2 *front braces;* 2 *middle braces;* 2 *rear braces*, the rear ends filled up by a piece welded in each brace; each fastened to the cheek-plate by 4 *bolts* No. 4 E and 4 *nuts*.

2 *front sub-braces*, fastened to cheek-plate by 4 *bolts* No. 4 E; 4 *nuts*.

2 *rear sub-braces*, fastened to the cheek-plates by 6 *bolts* No. 4 E; 6 *nuts*.

2 *shoes*, each fastened to the front brace by 1 *bolt* No. 4 E and 1 *nut;* to the rear brace by 1 *bolt* No. 4 E and 1 *nut;* to the front sub-brace by 2 *bolts* No. 4 H and 2 *nuts;* and to the rear sub-brace by 2 *bolts* No. 4 H and 2 *nuts*.

2 *trunnion-plates*, fastened to the front brace by 2 *bolts* No. 4 E; 2 *nuts;* and to the rear brace by 2 *bolts* No. 4 E; 2 *nuts*.

2 *axle-boxes*, (brass,) held in place by 2 *axle-box washers*, each fastened to the cheek-plate by 4 *bolts* No. 4 E; 4 *nuts*.

1 *handspike-fulcrum*, fastened to the left rear brace by 2 *rivets* No. 5 C 2 *arc-supports*, fastened to the right rear brace by 2 *bolts* No. 1 D, 2 *nuts* and 2 *rivets* No. 3 D.

1 *lanyard roller*, brass, fastened to the right rear-brace by 1 *nut* .375 inch.

2 *transoms*, fastened to the front braces by the 4 *bolts* which hold the braces to the cheek-plates.

1 *rear transom*, 5-inch trough-beam, with a piece welded in each end, fastened to the cheek-plate by 4 *bolts* No. 4 E; 4 *nuts*.

2 *brace-transoms*, fastened to the middle brace by the 4 bolts which hold the braces to the cheek-plates.

2 *diagonal braces*, fastened to the shoes by 4 bolts, which hold the shoe and sub-brace, and to each other by 1 *bolt* No. 4 E; 1 *nut*.

1 *axle-tree;* 2 *linch-pins;* 2 *truck-wheels.*

1 *elevating-screw box*, brass, fastened to the rear transom by 2 *bolts* No. 4 E, 2 *nuts;* 1 *elevating-screw;* 1 *bevel-wheel and nut*, fitting on elevating-screw; 1 *brass pinion*, mounted on 1 *elevating-screw arbor;* 1 *arbor-box*, (brass,) fastened to the cheek-plate by 2 *bolts* No. 1 E, 2 *nuts;* 1 *arbor-handle;* 1 *nut;* 1 *elevating-arc*, (brass).

Chassis.

2 *rails*, I-shaped, 9-inch.

1 *hurter-bar*, fastened to the rails by 4 *bolts* No. 4 E and 4 *nuts*.

2 *counter-hurters*, fastened to the rails by 8 *rivets* No. 5 D, countersunk on top.

1 *front transom*, fastened to the rails by 8 *bolts* No. 4 E and 8 *nuts*.

3 *transoms*, fastened to the rails each by 4 *bolts* No. 4 E and 4 *nuts*,—4 of them hook heads.

1 tongue, fastened to the front transom by 4 *bolts* No. 4 E and 4 *nuts*.

2 *front traverse-wheel forks*, (each in 2 pieces,) fastened to the rails by 12 *bolts* No. 4 E and 12 *nuts*, and by 4 bolts, which hold the front transom.

2 *rear traverse-wheel forks*, (each in 2 pieces,) fastened by 16 *bolts* No. 4 E, 16 *nuts*.

2 *front traverse-wheels;* 2 *front traverse-wheel bolts* (1.75 inch) 2 *nuts;* 2 *rear traverse-wheels;* 2 *rear traverse-wheel bolts* (1.75 inch) and 2 *nuts*.

2 *diagonal braces*, fastened to the under side of the rail by 4 *bolts* No. 4 E, 4 *nuts*, and to the front transom by the 4 bolts which hold the tongue.

The carriage assembled for the 8-inch gun answers for the 42-pounder by the addition of 2 trunnion-plates. The carriage assembled for the 32-pounder answers, in the same way, for the smaller guns.

24-*pounder Howitzer-Carriage for Flank-Casemates.*

The details of this carriage have not been sufficiently arranged for insertion here.

The embrasures of the new flank-casemates have been changed from the plan formerly used, by placing the pintle-hole 24 inches farther to the front. This requires the addition of an iron tongue, with a pintle-hole, to the wooden chassis. Other flank embrasures are made without a tongue-hole; for these, the iron tongue is placed above the upper pintle-plate, and held by the same 3 bolts, which are made stronger.

MORTAR-BEDS.

The mortar-beds for the *new-model mortars* are made of wrought iron. Their details are not determined with sufficient accuracy to be inserted at this time.

Beds for 8-inch and 10-inch Siege Mortars.

WOOD.—1 *bolster* for the quoin, fastened to the front transom by 2 *bolts* and 2 *nuts*.

IRON.—2 *cheeks;* 1 *middle transom*, 1 *front transom*, in one piece, (cast iron.)

4 *manœuvring-bolts*, wrought iron, cast in place.

2 *cap-squares*, fastened to the cheeks by 4 *straps*, held by 4 *bolts* and 4 *keys*.

Beds for 10-inch and 13-inch Sea-Coast Mortars.

WOOD.—1 *front transom;* 1 *rear transom.*

IRON.—2 *cheeks*, (cast iron;) 1 *middle transom*, (brass.)

2 *manœuvring-bolts* No. 10; 4 *nuts* No. 9.

6 *assembling-bolts* No. 10; 6 *nuts*.

4 *transom-straps;* 16 *screws*.

1 *elevating-screw bed*, fastened to the front transom by 2 *bolts* No. 5 A; 2 *nuts*.

1 *elevating-screw box*, (brass;) 1 *elevating-screw*.

COEHORN MORTAR.

WOOD.—1 *bed*, in 1 or 2 pieces.

IRON.—2 *assembling-bolts* No. 3 A; 4 *washers;* 2 *nuts*.

2 *cap-squares*, fastened to the bed by 4 *bolts* No. 2 B and 4 *nuts*.

4 *handles*, fastened to the sides by 4 *bolts* No. 3 A and 4 *nuts*.

PRESERVATION OF CARRIAGES.

Wooden carriages are preserved in well-ventilated storehouses, protected from the weather. If the timber be not perfectly dry, and the exigencies of the service will permit, they are left unpainted: the irons are first coated with linseed-oil and painted one coat.

Iron carriages require especial care to preserve them from oxidation. When the parts of a carriage are completed and ready to be assembled, all rust that may have formed is scraped off, and the parts are placed in a kettle containing linseed-oil, which is raised to its boiling-point. When the iron has become as warm as the oil, it is taken out and placed on the side of the vessel to drip. When dry, the carriage is assembled and painted with two coats of iron paint.

The carriages are preserved in dry buildings, on the ground-floor, taken to pieces and piled away. Pieces of the same kind are put in a pile by themselves.

Carriages that are mounted should have the paint renewed from time to time, as it is worn off; and if rust shall accumulate, it must be removed, and a coat of oil first applied and the carriage then painted.

Wheels.

		No. 1.	No. 2.	No. 3.	No. 4.	No. 5.
Wood.	Naves	1	1	1	1	1
	Spokes	14	14	12	12	14
	Fellies	7	7	6	6	7
	Dowels	7	7	6	6	7
	Wedges for spokes	14	14	12	12	14
Iron.	12 brow-bands......inches	1.25×.25	1.25×.25	1×.15	.75×.13	1.5×.38
	2 end-bands......inches	1.5×.25	1.5×.25	1.1×.2	1×.2	1.75×.38
	Nails for bands	12 No. 1 C.	12 No. 1 C.	12 No. 1 C.	12 No. 1 C.	12 No. 1 C.
	Tire, inches	2.75×0.5	2.75×.625	2.0×.5	2×.38	4×.75
	Tire-bolts, nuts, and washers	7 No. 2 H.	7 No. 2 H.	6 No. 2 H.	6 No. 1 H.	7 No. 4 H
	Nave-box	1	1	1	1	1

Wheel No. 1, for the 6-pdr. gun-carriage, caisson, forge, battery-wagon, and the limbers of all field carriages.

No. 2, for the 24 and 32 pdr. howitzers, and the 12-pdr. gun-carriages only.

No. 3, for the prairie carriage.

No. 4, for the mountain howitzer.

No. 5, for all siege carriages and their limbers.

Dimensions and Weights of Axle-Trees.

			No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.
			In.	In.	In.	In.	In.	
Length of	the body on the under side		45.5	45.5	34.35	18.68	42.	...
	the middle piece of body		15.5	22.	...	...	...	...
	the arm to the linch-washer		13.85	13.85	8.55	7.55	16.1	...
	the round end, including the hole		2.07	2.07	1.275	2.15	2.3	...
	Total		78.84	78.84	54.	38.3	81.8	...
The body.	Width	at the middle	2.5	3.5	2.	4.32	3.5	2.8
		at the shoulder	3.	3.	2.	4.32	3.5	3.0
	Thickness.	at the middle	1.5	3.	2.	3.54	3.5	2.8
		at the shoulder	3.	3.	2.	3.94	3.5	3.0
Diameter of the arm		at the shoulder	3.	3.	2.	3.5	3.5	2.9
		at the linch-washer	2.005	2.005	...	2.64	2.5	2.9
Weight......lbs.			116.	122.	...	...	232.	...

No. 1, for 6-pdr. gun-carriages, caissons, forge and battery wagons.

No. 2, for 12-pdr. gun-carriages, 24-pdr. and 32-pdr. howitzer-carriages

No. 3, for prairie carriages.

No. 4, for mountain howitzer carriages.

No. 5, for siege carriages.

No. 6, for iron carriages.

Nave-Boxes.

			No. 1.	No. 2.	No. 3.	No. 4.	No. 5.
			In.	In.	In.	In.	In.
Length of	the whole		13.75	8.0	8.26	16.5	3.0
	cylindrical part		2.0	...	...	2.0	2.1
	grease-chamber		4.59	3.0	3.26	5.6	...
Diameter.	Interior.	large end	3.05	2.0	3.55	3.55	3.0
		small end	2.05	1.5	2.6	2.55	3.0
	Exterior.	large end	3.85	2.5	4.05	4.4	5.0
		small end	2.85	2.0	3.1	3.4	5.0
Depth of grease-chamber			.125	.1	.1	.15	...
Flange	Length of		13.75	8.0	1.0	16.5	.5
	Width of, at base		.45	.45	.25	.4	...
	Projection of		.4	.4	.25	.4	.25

No. 1, for field axle-trees.
No. 2, " prairie "
No. 3, " mountain howitzer axle-trees.
No. 4, " siege axle-trees.
No. 5, " iron carriage axle-trees.
Nos. 3, 4, and 5 of brass; the rest iron cast.

Linch-Pins.

		No. 1.	No. 2.	No. 3.	No. 4.	No. 5.
		In.	In.	In.	In.	In.
Stem..	Length	3.85	2.35	4.	4.2	3.9
	Diameter	.62	.5	.5	.7	.5
Head..	Length	1.75	1.4	1.37	1.8	1.75
	Breadth at top	.8	.5	.6	.9	.75
	" at bottom	1.4	...	1.1	1.7	1.25
	Thickness at top	.8	.85	.8	1.0	.8
	" at bottom	.75	...	.5	8.5	.4
	" under chin	.45	.55	.45	.5	.4
Weight	oz.	11.68	4.62	8.01	14.26	5.24

No. 1 for field axle-trees.
No. 2 " prairie "
No. 3 " mountain howitzer axle-trees.
No. 4 " siege axle-trees.
No. 5 " iron carriage axle-trees.

Washers.

	Shoulder-washers.				Linch-washers.		
	No. 1.	No. 2.	No. 3.	No. 4.	No. 1.	No. 2.	No. 3.
	In.	In.	In.	In.	In.	In.	In.
Diameter of the washer..........	5.5	4.	6.	6.	4.	3.25	5.
" " " hole..............	3.05	2.	3.5	5.	2.05	1.6	2.55
Thickness..........................	.375	.25	.5	2.	.375	.35	.5
Weight.......................oz.	28.97	12.15	40.32	544.	15.00	15.54	55.22

No. 1, for field-carriages, axle-trees No. 1 and 2.
No. 2, for prairie carriages, axle-tree No. 3.
No. 3, for siege-carriages.
No. 4, for iron carriages.

Lock-Chains for Field-Carriages.

The lock-chain is the same for all field-carriages, except in the *number* of the links. It consists of 1 *toggle*, 7.7 in. long, 1 *link*, 1 *long link*, 4.9 in. long, with 1 *loose ring*, 1.5 in. diam., — number of links, 1 *ring* 2.56 in. diam., with 1 *loose ring* of same size, and — number of links to the eye-plate. The links are all No. 5.

	6-pdr. gun-carriage.	12-pdr. gun, 24-pdr. how. carriage.	Caisson.	Forge.	Battery-wagon.
Number of links from the long link to the ring............	16	18	13	16	16
" " " " " ring to the eye-plate............	6	7	4	4	10

A recent order requires these chains to be made of a new kind of chain, known as the loop-link chain, which is stronger for the same weight.

For Siege-Carriages.

The lock-chain consists of a chain of 4 *links*, No. 7, and 1 *toggle*, 7.75 in. long, with 1 *loose ring*, 3 in. diameter on the first link, which is attached to the ring in the lock-chain bolt by 1 *ring* 3¼ in. diam.; of a second chain of the same sized links, to which the shoe is attached, composed of 14 *links for the gun-carriage*, and 18 *links for the mortar-wagon*, and 1 *ring* 3¼ diam. which is joined to the ring in the lock-chain bolt by 15 *links* No. 5.

These chains are to be made of the loop-link chain, by recent order.

Table of Bolts, Nuts, and Washers.

	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.	No. 7.	No. 8.	No. 9.
BOLTS.	In.	In.	In.	In.	In.	In.	In.	In.	In.
Diameter of bolt	0.375	0.5	0.625	0.75	1.	1.125	1.25	1.375	1.5
Diameter of head. A	.85	1.1	1.4	1.7	2.3	2.5	2.75	3.	3.25
Diameter of head. B	1.	1.25	1.5	1.875	2.5	2.75	3.	3.5	3.75
Diameter of head. C. D. H	0.7	0.875	1.06	1.25	1.625	...	...	...	...
Diameter of head. E	.75	1.	1.25	1.5	2.	2.25	2.5	2.75	3.
Diameter of head. F. G	1.125	1.5	...	...	...	...	...	...	...
Thickness of head... A. B. E. F. G	0.3	0.375	.5	.6	.75	.8	.9	1.	1.1
Thickness of head... C. D. H	.25	.3	.35	.4	.5	...	...	...	...
Chamfer of head, A. E. F	.1	.125	.16	.19	.25	.28	.31	.344	.375
Length of square, under the heads A. B. C. D	.375	.5	.625	.75	1.	1.125	1.25	1.375	1.5
Usual length of thread cut	.75	1.	1.25	1.5	2.	2.25	2.5	2.75	3.
Number of threads to the inch	13	13	13	10	8	8	8	7	7
NUTS. Square	.75	1.	1.25	1.5	2.	2.25	2.5	2.75	3.
NUTS. Thickness	.375	.5	.625	.75	1.	1.125	1.25	1.375	1.5
NUTS. Chamfer	.1	.125	.16	.19	.25	.28	.31	.344	.375
NUTS. Diagonal	1.06	1.41	1.77	2.12	2.83	3.16	3.54	3.87	4.24
NUTS. Diameter of hole punched	.31	.43	.56	.69	.88	1.0	1.06	1.25	1.31
NUTS. Weight, rough, lbs.	0.052	0.15	0.275	0.5	1.0	1.4	2.0	2.5	3.35
WASHERS. Diameter	1.25	1.6	2.	2.45	3.15	3.5	4.	4.375	4.75
WASHERS. Thickness	0.125	.125	.125	.19	.19	.19	.25	.25	.25
WASHERS. Width of chamfer	.1	.1	.12	.16	.16	.17	.23	.25	.25
WASHERS. Depth of chamfer	.06	.06	.06	.1	.1	.1	.125	.125	.125

In the preceding table the number indicates the size of the bolt, and the letter the form of the head, as follows:

A. Bolt with round (cylindrical) head, chamfered; square under the head.

B. Round head, not chamfered; to be let into wood; square under the head.

C. Countersunk head; bolt square under the head.

D. Convex, or rose head; square under the head.

E. Square head, chamfered; round under the head; nut let into wood.

F. Round head, chamfered; applied to wood; round under the head.

G. Round head, not chamfered; to be let into wood; round under the head.

H. Countersunk head; bolt round under the head.

Rivets.

		No. 1.	No. 2.	No. 3.	No. 4.	No. 5.
		In.	In.	In.	In.	In.
Diameter of body		0.2	0.25	0.375	0.5	0.625
Diameter of head	B.	....	.75	1.125	1.5	1.875
	C. D	....	.5	.7	.875	1.0
	H.	.75				
Thickness of head	B.	....	.2	.25	.375	0.5
	C. D	....	.2	.25	.3	.375
	H.	.125				
BURRS.	Diameter	.75	.75	1.125	1.5	1.875
	Thickness	.125	.2	.25	.375	.5
	Exterior diameter of countersink	.3	.45	.6	.7	.87
	Depth of countersink	.1	.15	.17	.25	.375

B. Head not chamfered; to let into wood.
C. Countersunk head; to let into iron.
D. Rose head; resting on iron.
H. Rose head; resting on wood.

Chains.

No.	Thickness of iron.	LINKS. Kind.	Length.	Width.	Proof weight.	Remarks.
	In.		In.	In.	Lbs.	
1	0.15	Twisted.	1.1	0.6	400	All chains are welded
2	.2	Twisted.	1.25	.75	800	
3	.25	Twisted.	1.6	1.1	1,200	
4	.25	Straight.	2.	1.	1,500	
5	.375	Straight.	3.	1.5	2,500	
6	.5	Straight.	3.	1.75	5,000	
7	.625	Straight.	3.4	2.25	6,500	

Eye-Pins.

	No. 1.	No. 2.	No. 3.
	In.	In.	In.
Diameter of stem	0.3	0.375	0.5
Diameter of eye	.25	.3	.375

Rings.

Designation.		Thickness of wire.	Exterior diameter of ring.	Remarks.	
		In.	In.		
No. 1	A.	0.2	1.4	Welded.	These are the rings most commonly used in field and siege carriages, with the chains Nos. 1, 2, & 3.
	B.	.2	1.	Coldshut.	
No. 2	A.	.25	1.5	Welded.	
	B.	.25	1.25	Coldshut.	

Wrought Nails.

		No. 1.	No. 2.	No. 3.	No. 4.	Remarks.
		In.	In.	In.	In.	
Body; diameter or thickness		.25	.3	.375	.5	C. Square nail, with countersunk head.
Heads C. D.	Diameter	.5	.6	.7	.875	D. Round nail, with rose head.
	Thickness	.2	.25	.25	.3	

Cut Nails.

	2*d.*	2*d.*	4*d.*	6*d.*	8*d.*	10*d.*	12*d.*	20*d.*
	In.	In.	In.	In.	In.	In.	In.	In.
Length	1	1.25	1.5	2	2.5	3	3.5	4
Number in 1 lb.	550	450	340	150	100	60	40	25

Spikes are large nails, *wrought* or *cut:* the size is designated by the length in inches.

Bellows-nails and *clout-nails* are short wrought nails, with large heads, slightly convex; they are used chiefly for nailing leather, canvas, &c., on wood.

Bellows-nails are 1.13 inch long, 0.1 inch thick, with heads .75 inch to 1 inch in diameter; should weigh about 120 to 1 lb.

Principal Dimensions and Weights of Field-Gun Carriages and Limbers.

Dimensions.	6-pounder Gun and 12-pounder Howitzer.	24-pounder Howitzer.	12-pounder Gun and 32-pounder Howitzer.	Prairie Carriage.
	Inches.	Inches.	Inches.	Inches.
Distance between the inside of the trunnion-plates	9.6	11.65	12.15	7.
Diameter of the trunnion-holes	3.7	4.25	4.65	2.75
Depth of the centre of trunnion-hole below the upper face of the trunnion-plate	1.	0.95	0.95	0.6
Distance of axis of trunnions in rear of axis of axle-tree, the piece being in battery on horizontal ground	0.5	1.	0.8	3.45
Distance from axis of trunnions to axis of axle-tree	14.65	16.2	16.6	10.4
Height of axis of trunnions above the ground	43.1	44.8	45.2	30.5
Vertical field of fire, above the horizontal line. Gun	12°	....	13°	
Vertical field of fire, above the horizontal line. Howitzer	13°	13°	12°	8°45′
Vertical field of fire, below the horizontal line. Gun	8°	....	7°	
Vertical field of fire, below the horizontal line. Howitzer	6°	8°	6°	4°
Distance between the points of contact of trail and wheels with the ground-line	74.4	79.8	79.8	48.0
Distance from front of wheels to end of trail, the piece being in battery	116.6	122.75	122.75	83.0
Distance of the muzzle of the piece in battery from the front of the wheels. Gun, in front of wheels	5.91	....	15.70	
Distance of the muzzle of the piece in battery from the front of the wheels. Howitzer.. front of wheels	....	5.9	12.7	7.0
Distance of the muzzle of the piece in battery from the front of the wheels. Howitzer.. rear of wheels	1.09			
Length of gun-carriage without wheels	104.4	111.4	113.5	68.0
Length of limber without wheels	161.2	161.2	161.2	141.0
Length of limber without wheels or pole	52.85	52.85	52.85	37.5
Length of limber with wheels and pole	173.08	173.08	173.08	152.0
Distance between the centres of the axle-trees of gun-carriage and limber	96.	101.7	101.7	64.0
Length of the carriage limbered up	269.08	274.78	274.78	216.0
Distance from the muzzle of the piece, when limbered, to the front of pole. Gun	279.1	....	294.	
Distance from the muzzle of the piece, when limbered, to the front of pole. Howitzer	272.1	283.78	291.	
Whole length of the axle-tree	78.84	78.84	78.84	54.0
Track of the wheels	60.	60.	60.	42.5
Height of wheel	57.	57.	57.	42.0
Dish of finished wheel	1.5	1.5	1.5	1.0
	Lbs.	Lbs.	Lbs.	Lbs.
Weights. Gun-carriage, without wheels	540	736	783	267
Weights. Limber, without wheels or ammunition-chest	335	335	335	163
Weights. Ammunition-chest, without divisions	165	165	165	
Weights. One wheel. Gun-carriage	180	196	196	69
Weights. One wheel. Limber	180	180	180	69
Weights. Gun-carriage complete, without implements	900	1128	1175	363
Weights. Limber complete, without implements	860	860	860	343
Weights. Gun-carriage and limber, without implements	1760	1988	2035	720

NOTE.—The 12-pounder gun, model 1857, is mounted on the same carriage as the 24-pounder howitzer. The cheeks are a little shortened, and the elevating-screw brought forward. The distance of axis of trunnions in rear of axle-tree, 0.25 in. Weight of trail on ground, 216 pounds.

Dimensions and Weights of Gun-Carriage and Equipment for 12-pounder Mountain Howitzer.

DIMENSIONS.	Inches.
Distance between the inside of trunnion-plates	7.
Diameter of trunnion-holes	2.75
Depth of axis of trunnions below upper face of trunnion-plate	0.62
Distance of axis of trunnions in rear of axis of axle-tree, the piece being in battery, on horizontal ground	2.5
Distance from axis of trunnions to axis of axle-tree	8.5
Height of axis of trunnions above the ground	27.
Vertical field of fire, above the horizontal line	9°
Vertical field of fire, below the horizontal line	7°
Distance between the points of contact of wheels and trail with the ground-line	43.7
Distance from front of wheels to end of trail, the piece being in battery	71.8
Distance of the muzzle of the piece, in battery, in rear of wheels	4.8
Length of gun-carriage, without wheels	61.
Length of thill	73.
Whole length of the axle-tree	38.25
Track of the wheels	30.2
Height of wheel	38.
Dish of finished wheel	2.
Ammunition-Chest, or *Carriage-maker's Tool-Chest.* Interior length	32.8
" " width	4.75
" " depth	9.35
Forge-Chest, or *Smith's Tool-Chest.* Interior length	32.8
" " width	7.8
" " depth	16.1
WEIGHTS.	Pounds.
Howitzer	214
Gun-carriage, without wheels	157
One wheel	60
Handspike	5
Sponge and rammer	3
Gun-carriage complete, with implements	287
Thill	30
Bridle	3
Halter	3.5
Pack-saddle and harness	47
Lashing girth and rope	3
Ammunition-chest, or carriage-maker's tool-chest, empty	20
Forge-chest, or smith's tool-chest, empty	42
Ammunition-chest, packed	112
Forge-chest, packed	115
Smith's tool-chest, packed	117
Coal-sack, filled with charcoal	25
Carriage-maker's tool-chests.. A	48
Carriage-maker's tool-chests.. B	45

Dimensions and Weights of Prairie Ammunition-Cart.

	Inches.
Whole length of cart	127.
Length of implement-chest	31.5
Width " "	6.0
Depth " " in front	7.25
" " " in rear	9.
	Pounds.
Weight of cart, empty, without wheels	296
" " packed with ammunition	802
" two-wheels	138

Principal Dimensions and Weights of Siege-Gun Carriages and Limbers.

DIMENSIONS.	12-pounder Gun.	18-pounder Gun.	24-pounder Gun and 8-inch Howitzer.
	Inches.	Inches.	Inches.
Distance between the inside of the trunnion-plates	14.95	16.95	18.15
Diameter of the trunnion-holes	4.65	5.35	5.85
Depth of centre of trunnion-hole below the upper face of trunnion-plate	1.1	1.2	1.4
Distance of axis of trunnions in rear of axis of axle-tree, the piece being in battery on horizontal gronnd	3.	2.5	2.75
Distance from axis of trunnions to axis of axle-tree	22.45	22.85	23.25
Height of axis of trunnions above the ground	52.2	52.6	53.
Vertical field of fire — above the horizontal line. — Gun	13°	12°	12°
Vertical field of fire — above the horizontal line. — Howitzer	....	....	15°
Vertical field of fire — below the horizontal line. — Gnn	4°	4°	4°
Vertical field of fire — below the horizontal line. — Howitzer	....	....	10°
Distance between the points of contact of the wheels and trail with the ground-line	100.	101.	101.
Distance from the front of the wheels to the end of the trail, the piece being in battery	141.	142.	142.
Distance of tho muzzle of the piece in battery from the front of the wheels — Gun, in front of the wheels	30.74	35.35	35.34
Distance of tho muzzle of the piece in battery from the front of the wheels — Howitzer, in rear of wheels	....	....	7.66
Length of gun-carriage, without wheels	130.	133.	133.6
Length of limber, without wheels	176.65	176.65	176.65
Length of limber, without wheels or pole	59.8	59.8	59.8
Length of limber, with wheels and pole	184.9	184.9	184.9
Distance between the centres of the axle-trees of gun-carriage and limber	94.	96.	96.
Length of the carriage, limbered up	278.9	280.9	280.9
Distance from the muzzle of the gun, in its travelling position, to front end of pole	285.15	291.42	290.
Whole length of the axle-tree	81.8	81.8	81.8
Track of the wheels	60.	60.	60.
Height of wheels	60.	60.	60.
Dish of finished wheels	2.	2.	2.
	Lbs.	Lbs.	Lbs.
WEIGHTS... Gun-carriage, without wheels	1440	1542	1714
WEIGHTS... Limber, without wheels	585	585	585
WEIGHTS... One wheel	404	404	404
WEIGHTS... Gun-carriage, complete, without implements	2248	2350	2522
WEIGHTS... Limber, complete	1393	1393	1393
WEIGHTS... Gun-carriage and limber, without implements	3641	3743	3915

Field and Siege Wagons.

Dimensions and Weights.		Caisson.	Forge.	Battery-Wagon.	Mortar-Wagon.
		In.	In.	In.	In.
Length		125.5	130.	154.	143.6
Distance between the axle-trees of carriage and limber		92.	97.8	112.93	102.95
Whole length, when limbered up		274.7	279.	393.13	287.85
Height, above the ground		58.75	70.5	73.55	60.
		Lbs.	Lbs.	Lbs.	Lbs.
Weight.	Carriage-body, without wheels	432	997	910	984
	Limber, without wheels or chest	335	335	335	585
	One wheel	180	180	180	404
	Carriage and limber, complete, without implements or spare parts	1,982	2,217	2,130	3,185

Interior Dimensions.		Length.	Width.	Depth.	Weight.
		In.	In.	In.	Lbs.
Ammunition or limber chest, without divisions		40.	18.	14.75	165
Travelling forge	Iron room	40.	32.	7.5	
	Coal-box	31.	13.	17.	100
Battery-wagon, body		98.8	36.	22.	
Mortar-wagon, floor		63.85	40.		

Mortar-Beds.	Siege.		Coehorn.
	8-inch.	10-inch.	
	In.	In.	In.
Length	42.	51.8	31.
Exterior width, including manœuvring-bolts	34.	40.	15.
Weight pounds	920	1830	132

Principal Dimensions and Weights of Barbette-Carriages, (wooden.)

DIMENSIONS.	12-pdr. Gun.	18-pdr. Gun.	24-pdr. Gun.	32-pdr. Gun and 8-in. Howitzer.	42-pdr. Gun.
	In.	In.	In.	In.	In.
Distance between the inside of the trunnion-plates	14.9	16.9	18.1	20.8	22.1
Diameter of the trunnion-holes	4.65	5.35	5.85	6.45	7.05
Depth of the centre of trunnion-hole below upper face of trunnion-plate	1.	1.	1.	1.	1.
Horizontal distance of axis of trunnions in rear of axis of axle-tree	3.9	3.9	4.	4.1	4.2
Distance of axis of trunnions from axis of axle-tree	41.3	41.3	42.	43.4	44.1
Height of the axis of trunnions, in battery, above the traverse-circle	71.76	71.76	73.45	75.77	77.47
Horizontal distance from axis of trunnions to axis of elevating-screw { Gun	43.1	44.5	44.25	43.9	44.8
Horizontal distance from axis of trunnions to axis of elevating-screw { Howitzer	....	......	......	39.	
Vertical field of fire, { above the horizontal line	11°	11°	11°	11°	11°
Vertical field of fire, { below the horizontal line	5°	5°	5°	5°	5°
Length of gun-carriage, from front of wheels to rear of lunette	89.5	89.5	90.75	90.75	92.05
Whole length of the axle-tree	57.76	57.76	59.76	66.06	68.31
Distance between the exterior faces of the gun-carriage wheels	55.70	55.70	57.70	64.	66.25
Inclination of the chassis in 100 inches	5.	5.	5.	5.	5.
Whole length of the chassis	184.06	184.06	183.38	182.86	182.71
Width of the chassis between the outside of the rails	43.	43.	45.	51.30	53.5
Horizontal distance from centre of pintle to front end of rails	9.5	9.5	9.5	9.5	9.5
Horizontal distance from centre of pintle to rear end of chassis	174.3	174.3	174.22	173.76	173.66
Horizontal distance from centre of pintle to centre of traverse-wheels	120.33	120.33	120.33	120.33	120.33
Horizontal distance from centre of pintle to the face of the piece, in battery { Gun	59.	63.15	63.29	63.70	65.30
Horizontal distance from centre of pintle to the face of the piece, in battery { Howitzer	....	....	....	52.5	

Principal Dimensions and Weights of Barbette-Carriages.—Continued.

Dimensions.	12-pdr. Gun.	18-pdr. Gun.	24-pdr. Gun.	32-pdr. Gun and 8-in. Howitzer.	42-pdr. Gun.
	In.	In.	In.	In.	In.
Horizontal distance from centre of pintle to axis of axle-tree — the piece being in battery	0.8	0.8	0.8	0.8	0.8
Horizontal distance from centre of pintle to axis of axle-tree — the piece recoiled to counter-hurters	113.07	113.07	113.	112.53	112.43
Diameter of gun-carriage roller	13.	13.	13.	13.	13.
Diameter of gun-carriage wheel	43.5	43.5	43.5	43.5	43.5
Diameter of traverse-wheel of chassis	15.	15.	15.	15.	15.
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
Weights. Gun-carriage, without wheels or rollers	780	800	1073	1327	1400
One gun-carriage roller	135	135	135	146	146
One gun-carriage wheel	308	308	308	308	308
Chassis, without traverse-wheels or forks	1100	1100	1420	1836	2000
One traverse-wheel and fork	97	97	97	97	97
Pintle,—new pattern	17	17	17	17	17
Gun-carriage, complete, without implements	1666	1686	1959	2213	2308
Chassis, complete, without pintle	1294	1294	1614	2030	2194

Principal Dimensions and Weights of Casemate-Carriages, (wooden.)

DIMENSIONS.	24-pdr. Gun.	32-pdr. Gun.	42-pdr. Gun.	8-in. Columbiad.	24-pdr. Howitzer.
	In.	In.	In.	In.	In.
Distance between the inside of the trunnion-plates, measured in the axis of trunnion-holes	18.52	21.26	22.56	25.10	12.95
Diameter of the trunnion-holes	5.85	6.45	7.05	8.05	4.65
Depth of axis of trunnion-hole below the upper face of trunnion-plate	0.75	0.75	0.75	0.75	0.
Horizontal distance of axis of trunnions in rear of axis of axle-tree	1.90	1.90	1.90	3.00	
Distance of axis of trunnions from axis of axle-tree	26.32	27.51	28.21	28.31	
Height of axis of trunnions, in battery, above the traverse-circle	48.75	49.95	50.65	50.65	48.25
Vertical field of fire, above the horizontal line	9°	8°	8°	8°	
Vertical field of fire, below the horizontal line	4°	4°	4°	4°	
Length of gun-carriage, from front of cheeks to rear of trail-roller	67.35	67.35	67.35	67.20	48.25
Whole length of the axle-tree	48.50	53.	55.05	57.60	
Distance between the exterior faces of gun-carriage trucks	40.	44.50	46.55	49.10	
Inclination of the chassis in 100 inches	7.35	7.35	7.35	7.35	5.83
Whole length of chassis (including 3 inches for the tongue-fork)	189.15	189.15	189.15	189.15	151.
Width of chassis between the outsides of the rails	40.	44.50	46.76	49.16	22.
Length of rear transom of chassis	59.50	64.	66.26	68.66	
Horizontal distance from centre of pintle to front end of rails, upper side	49.94	49.94	49.94	49.94	7.
Horizontal distance from centre of pintle to middle of rear transom of chassis	193.40	193.40	193.40	193.40	
Horizontal distance from centre of pintle to rear end of chassis	235.	235.	235.	235.	144.

Principal Dimensions and Weights of Casemate-Carriages.—Continued

Dimensions.	24-pdr. Gun.	32-pdr. Gun.	42-pdr. Gun.	8-in. Columbiad.	24-pdr. Howitzer.
	In.	In.	In.	In.	In.
Horizontal distance from centre of pintle to centre of rear traverse-wheels	194.5	194.5	194.5	194.5	120.
Horizontal distance from centre of pintle to centre of front traverse-wheels	62.5	62.5	62.5	62.5	
Horizontal distance from centre of pintle in rear of face of the piece, in battery	0.52	1.03	2.73	4.83	25.6
Horizontal distance from centre of pintle to axis of axle-tree... { piece in battery	65.67	65.67	65.67	65.67	
Horizontal distance from centre of pintle to axis of axle-tree... { piece recoiled to counter-hurters	177.13	177.13	177.13	177.13	
Diameter of gun-carriage truck-wheel	20.	20.	20.	20.	3.8
Diameter of rear traverse-wheels (mean)	15.90	15.90	15.90	15.90	6.
Diameter of front traverse-wheels (mean)	7.84	7.84	7.84	7.84	
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
Weights... Gun-carriage, without truck-wheels	908	1064	1120	1128	
One gun-carriage truck-wheel	223	223	223	223	
Chassis, without traverse-wheels	2120	2430	2575	2600	
One rear traverse-wheel	99	99	99	99	
One front traverse-wheel	30	30	30	30	
One pintle	92	92	92	92	50
Gun-carriage, complete, without implements	1354	1510	1566	1574	620
Chassis, complete, without pintle	2378	2688	2833	2858	660

Principal Dimensions and Weights of Columbiad Barbette-Carriages, (wooden.)

Dimensions.	8-in.	10-in.
Distance between the inside of the trunnion-plates	25.2	31.2
Diameter of the trunnion-holes	8.05	100.5
Depth of the centre of the trunnion-hole below upper face of trunnion-plate	0.	0.
Horizontal distance of axis of trunnions in rear of axis of axle-tree	3.	3.25
Distance of axis of trunnions from axis of axle-tree	32.6	34.6
Height of the axis of trunnions, in battery, above traverse-circle	61.	63.2
Horizontal distance from axis of trunnions to axis of elevating-screw	48.5	48.85
Vertical field of fire, above the horizontal line	30½°	28°
Vertical field of fire, below the horizontal line	4°	3°
Length of top carriage	74.	76.
Whole length of the axle-tree	49.6	60.6
Distance between the exterior faces of the wheels of top carriage	44.6	55.6
Inclination of the chassis in 100 inches	5.	5.
Whole length of the chassis	165.	165.
Width of the chassis between the outside of the rails	46.2	57.2
Horizontal distance from centre of pintle to front end of chassis	74.06	74.42
" " " " rear end of chassis	91.	90.58
" " " " centre of traverse-wheels	64.	64.
" " " " face of piece in battery	132.56	133.57
" " " " axis of axle-tree to piece in battery	62.06	61.42
" " " " axis of axle-tree to top carriage against counter-hurters	24.93	23.55
Diameter of wheel of top carriage	13.	13.
Diameter of traverse-wheel of chassis	12.	12.
Weight of top carriage	1952	2770
Weight of one wheel of top carriage	93.	93.
Weight of one traverse-wheel of chassis	95.5	95.5
Weight of one pintle	49.	49.
Weight of chassis	3.050	3.784

Principal Dimensions of the Iron Carriages.

DIMENSIONS.	BARBETTE.					CASEMATE.	
	FRONT PINTLE.			CENTRE PINTLE.			
	10-in.	8-in. and 42-pdr.	32 and 24 pdr.	10-in.	8-in.	8-in. and 42-pdr.	32 and 24 pdr.
Distance between the inside of the trunnion-plates	32.2	25.8	20.8	32.2	25.8	25.8	20.8
Diameter of the trunnion-holes	10.05	8.05	6.45	10.05	8.05	8.05	6.45
Depth of the centre of trunnion-hole below upper face of trunnion-plate	0	0	0	0	0	0	0
Horizontal distance of axis of trunnions in rear of axis of axle-tree	3.	2.0	2.0	3.	2.0	1.5	1.5
Distance of axis of trunnions from axis of axle-tree	35.15	33.9	33.9	35.15	33.9	24.9	24.9
Height of axis of trunnions, in battery, above the traverse-circle	79.72	77.47	77.47	61.	63.2	50.65	50.65
Vertical field of fire, above the horizontal line	30°	30°	14°	30°	30°	7°	10°
Vertical field of fire, below the horizontal line	6°	6°	6°	6°	6°	6°	2°
Length of top carriage from front to rear of shoe	75.4	75.6	75.6	75.4	75.6	65.38	65.38
Whole length of axle-tree	47.7	41.3	36.3	47.7	41.3	41.3	36.3
Distance between the exterior faces of trucks	43.2	36.80	31.8	43.2	36.80	36.80	31.8
Inclination of the chassis in 100 inches	5.23	5.23	5.23	5.23	5.23	5.23	5.23
Whole length of chassis, excluding tongue	173.	173.	173.	173.	173.	164.	164.
Width of chassis between the outside of rails	42.75	36.35	31.35	42.75	36.35	36.35	31.35
Horizontal distance from centre of pintle to front end of rails	24.25	20.5	9.42	77.09	77.09	49.	48.1
" " " " rear end of chassis	166.13	165.47	163.58	95.65	95.65	212.	211.8
" " " " centre of rear traverse-wheels	120.33	120.33	120.33	64.	64.	194.50	194.50
" " " " centre of front traverse-wheels	....	....	....	64.	64.	62.5	62.5
" " " " in rear of face of piece in battery	66.38	65.28	60.08	134.38	134.18	10.61	.46
" " " " to axis of axle-tree, in battery	8.06	8.26	8.26	60.14	59.94	69.64	69.64
" " " " to axis of axle-tree, against counter-hurters	95.16	95.16	95.16	20.58	20.78	142.53	142.53
Diameter of top carriage truck-wheel	12.	12.	12.	12.	12.	12.	12.
" " rear traverse-wheel, mean	18.	18.	18.	14.6	14.6	15.85	15.85
" " front " " "	....	....	....	11.63	11.63	7.85	7.85
WEIGHTS. Top carriage, without truck-wheels ... Lbs.	1847	1760	1658	1847	1760	1385	1354
" " complete, without implements ... Lbs.	1947	1860	1758	1947	1860	1485	1454
Chassis, without traverse-wheels ... Lbs.	2896	2851	2834	2435	2435	2053	2031
" complete, without pintle ... Lbs.	3035	2990	2973	2630	2630	2175	2153
One rear traverse-wheel ... Lbs.	139	139	139	118	118	99	99
One front traverse-wheel ... Lbs.	....	....	....	77	77	30	30
One pintle ... Lbs.	49	49	49	49	49	92	92

Bills of Timber for Field-Carriages.

Names of Parts.		No. of pieces.	Rough dimensions of each piece. Long.	Wide.	Thick.	Contents. Each piece.	Total.	Kind of wood.
GUN-CARRIAGES.			In.	In.	In.	Sup. ft.	Sup. ft.	
For 6-pdr. gun and 12-pdr. howitzer.	Stock	2	100	9.25	4.5	28.90	57.80	Oak.
	Cheeks	2	40	13.5	3.5	13.12	26.24	"
	Axle-body	1	50	7.	6.	14.58	14.58	"
							98.62	
For 12-pdr. gun, 24-pdr. and 32-pdr. howitzers.	Stock	2	108	11.	5.75	47.44	94.88	"
	Cheeks	2	50	16.	4.	22.22	44.44	"
	Axle-body	1	50	7.	7.	17.01	17.01	"
							156.33	
WHEELS, Nos. 1 and 2.								
Nave		1	16	14.	Round	17.09	17.09	"
Spokes		14	32	3.5	2.	1.55	21.70	"
Fellies		7	27	7.	3.5	4.59	32.13	"
							70.92	
LIMBER.								
Axle-body		1	50	9.	6.	18.75	18.75	"
Hounds		2	56	4.5	3.25	5.68	11.36	"
Fork		1	40	9.25	4.	10.27	10.27	"
Splinter-bar		1	72	4.25	3.5	7.43	7.43	"
Brackets		4	9	2.3	1.6	....	....	Cuttings.
Front foot-board		1	46	8.75	1.13	3.14	3.14	Oak.
Rear foot-board		1	46	5.	1.13	1.86	1.86	"
Pole ...	Large end	1	132	4.5	4.5	14.11	14.11	Oak or ash.
	Small end			3.25	3.25			
Pole-prop		1	30	2.25	2.25	1.05	1.05	Hickory.
							67.97	
AMMUNITION-CHEST.								
Ends		2	22	17.	1.31	3.40	6.80	Walnut.
Sides		2	44	17.	1.31	6.80	13.60	"
Principal partition		1	22	17.	1.31	3.40	3.40	"
Cover-frame...	Sides	2	69	3.75	2.	3.59	7.18	"
	Ends	2						
Bottom		1	44	20.	1.31	8.00	8.00	Oak.
Panel for cover		1	42	17.5	2.	10.21	10.21	Poplar.
Cover-lining		1	42	20.	0.5	5.83	5.83	Poplar.
							55.02	

Bills of Timber for Field-Carriages.

NAMES OF PARTS.	No. of pieces.	ROUGH DIMENSIONS OF EACH PIECE.			CONTENTS.		Kind of wood.
		Long.	Wide.	Thick.	Each piece.	Total.	
CAISSON.		In.	In.	In.	Sup. ft.	Sup. ft.	
Middle rail	1	76	5.75	4.75	14.41	14.41	Oak.
Side rails	2	78	5.	3.25	8.79	17.58	"
Stock	1	84	6.	4.75	16.62	16.62	"
Axle-body	1	50	6.	6.	12.50	12.50	"
Cross-bar	1	40	4.	3.	3.33	3.33	"
Foot-board bolster	1	14	4.	1.25	.48	.48	"
Front foot-board	1	42	7.5	2.13	4.65	4.65	"
Rear foot-board	1	42	5.	1.25	1.82	1.82	"
						71.39	
FORGE—*Body.*							
Side rails	2	96	4.75	3.75	11.87	23.74	Oak.
Middle rail	1	50	4.75	4.25	7.01	7.01	"
Stock	1	90	6.	4.75	17.81	17.81	"
Axle-body	1	50	7.25	6.	15.10	15.10	"
Front cross-bar	1	40	3.5	3.5	3.40	3.40	"
Rear middle cross-bar	1	40	3.5	3.5	3.40	3.40	"
Front middle cross-bar	1	40	10.	3.5	9.72	9.72	"
Rear cross-bar	1	40	3.	3.	2.50	2.50	"
Floor-boards	4	48	8.	1.25	3.33	13.32	"
Roof-bows	2	42	9.	1.25	3.28	6.56	"
Corner-studs	4	36	3.5	2.5	2.19	8.75	"
Side-studs	2	36	3.	2.5	1.88	3.75	"
Plates	2	46	3.	2.5	2.39	4.78	"
Front end-stud	1	22	6.	1.25	1.14	1.14	"
Front of iron room	1	40	9.5	1.25	3.30	3.30	"
Rear of iron room	1	36	3.	1.25	0.94	.94	"
Lining of iron room	2	44	8.5	1.	2.59	5.18	"
Cleats for grooves	2	44	2.	1.	0.61	1.22	"
Braces	2	48	4.	2.	2.67	5.34	"
Front end of roof	1	42	10.	1.75	5.10	5.10	Walnut.
Rear end of roof	1	42	12.	1.75	6.13	6.13	"
Cap for coal-box	1	36	2.5	1.25	0.78	.78	"
Boards for sides	10	42	7.	0.75	2.04	20.40	White pine.
Boards for roof	7	46	7.	.75	2.23	15.61	"
Boards for sliding-cover	6	36	8.	.75	2.00	12.00	"
Prop for stock	1	30	2.25	2.25	1.05	1.05	Hickory.
Bellows-pole	1	57	2.	2.	1.58	1.58	"
						199.61	

Bills of Timber for Field-Carriages.

Names of Parts.	No. of pieces.	Rough dimensions of each piece. Long.	Wide.	Thick.	Contents. Each piece.	Total.	Kind of wood.
Forge.—*Bellows.*		In.	In.	In.	Sup. ft.	Sup. ft.	
Upper and lower planks.	4	34	15.	2.	7.08	28.32	Poplar.
Middle plank	2	44	15.	2.	9.17	18.34	"
Cross-heads	2	32	3.5	3.	2.33	4.66	"
Ribs. Sides	4	36	3.	1.	0.75	3.00	"
Ribs. Ends	2	32	3.	1.	0.67	1.34	"
Ribs. Cross-bars	2	32	2.25	1.	0.50	1.00	"
Cleats	4	7	2.75	.75	......	......	Cuttings.
Valves	2	9	9.	.75	0.55	1.11	Walnut.
Battens for valves	2	9	4.5	.75	0.27	.55	"
						58.32	
Coal-Box.							
Sides and top piece	2	36	24.	1.38	8.28	16.56	Walnut.
Ends	2	16	24.	1.38	3.68	7.36	"
Lid	1	36	14.	1.25	4.37	4.37	"
Clamps for lid	2	14	2.5	1.25	.30	.60	"
Bottom	1	36	15.	1.31	4.91	4.91	Oak.
						33.80	
Battery-Wagon.—*Body.*							
Lower side rails	2	116	6.5	4.	20.94	41.88	Oak.
Upper side rails	2	108	3.	3.	6.75	13.50	"
Stock	1	108	6.	6.	27.00	27.00	"
Axle-body	1	50	6.25	6.25	13.56	13.56	"
Front cross-bar	1	40	5.5	5.	7.64	7.64	"
Front middle cross-bars	2	40	4.25	4.	4.72	9.44	"
Rear middle cross-bar	1	38	4.	2.5	2.64	2.64	"
Rear cross-bar	1	40	4.	3.5	3.88	3.88	"
Floor-boards	3	106	11.5	1.25	10.58	31.74	Wh. Pine.
Sides of body	2	108	21.5	1.38	22.25	44.50	"
Side of till	1	104	11.5	1.25	10.38	10.38	"
Bottom of till	1	104	10.	1.25	9.02	9.02	"
Cleats for till	2	10	1.25	1.	.....	......	Cuttings.
Ends of body	2	40	24.	1.38	9.20	18.40	Walnut.
Forage-rack sides	2	36	5.5	2.	2.75	5.50	Oak.
Forage-rack bars	3	46	3.5	1.	1.03	1.03	"
						240.11	
Cover.							
Side rails	2	108	3.	3.	6.75	13.5	Oak.
Ridge-pole	1	108	3.	3.	6.75	6.75	"
End rails	2	42	3.	3.	2.63	5.25	"
End studs	2	18	2.5	1.5	0.47	.94	"
End boards	2	42	13.5	1.25	4.91	9.82	Walnut.
Roof-boards	9	108	7.	0.75	5.25	47.25	Wh. pine.
						83.51	

Bill of Timber for Mountain-Howitzer Carriage, &c.

NAMES OF PARTS.	No. of pieces.	DIMENSIONS OF EACH PIECE, (ROUGH.)			CONTENTS.		Kind of wood.
		Length.	Width.	Thickness.	Each piece.	Total.	
Gun-carriage body.		In.	In.	In.			
Stock....................	2	66	9.	7.	28.84	57.68	Oak.
Axle-tree...............	2	44	5.	3.	4.56	9.12	Young, tough hickory.
						66.80	
Two wheels.							
Nave.....................	2	11	9.	Round	4.86	9.72	Oak.
Spokes..................	24	20	2.5	1.5	.52	12.48	"
Fellies..................	12	21	5.5	2.5	2.0	24.0	"
						46.20	
One thill.							
Shafts....................	2	72	3.	2.25	3.37	6.75	Ash.
Cross-bar...............	1	33	3.5	2.25	1.80	1.80	"
						8.55	
One ammunition-chest.							
Sides and ends.........	2	44	11.	1.	3.36	6.72	Poplar.
Bottom....................	1	36	7.	1.	1.05	1.05	"
Cover and partitions..	1	66	8.	1.	3.67	3.67	"
						11.44	
One pack-saddle.							
Arcs......................	1	50	12.	1.25	5.21	5.21	Ash or
Transoms	1	20	12.	1.75	2.90	2.90	beech.
Cross-bar...............	1	14	6.	1.25	.72	.72	"
Side bars................	1	42	12.	0.75	3.5	3.5	"
Round bars.............	2	20	1.5	1.5	.31	.62	Hickory.
One handspike..........	1	50	2.5	2.5	2.15	12.95 2.15	Hickory.

Bills of Timber for Siege-Carriages.

Names of Parts.		No. of pieces.	Rough dimensions of each piece. Long.	Wide.	Thick.	Contents. Each piece.	Total.	Kind of wood.
GUN-CARRIAGES.			In.	In.	In.	Sup. ft.	Sup. ft.	
12-pdr...	Stock......	2	130.	11.5	7.	72.67	145.34	
	Cheeks....	2	55.	19.5	5.5	40.96	81.92	
	Axle-body	1	48.	9.5	8.5	26.92	26.92	
	Bolster....	1	14.	6.5	6.5	4.11	4.11	
							258.29	
18-pdr...	Stock......	2	132.	11.5	8.	84.33	168.66	
	Cheeks....	2	60.	20.	5.75	47.92	95.84	
	Axle-body	1	48.	9.5	8.5	26.92	26.92	
	Bolster ...	1	14.	6.5	6.5	4.11	4.11	
							295.53	
24-pdr...	Stock......	2	132.	11.5	8.75	92.24	184.48	
	Cheeks....	2	60.	20.5	6.25	53.39	106.78	
	Axle-body	1	48.	9.5	8.5	26.92	26.92	
	Bolster....	1	16.	6.5	6.5	4.70	4.70	
							322.88	Oak.
ONE-WHEEL.								
Nave......................		1	19.	16.	Round	26.53	26.53	
Spokes		14	32.	4.25	2.5	2.36	33.04	
Fellies....................		7	28.	8.	4.5	7.	49.00	
							108.57	
LIMBER.								
Fork......................		1	60.	11.	7.25	33.23	33.23	
Hounds....................		2	50.	5.	3.75	6.51	13.02	
Splinter-bar.............		1	70.	4.	3.75	7.29	7.29	
Pole...	Large end.	1	142.	5.5	5.5	22.25	22.25	
	Small end.			4.	4.			
Leading-bar.............		1	70.	4.	3.75	7.29	7.29	
							83.08	
MORTAR-WAGON.								
Middle rails..............		2	142.	8.	5.75	45.36	90.72	
Front transom..........		1	28.	7.	3.75	5.10	5.10	
Middle transom.........		1	4.	4.	3.12	......	.....	Cuttings.
Rear transom............		1	4.	6.7	5.9	......	.....	
Side rails......		2	92.	7.5	5.	23.96	47.92	
Rear cross-bar.........		1	42.	4.5	3.	3.94	3.94	
Middle cross-bars......		6	16.	4.5	3.	1.5	9.00	
Front cross-bars........		2	14.	4.5	2.5	1.09	2.18	
Bottom planks.........		2	78.	8.	2.	8.67	17.34	Oak.
Axle-body		1	48.	9.5	8.5	26.92	26.92	
Windlass..................		1	36.	6.5	6.5	10.56	10.56	
Muzzle-bolster		1	12.	6.5	6.5	3.52	3.52	
Stakes....................		6	20.	3.5	3.25	1.58	9.48	
Handspikes..............		2	56.	4.	4.	6.22	12.44	Hickory.
							239.12	

Bills of Iron for Field-Carriages.

Kind of carriage.	Width.	Thickness.	Length.	Weight.	Remarks.
	In.	In.	Feet.	Lbs.	
6-PDR. GUN-CARRIAGE.	0.15	Round	2.81	0.18	For chains No. 1.
	0.2	Round	8.50	.90	2.3 feet for chains No. 2.
	0.25	Round	1.1	.18	
	0.375	Round	18.	6.62	
	0.5	Round	7.2	4.70	
	0.625	Round	4.10	4.18	
	0.75	Round	10.86	15.96	
	0.875	Round	0.65	1.30	
	1.	Round	2.58	6.73	
	1.5	Round	2.17	12.78	
	2.	Round	1.46	15.28	Hammered.
	0.25	0.25	2.21	.46	
	0.3	0.3	7.87	2.36	
	0.75	0.375	1.33	1.25	Hammered.
	1.0	0.375	0.23	.29	
	1.0	0.5	1.5	2.52	
	1.0	1.0	0.58	1.94	
	1.25	0.5	2.16	4.53	
	1.25	0.625	0.84	2.20	Hammered.
	1.25	0.75	0.7	2.20	
	1.375	0.05	3.0	.70	
	1.375	0.25	0.33	.38	
	1.5	0.25	3.75	4.72	
	1.5	0.375	.46	.86	
	1.5	0.5	1.16	2.92	Hammered.
	1.5	0.625	1.66	5.22	Hammered.
	1.5	0.75	3.3	12.47	Hammered.
	1.5	1.5	.59	4.46	Hammered.
	1.75	0.25	.93	1.36	
	2.0	0.125	.33	.27	
	2.0	0.75	.93	4.68	
	2.0	1.	.5	3.36	Hammered.
	2.0	1.25	.38	3.19	Hammered.
	2.5	0.188	1.66	2.60	
	2.5	0.875	.33	2.42	
	2.5	1.25	1.5	15.75	Hammered; or 2 drafts for cap-squares.
	2.5	1.5	1.66	20.91	Hammered; or 2 drafts for trunnion-plates.
	2.5	1.75	.5	7.35	Hammered.
	2.75	0.5	10.23	47.26	
	3.25	0.375	0.39	1.23	
	3.75	0.15	.5	.95	
	3.75	0.2	.44	1.11	
	3.75	0.25	0.38	1.19	
	5.	0.25	.83	3.48	

Bills of Iron for Field-Carriages.—Continued.

Kind of carriage.	Width.	Thickness.	Length.	Weight.	Remarks.
	In.	In.	Feet.	Lbs.	
6-PDR. GUN-CARRIAGE.—Cont'd.	5.5	0.2	1.5	5.53	
				136.00	2 drafts for axle-tree.
				28.00	1 draft for lunette.
				404.93	
	1.0	0.375	0.21	.26	Steel for lunette.
				17.00	4 small rondelles, } Cast iron.
				13.00	2 large rondelles, } Cast iron.
				30.00	
				8.00	Brass box of elevating-screw.
				.42	Brass for turnbuckles.
				8.42	
24-PDR. HOWITZER.	0.15	Round	2.81	0.18	For chain No. 1.
	0.2	Round	9.80	1.03	2.3 feet for chain No. 2.
	0.25	Round	1.08	.18	
	0.375	Round	19.6	7.21	
	0.5	Round	7.54	4.93	
	0.625	Round	4.50	4.59	
	0.75	Round	1.42	2.08	
	0.875	Round	0.65	1.30	
	1.0	Round	15.83	41.32	
	1.5	Round	0.5	2.94	
	2.0	Round	3.58	37.48	Hammered.
	0.25	0.25	2.21	.46	
	0.3	0.3	7.88	2.36	
	0.75	0.375	1.33	1.25	Hammered.
	1.0	0.375	0.23	.29	
	1.0	0.5	1.5	2.52	
	1.0	1.0	0.58	1.94	
	1.25	0.5	2.16	4.53	
	1.25	0.625	0.84	2.20	Hammered.
	1.25	0.75	0.71	2.23	
	1.375	0.05	4.0	.92	
	1.375	0.25	0.33	.37	
	1.5	0.25	4.0	5.04	
	1.5	0.5	1.08	2.72	Hammered.
	1.5	0.625	1.66	5.22	Hammered.
	1.5	0.75	0.37	1.39	Hammered.
	1.5	1.5	0.59	4.46	Hammered.

Bills of Iron for Field-Carriages.—Continued.

Kind of carriage.	Width.	Thickness.	Length.	Weight.	Remarks.
	In.	In.	Feet.	Lbs.	
24-POUNDER HOWITZER-CARRIAGE.—Cont'd.	1.75	0.25	0.93	1.36	
	1.75	0.375	3.5	7.70	
	2.0	0.125	0.33	.28	Hammered.
	2.0	0.75	0.92	4.63	
	2.0	1.0	4.0	26.88	Hammered.
	2.0	1.25	0.38	3.19	Hammered.
	2.5	1.75	0.5	7.35	Hammered.
	2.75	1.	0.33	3.04	
	3.0	0.5	11.23	56.59	
	3.0	1.25	1.84	23.18	Hammered; or 2 drafts for cap-squares.
	3.0	1.5	2.33	35.22	Hammered; or 2 drafts for trunnion-plates.
	3.25	0.188	2.57	5.24	
	3.25	0.375	0.30	1.22	
	3.75	0.15	0.5	.94	
	3.75	0.2	0.57	1.43	
	3.75	0.25	0.38	1.19	
	5.0	0.25	0.83	3.48	
	6.0	0.2	1.5	6.04	
				200.	Draft for axle-tree.
				37.	Draft for lunette.
				567.10	
	1.0	0.375	0.21	0.26	Steel for lunette.
				17.	4 small rondelles, } Cast iron.
				13.	2 large rondelles, } Cast iron.
				30.	
				8.	Brass for box of elevating-screw.
				.42	Brass for 2 turnbuckles.
				8.42	
12-PDR. GUN-CARRIAGE.	0.15	Round	2.81	0.18	For chains No. 1.
	0.2	Round	9.80	1.03	2.3 feet for chains No. 2.
	0.25	Round	1.08	.18	
	0.375	Round	19.60	7.21	
	0.5	Round	7.54	4.93	
	0.625	Round	4.73	4.82	
	0.75	Round	1.42	2.08	
	0.875	Round	0.65	1.30	

Bills of Iron for Field-Carriages.—Continued.

Kind of carriage.	Width.	Thickness.	Length.	Weight.	Remarks.
	In.	In.	Feet.	Lbs.	
12-PDR. GUN-CARRIAGE.—Cont'd.	1.0	Round	15.83	41.32	
	1.5	Round	0.5	2.94	
	2.0	Round	3.58	37.48	Hammered.
	0.25	0.25	2.21	.46	
	0.3	0.3	7.88	2.36	
	0.75	0.375	1.33	1.25	Hammered.
	1.0	0.375	.23	.29	
	1.0	0.5	1.5	2.52	
	1.0	1.0	.58	1.04	
	1.25	0.5	2.16	4.53	
	1.25	0.625	0.84	2.20	Hammered.
	1.25	0.75	0.71	2.23	
	1.375	0.05	4.00	.92	
	1.375	0.25	0.33	.37	
	1.5	0.25	4.00	5.04	
	1.5	0.5	1.08	2.72	Hammered.
	1.5	0.625	1.66	5.22	Hammered.
	1.5	0.75	.37	1.39	Hammered.
	1.5	1.5	.59	4.46	Hammered.
	1.75	0.25	.93	1.36	
	1.75	0.375	.5	1.10	
	2.0	0.125	.33	.28	Hammered.
	2.0	0.75	0.92	4.63	
	2.0	1.0	4.00	26.88	Hammered.
	2.0	1.25	0.38	3.19	Hammered.
	2.5	1.75	0.5	7.35	Hammered.
	2.75	1.0	0.33	3.04	
	3.25	1.25	1.84	25.12	Hammered; or 2 drafts for cap-squares.
	3.25	1.5	2.33	38.16	Hammered; or 2 drafts for trunnion-plates.
	3.25	0.5	7.23	39.47	
	3.25	0.188	2.17	4.42	
	3.25	0.375	0.30	1.22	
	3.25	0.5	5.00	27.30	
	3.75	0.15	0.5	.94	
	3.75	0.2	0.57	1.43	
	3.75	0.25	0.38	1.19	
	5.0	0.25	0.83	3.48	
	6.5	0.2	1.5	6.54	
				200.	Draft for axle-tree.
				42.	Draft for lunette.
				574.08	
	1.0	0.375	.21	0.26	Steel for lunette.

Bills of Iron for Field-Carriages.—Continued.

Kind of carriage.	Width.	Thickness.	Length.	Weight.	Remarks.
	In.	In.	Feet.	Lbs.	
12-PDR. GUN-CARRIAGE.—Cont'd.				17.	4 small rondelles, Cast iron.
				13.	2 large rondelles, Cast iron.
				30.	
				8.	Brass for box of elevating-screw.
				.42	Brass for 2 turnbuckles.
				8.42	
WHEEL No. 1.	0.5	Round	2.93	1.91	
	0.25	0.25	1.63	0.34	
	1.0	0.5	0.58	0.97	
	1.25	0.25	5.83	6.12	
	1.5	0.25	4.67	5.88	
	1.625	0.125	1.00	0.68	
	2.75	0.5	15.00	69.30	In one piece; for tire.
				85.20	
				15.5	Cast iron for nave-box.
WHEEL No. 2.	0.5	Round	3.15	2.06	
	0.25	0.25	1.63	0.34	
	1.0	0.5	0.58	0.97	
	1.25	0.25	6.29	6.60	
	1.5	0.25	5.33	6.72	
	1.625	0.125	1.00	0.68	
	2.75	0.625	15.00	86.55	In one piece; for tire.
				103.92	
				15.5	Cast iron for nave-box.
LIMBER.......	0.15	Round	2.08	0.13	For chains No. 1.
	0.2	Round	3.67	.38	2.3 feet for chains No. 2.
	0.25	Round	4.95	.80	2.33 feet for chains No. 3.
	0.5	Round	1.30	.85	
	0.625	Round	1.80	1.83	
	0.75	Round	4.75	6.98	
	0.875	Round	0.30	.60	
	1.0	Round	2.69	7.02	
	1.25	Round	1.08	4.41	
	1.625	Round	0.75	5.18	
	0.25	0.25	2.3	.48	

Bills of Iron for Field-Carriages.—Continued.

Kind of carriage.	Width.	Thickness.	Length.	Weight.	Remarks.
	In.	In.	Feet.	Lbs.	
LIMBER.........—Cont'd.	0.3	0.3	1.19	.35	
	0.5	0.25	0.17	.07	
	0.5	0.5	0.95	.80	
	1.0	0.25	0.93	.78	
	1.0	0.5	3.33	5.59	Hammered.
	1.0	1.0	0.5	1.68	Hammered.
	1.25	0.25	4.19	4.40	Hammered.
	1.25	0.5	2.67	5.60	
	1.25	0.625	1.15	3.01	
	1.25	0.75	0.71	2.23	Hammered.
	1.25	1.25	1.0	5.25	
	1.5	0.125	1.0	.63	
	1.5	0.5	2.17	5.46	Hammered.
	1.5	0.625	2.12	6.67	Hammered.
	1.5	0.75	.38	1.43	
	1.75	0.375	1.0	2.20	
	1.75	0.5	0.5	1.47	
	2.0	0.125	1.33	1.11	
	2.5	0.188	0.54	.85	
	2.5	0.5	3.84	16.12	
	2.75	0.5	0.54	2.49	
	3.0	0.625	0.5	3.15	
	3.5	2.5	0.84	24.69	Hammered; middle piece for axle-tree.
	4.25	0.25	0.75	2.67	
				120.	2 drafts for axle-tree.
				25.	Draft for pintle-hook.
				272.36	
	1.0	0.375	0.21	0.26	Steel for pintle-hook.
AMMUNITION-CHEST......	0.375	Round	1.5	0.55	
	0.5	Round	3.16	2.06	
	0.75	Round	4.13	6.07	
	1.0	Round	0.25	.65	
	1.0	0.5	0.08	.13	
	1.0	1.0	2.00	6.72	
	1.5	0.375	1.73	3.26	
	1.5	0.75	4.58	17.31	
	1.5	1.0	0.2	1.00	
	1.5	1.5	1.0	7.56	
	1.75	0.75	0.33	1.45	
	15.5	0.1	4.0	20.50	
				67.26	

Bills of Iron for Field-Carriages.—Continued.

Kind of carriage.	Width.	Thickness.	Length.	Weight.	Remarks.
	In.	In.	Feet.	Lbs.	
AMMUNITION-CHEST.—Cont'd.	25.0	No. 24	4.	9.50	Sheet copper for cover.
				0.21	Brass for turnbuckle.
CAISSON......	0.15	Round	8.53	0.50	For chains No. 1.
	0.2	Round	4.08	0.43	
	0.25	Round	0.71	.11	
	0.375	Round	15.04	5.53	
	0.5	Round	0.63	.41	
	0.875	Round	1.02	2.04	
	1.0	Round	4.49	11.71	
	1.25	Round	2.61	10.67	
	0.25	0.25	2.92	.61	
	0.3	0.3	6.23	1.87	
	1.0	0.25	1.75	1.47	
	1.0	0.5	1.5	2.52	
	1.0	1.0	2.79	9.37	Hammered.
	1.125	0.25	0.19	.18	
	1.25	0.5	3.18	6.68	
	1.25	0.625	3.1	8.12	Hammered.
	1.25	0.75	0.70	2.20	Hammered.
	1.5	0.125	2.0	1.26	
	1.5	0.25	3.0	3.78	
	1.5	0.5	0.33	.83	
	1.5	0.625	.83	2.61	Hammered.
	1.5	0.75	1.33	5.02	Hammered.
	1.5	1.5	1.33	10.05	
	2.0	0.125	1.67	1.40	
	2.0	0.5	0.75	2.52	
	2.31	0.25	0.69	1.33	
	2.5	0.5	7.0	29.40	
	3.0	0.5	6.46	32.55	
	3.5	0.25	0.5	1.47	
	3.5	1.0	3.17	37.27	Hammered; or 2 drafts for lunette.
	4.0	0.25	0.84	2.82	
	4.25	1.25	1.5	26.77	
	5.75	0.5	0.48	4.63	
	6.00	0.5	0.5	5.04	
				136.	2 drafts for axle-tree.
				369.17	
FORGE.........	0.15	Round	1.5	0.09	For chain No. 1.
	0.2	Round	3.75	.38	2.3 feet for chain No. 2.

Bills of Iron for Field-Carriages.—Continued.

Kind of carriage.	Width.	Thickness.	Length.	Weight.	Remarks.
	In.	In.	Feet.	Lbs.	
FORGE.—Continued.	0.25	Round	0.57	.93	
	0.375	Round	19.48	7.17	
	0.625	Round	0.24	.24	
	0.5	Round	3.51	2.29	
	0.75	Round	4.58	6.73	
	0.875	Round	0.58	1.16	
	1.0	Round	1.88	4.90	
	1.25	Round	3.48	14.23	
	1.5	Round	0.3	1.76	
	2.5	Round	0.67	10.96	
	0.25	0.25	1.32	.28	
	0.3	0.3	6.23	1.88	
	0.5	0.25	.17	.07	
	0.625	0.375	.79	1.89	
	0.75	0.75	1.0	.63	
	1.0	0.25	1.25	1.05	
	1.0	0.375	0.84	1.06	
	1.0	0.5	2.75	4.62	
	1.25	0.25	0.5	.52	
	1.25	0.375	0.88	1.38	
	1.25	0.5	4.31	9.05	
	1.25	0.625	1.56	4.08	Hammered.
	1.25	0.75	0.7	2.20	
	1.25	1.0	1.0	4.20	Hammered.
	1.25	1.25	0.5	2.62	
	1.5	0.25	3.17	4.00	Hammered.
	1.5	0.375	1.88	3.55	
	1.5	0.5	5.66	14.26	
	1.5	0.75	2.42	9.14	Hammered.
	1.5	1.0	0.66	3.32	Hammered.
	1.625	0.125	1.25	.85	
	1.75	0.75	0.33	1.45	Hammered.
	2.0	0.125	1.17	.98	
	2.0	0.15	0.84	.84	
	2.0	0.25	0.67	1.12	
	2.0	0.5	1.5	5.04	
	2.0	1.0	0.83	5.58	Hammered.
	2.0	1.375	2.17	20.03	Hammered.
	2.25	0.15	0.33	.37	
	2.5	0.5	7.5	31.50	
	2.625	0.25	1.0	2.20	
	3.0	0.625	0.5	3.15	Hammered.
	3.5	1.0	3.17	37.27	Hammered; or 2 drafts for lunette.
	4.0	0.25	0.84	2.82	
	10.	No. 12	3.4	12.5	Sheet iron.

Bills of Iron for Field-Carriages.—Continued.

Kind of carriage.	Width.	Thickness.	Length.	Weight.	Remarks.
	In.	In.	Feet.	Lbs.	
FORGE.—Continued.	13.25	No. 11	2.58	14.25	Sheet iron.
	27.	No. 8	7.5	122.00	Sheet iron.
	28.	No. 24	5.	11.85	Russia sheet iron.
				136.	2 drafts for axle-tree.
				530.44	
	0.75	0.5	0.67	0.84	Cast steel.
	1.0	0.25	0.33	.27	Spring steel.
				36.5	Cast iron air-back.
				6.	Brass for windpipe.
	22.5	No. 24	7.33	15.75	Sheet copper; in 2 sheets 44 inches long.
	18.5	No. 24	3.04	5.25	Sheet copper.
	20.	No. 18	0.50	1.90	Sheet copper.
				22.90	
BATTERY-WAGON.	0.25	Round	26.08	4.25	24.7 feet for chains No. 4.
	0.375	Round	20.3	7.47	
	0.5	Round	6.92	4.52	
	0.625	Round	1.92	1.95	
	0.75	Round	6.22	9.14	
	1.0	Round	1.38	3.60	
	1.25	Round	2.60	10.63	
	1.5	Round	3.11	18.31	
	0.25	0.25	0.44	.09	
	0.3	0.3	6.23	1.88	
	0.75	0.375	1.38	1.29	
	1.0	0.125	6.25	2.62	
	1.0	0.25	8.41	7.06	
	1.0	0.375	5.92	7.46	
	1.0	0.5	1.5	2.52	
	1.0	1.0	2.84	9.54	Hammered.
	1.125	0.25	1.12	2.11	
	1.25	0.25	0.38	.40	
	1.25	0.375	1.71	2.68	
	1.25	0.5	2.18	4.58	
	1.25	0.625	0.73	1.91	Hammered.
	1.25	0.75	0.71	2.23	Hammered.
	1.5	0.25	11.25	14.17	
	1.5	0.375	1.5	2.83	
	1.5	0.5	0.33	.83	

Bills of Iron for Field-Carriages.—Continued.

Kind of carriage.	Width.	Thickness.	Length.	Weight.	
	In.	In.	Feet.	Lbs.	
BATTERY-WAGON.—Continued.	1.5	0.75	2.47	9.32	Hammered.
	1.5	1.0	0.93	4.18	
	1.625	0.5	16.67	45.50	
	2.0	0.125	0.83	.70	
	2.0	0.75	0.5	2.52	
	2.5	0.188	1.67	2.62	
	2.5	0.5	5.33	22.38	
	3.5	1.0	3.17	37.27	Hammered; or 2 drafts for lunette.
	3.75	0.15	8.48	16.02	
	4.0	0.25	0.83	2.79	
	5.25	0.25	0.65	2.87	
	5.5	0.375	1.66	11.50	
				136.00	2 drafts for axle-tree.
				417.74	
				0.21	Cast brass for turnbuckle.
	In.	In.	In.	Lbs.	
MOUNTAIN-HOWITZER CARRIAGE.	0.15	Round	25.	0.13	Cap-square and key-chains No. 1.
	.25	Do.	54.	0.73	Rivets No. 2, nails No. 1, and staples.
	.3	Do.	18.	0.36	Nails No. 2.
	.375	Do.	44.	1.35	Handspike-staple, bolts No. 1, and rivets No. 3.
	.625	Do.	11.	0.94	Implement-hooks, and bolt No. 3.
	.75	Do.	84.	10.30	Bolts No. 4.
	.875	Do.	7.	1.16	Eye-pins No. 1.
	1.75	Do.	11.	7.34	Elevating-screw.
	0.75	0.375	1.5	0.12	Nuts No. 1.
	1.	0.5	16.	2.24	Handspike-strap and linch-pins.
	1.25	0.125	2.5	0.11	Washers No. 1.
	1.25	0.2	34.	2.38	Axle-bands.
	1.25	0.25	3.	0.26	Cap-square keys.
	1.25	0.625	1.25	0.27	Nut No. 3.
	1.25	0.75	16.	4.20	Heads of key and chin bolts.
	1.5	0.75	11.	3.47	Nuts No. 4.
	2.	0.25	15.	2.10	Ferrules for axle-tree.
	2.	0.375	8.	1.68	Washer-hooks.
	2.	0.5	36.	10.08	Under-straps.
	2.	1.25	5.	3.50	Handles for elevating-screw.
	2.25	1.	42.	26.46	Trunnion-plates and cap-squares.

Bills of Iron for Field-Carriages.—Continued.

Kind of carriage.	Width.	Thick-ness.	Length.	Weight.	
	In.	In.	In.	Lbs.	
MOUNTAIN HOWITZER CARRIAGE.—Continued.	2.5	0.188	10.	1.31	Washers No. 4.
	2.5	1.	4.	2.80	Knee of lunette.
	4.	0.2	12.5	2.80	Trail-plate.
	4.	0.375	38.	15.96	Axle-skean.
	4.	0.5	18.	10.08	Lunette.
				112.13	
Two wheels.	......	......	......	3.0	Box for elevating-screw.
	0.25	Round	48.	0.65	Band-nails No. 1.
	0.375	Do.	42.	1.29	Tire-bolts No. 1.
	0.75	0.125	96.	2.50	Brow-bands.
	0.75	0.375	10.	0.78	Nuts No. 1.
	1.	0.2	82.	4.59	End-bands.
	1.25	0.125	15.	0.65	Washers No. 1.
	2.00	0.375	240.	50.40	Tires.
				60.86	
Thill.	......	......	......	10.0	Nave-boxes.
	0.15	Round	12.	0.06	Key-chain No. 1.
	0.25	Do.	12.	0.16	Rivets No. 2.
	0.375	Do.	26.	0.80	Staples.
	0.5	Do.	7.	0.38	Bolts No. 2.
	0.75	Do.	4.	0.49	Key.
	1.	0.5	48.	6.72	Supporting-bar.
	2.75	0.25	30.	5.78	Cross-bar plate.
				14.39	
Ammunition-Chest.	0.25	Round	43.	0.60	Chains, and rivets No. 2.
	1.	0.375	38.	4.00	Hinges and hasp-strap.
	1.	0.5	4.	0.56	Bridles and brace.
	1.	0.625	3.5	0.61	Hasp.
	1.5	0.1	3.5	0.15	Turnbuckle-plate.
	2.4	No. 18.	40.	1.35	Corner-plates.
				7.27	
Pack-Saddle.	......	......	......	0.10	Turnbuckle.
	0.25	Round	12.	0.16	Staples and rivets.
	0.375	Do.	37.	1.13	Bolts.
	0.75	0.375	1.25	0.10	Nuts.
	1.25	0.2	36.	2.52	Arc-plates.
				3.91	

Bills of Iron for Siege-Gun Carriages.

Width.	Thickness.	12-pounder.		18-pounder.		24-pounder.		
In.	In.	Feet.	Lbs.	Feet.	Lbs.	Feet.	Lbs.	
0.2	Round	2.29	0.24	2.29	0.24	2.29	0.24	For chains No. 2.
0.25	Round	5.17	.84	5.17	.84	5.17	.84	3 feet 6 inches for chains No. 3.
0.375	Round	9.03	3.32	9.03	3.32	9.03	3.32	
0.5	Round	.62	.40	.62	.40	.62	.40	
0.625	Round	13.05	13.31	13.05	13.31	13.05	13.31	
0.75	Round	7.40	10.88	7.46	10.96	7.52	11.05	
1.0	Round	3.	7.83	3.	7.83	3.	7.83	
1.125	Round	2.17	7.18	2.17	7.18	2.17	7.18	
1.25	Round	18.57	75.95	17.12	70.01	18.11	74.07	
1.5	Round	2.18	12.84	4.64	27.33	4.91	28.92	
2.0	Round	.5	5.23	.5	5.23	.5	5.23	
2.375	Round	1.58	23.32	1.58	23.32	1.58	23.32	Hammered.
2.5	Round	2.04	33.37	2.04	33.37	2.04	33.37	
3.0	Round	.33	7.77	.33	7.77	.33	7.77	
0.25	0.25	1.33	.28	1.33	.28	1.33	.28	
0.3	0.3	3.17	.95	3.17	.95	3.17	.95	
0.375	0.375	8.75	4.11	8.75	4.11	8.75	4.11	
1.	0.5	.38	.64	.38	.64	.38	.64	
1.25	0.625	.21	.55	.21	.55	.21	.55	
1.25	1.25	1.67	8.77	1.71	8.97	1.73	9.08	
1.5	0.125	.5	.31	.5	.31	.5	.31	
1.5	0.375	5.0	9.45	5.0	9.45	5.0	9.45	
1.5	0.625	2.42	7.62	2.42	7.62	2.42	7.62	
1.5	0.75	1.71	6.46	1.71	6.46	1.71	6.46	
1.75	0.5	.58	1.70	.58	1.70	.58	1.70	
2.0	0.75	.58	2.92	.58	2.92	.58	2.92	
2.0	1.0	.67	4.50	.67	4.50	.67	4.50	
2.5	0.188	1.67	2.62	1.67	2.62	1.67	2.62	
2.5	1.25	5.33	55.95	4.42	46.41	4.42	46.41	Hammered
2.75	1.5	......	......	.93	12.89	.93	12.89	Hammered.
3.0	0.625	.93	5.86	.93	5.86	.93	5.86	
3.5	0.25	.58	1.70	.58	1.70	.58	1.70	
3.5	0.375	.58	2.56	.58	2.56	.58	2.56	
3.5	0.625	.96	7.04	.96	7.04	.96	7.04	
3.5	2.	.29	6.82	.29	6.82	.29	6.82	
3.75	2.	.38	9.57	.38	9.57	.38	9.57	
4.0	0.25	4.33	14.54	4.33	14.54	4.33	14.54	
4.0	0.5	1.23	8.26	1.23	8.26	1.23	8.26	
4.0	0.625	6.34	53.25	......	......	......	......	In one piece.
4.0	0.75	6.12	61.69	......	......	......	......	In one piece.
4.25	0.625	......	......	7.00	61.76	......	......	In one piece.
4.25	0.75	......	......	6.26	67.04	......	......	In one piece.
4.75	0.25	.40	1.60	.40	1.60	.40	1.60	In one piece.
4.75	0.625	......	......	......	......	3.38	33.70	In one piece.
4.75	0.75	......	......	......	......	6.26	74.92	In one piece.
5.	0.625	.42	4.41	.42	4.41	.42	4.41	

Bills of Iron for Siege-Gun Carriages.—Continued.

Width.	Thickness.	12-pounder.		18-pounder.		24-pounder.		
In.	In.	Feet.	Lbs.	Feet.	Lbs.	Feet.	Lbs.	
5.75	0.5	.75	7.24	.75	7.24	.75	7.24	
6.5	0.25	1.08	5.89	1.08	5.89	1.08	5.89	
9.0	0.5	3.25	49.14	3.25	49.14	3.25	49.14	In one piece.
5.75	0.375	0.79	....	0.79	....	0.79	....	Steel for shoe.
Drafts.......		......	26.3	......	29.2	......	36.14	2 trunnion-plates.
		......	16.	......	17.7	......	20.45	2 cap-squares.
		......	222.	......	222.	......	252.	1 axle-tree.
		......	16.5	......	16.5	......	16.5	1 lunette.
		......	21.5	......	21.5	......	21.5	1 shoe.
			793.71	......	817.4	......	839.72	
Cast iron...		......	43.5	......	43.5	......	43.5	2 rondelles.
		......	52.5	......	52.5	......	52.5	4 rondelles.
		......	96.	......	96.	......	96.	
Cast brass....		......	15.37	......	15.37	......	15.37	Box for screw.

Bill of Iron for one Siege-Carriage Wheel.

Width.	Thickness.	Length.	Weight.	Remarks.
In.	In.	Feet.	Lbs.	
0.75	Round.	4.33	6.36	
0.25	0.25	2.12	.44	
1.5	0.375	7.66	14.48	
1.5	0.75	.87	3.29	
1.75	0.375	6.08	13.37	
2.5	0.188	1.46	2.29	
4.	0.75	15.5	156.24	Tire; in one piece.
			196.47	
Cast brass.........................			24.	Nave-box.

Bill of Iron for one Siege-Carriage Limber.

Width.	Thickness.	Length.	Weight.	Remarks.
In.	In.	Feet.	Lbs.	
0.25	Round	2.92	0.47	
0.5	Round	14.83	9.70	
0.75	Round	15.58	22.90	
1.0	Round	1.5	3.91	
1.25	Round	2.71	11.08	
0.3	0.3	1.04	.31	
0.375	0.375	1.83	.86	
1.0	0.5	.17	.28	
1.125	0.25	.09	.08	
1.5	0.5	0.5	1.26	
1.5	0.625	2.42	7.62	
1.5	0.75	3.21	12.13	
1.75	0.5	1.33	3.91	
2.	0.2	.83	1.11	
2.	0.5	1.33	4.46	
2.5	0.188	3.33	5.23	
2.5	0.5	.83	3.48	Hammered.
2.5	0.625	6.08	31.92	Hammered.
2.5	1.25	.21	2.20	
2.5	2.5	.96	20.16	Hammered.
2.75	0.625	5.33	30.75	
3.0	0.625	3.	18.90	
3.5	0.625	.96	7.05	Hammered.
4.0	0.75	4.	40.32	
5.5	1.	.83	15.34	
			222.00	Draft for axle-tree.
			36.50	Draft for pintle-plate.
			513.93	

Bill of Iron for one Mortar-Wagon.

Width.	Thickness.	Length.	Weight.	Remarks.
In.	In.	Feet.	Lbs.	
0.25	Round	0.42	0.06	
0.375	Round	8.79	3.23	
0.5	Round	.62	.40	
0.625	Round	17.46	17.81	
0.75	Round	17.87	26.27	
1.	Round	2.92	7.62	
1.25	Round	.83	3.39	
1.5	Round	2.75	16.20	
1.625	Round	1.08	7.46	
0.25	0.25	8.03	1.68	
0.3	0.3	8.40	2.53	
0.375	0.375	3.32	1.56	
1.	0.25	.42	.35	
1.	0.5	.37	.62	
1.25	0.2	2.89	2.43	
1.25	0.625	1.67	4.37	
1.5	0.375	1.08	2.04	
1.5	0.5	.58	1.46	
1.5	0.625	2.42	7.62	
1.5	0.75	4.21	15.91	
2.	0.125	2.	1.68	
2.	0.75	.58	2.92	
2.	2.	.50	6.72	
2.5	0.188	3.12	4.90	
2.5	0.375	6.	18.90	
2.5	0.5	1.67	7.01	
2.5	0.625	.50	2.62	Hammered.
2.75	0.5	5.17	23.88	
3.	1.5	.29	4.38	
3.375	0.5	7.33	41.56	
3.5	0.625	.92	6.56	
3.75	0.75	3.21	30.33	
4.	0.75	.42	4.23	
5.	0.3	.92	4.63	
5.5	0.3	3.58	19.83	
6.	0.3	1.	6.04	
6.	0.75	.75	11.34	
6.5	0.25	1.08	5.89	
6.5	0.3	.60	3.93	
8.	0.5	.80	10.75	
			222.00	Draft for axle-tree.
			21.50	Draft for shoe.
			584.61	
5.75	0.375	0.79	5.72	Steel for shoe.
			3.5	Brass for two journal-boxes.

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Bills of Iron for one 8-inch Barbette-Carriage.

TOP CARRIAGE.

No. of pieces.	Names of parts.	Dimensions of each piece.			Total length.	Total weight.
		In.	In.	In.	Feet.	Lbs.
2	Cheek-plates (see drawings)	74.0	37.5	.4		468.00
2	Front braces	38.8	6.0	2.75	24.	432.00
2	Middle do.	39.75	6.0	2.75		
2	Rear do.	65.25	6.0	2.75		
2	Sub-braces, angle-iron, front	20.0	3.25	2.75	10.46	93.26
	rear	42.8	3.25	2.75		
2	Ends for rear brace	6.0	3.0	0.5	1.0	5.04
2	Diagonal braces	48.5	3.5	.5	8.01	47.09
2	Shoes ... shapes, or	32.0	3.5	2.25	5.33	138.85
		47.0	3.25	1.0	7.83	85.40
1	Fulcrum for handspike	6.0	2.5	1.5	0.5	6.30
2	Transoms	38.0	4.5	.75	6.33	71.78
2	Brace-transoms	40.0	4.5	.75	6.66	75.52
		10.0	5.5	.75	1.66	23.00
2	Rear transoms (5-in. trough-beams)	29.5	6.5	5.0	4.91	158.71
2	Rear transom ends	6.0	3.25	1.5	1.0	16.38
2	Trunnion-plates	34.0	3.25	.75	5.66	46.35
1	Axle, hammered..shapes, or	38.0	3.125	Round	3.16	80.77
2	Axle-stops	4.25	1.0	Round	.70	1.83
2	Linch-pins	3.5	1.25	.5	.59	1.24
2	Axle-boxes, brass (see drawing)					
2	Axle-box washers (cast iron: see drawing)					
2	Arc-supports	6.0	1.75	.375	1.0	2.20
1	Elevating-arc (brass)	30.	....	.2		
1	" bed (cast iron)					
1	" screw, stem	12.0	2.625	Round	1.0	18.03
1	Pawl ... body	10.0	3.0	2.5	.83	20.92
	collar and handle	10.0	1.25	Round	.83	3.39
	pin	4.5	.75	Round	.37	.54
1	Pawl-port (cast iron)					
1	Elevating-screw box (brass)					
1	" " arbor	18.0	1.5	Round	1.5	8.83
1	Arbor-box (brass)					
1	" handle	6.0	2.5	.875	0.5	3.67
		24.0	.75	Round	2.0	2.94
1	Wheel and pinion (brass)					
8	Bolts for axle-box	4.0	.75	Round	2.66	3.91
	or	3.5	.875	Round		
6	" " sub-brace and shoe	2.5	.75	Round	1.25	1.84
	or	1.75	.875	Round		

Bills of Iron for one 8-inch Barbette-Carriage.—Continued.

TOP CARRIAGE.

No. of pieces.	Names of parts.	Dimensions of each piece.			Total length.	Total weight.
		In.	In.	In.	Feet.	Lbs.
4	Bolts for diagonal brace and shoe...............	3.0	.75	Round	1.0	1.47
	or	2.0	.875	Round		
2	" " front brace and shoe...............	2.5	1.5	1.5	.42	3.17
2	" " rear brace and shoe............	2.5	.75	Round	.42	6.07
		1.75	.875	Round		
4	" " trunnion-plates...	2.25	1.5	1.5	.75	5.67
16	" " transoms............	2.75	1.5	1.5	3.66	27.67
26	" " brace and cheek plates............	2.25	1.5	1.5	4.87	36.82
1	" " diagonal braces ...	2.0	1.5	1.5	.16	1.21
4	" " elevating-bed......	2.25	1.5	1.5	.75	5.67
2	" " " screw-box	2.75	1.5	1.5	.46	3.48
2	" " arbor-box..........	2.5	.375	Round	.41	0.15
2	" " arc-supports.......	3.5	.5	Round	0.59	.38
2	Rivets for "	3.5	.5	Round	.58	.38
2	" for fulcrum...........	1.5	.625	Round	.25	.25
75	Nuts (hexagonal, .75 in.)...	1.5	1.5	.75	8.1	30.62
3	" " .375)	.75	.75	.375	.25	.23
2	Truck-wheels (cast iron) 12 in. dia.....................					
						1941.03
				Cast	iron.	....
				Cast	brass.	....

Bills of Iron for one 8-inch Barbette-Carriage.

CHASSIS, CENTRE PINTLE.

No. of pieces.	Names of parts.	Dimensions of each piece.			Total length.	Total weight.
		In.	In.	In.	Feet.	Lbs.
2	Rails (9-inch I-beams).....	171.	5.375	9.0	28.5	1412.00
1	Hurter-bar	36.0	6.0	1.0	3.00	60.48
2	Counter-hurters	7.0	5.25	1.0	1.16	20.46
8	" " rivets........	3.0	.875 or .75	Round	2.0	4.00
4	Transoms	40.0	5.5	.75	13.33	184.75
1	Middle transoms.............	43.25	18.0	0.5	3.60	108.86
2	Bolsters (2 pieces)...........	18.0	15.5 14.6	0.5	6.0	151.20
4	Diagonal braces..............	52.0	4.0	.625	17.33	145.57
2	Forks for front traverse-wheels (shapes).........or	46.0	5.5	1.25	7.66	176.95
2	Forks for rear traverse-wheels (shapes).........or	54.0	5.5	1.25	9.0	207.90
16	Bolts for transoms..........	2.75	1.5	1.5	3.66	27.67
8	" diagonal brace....	3.25	.75	Round	2.16	3.17
8	" " "	2.5	1.5	1.5	1.66	12.55
16	" middle transom...	2.0	.75	Round	2.66	3.91
2	" front traverse-wheels	6.5	2.75	Round	1.08	21.37
2	" rear traverse-wheels	6.5	2.5	Round	1.08	17.67
32	" traverse-forks	3.0	1.5	1.5	8.0	60.48
6	" hooks for hand-spikes	4.0	1.25	Round	2.0	8.18
	or {	4.0	1.75	0.5		
		2.0	.75	Round		
86	Nuts (hexagonal) .75 in....	1.5	1.5	.75	10.75	40.63
4	" for fork-bolts...........	2.75	2.25	.75	.91	5.15
2	Front traverse-wheels (cast iron)					
2	Rear traverse-wheels (cast iron).........................					
2	Manœuvring-bars........... {	4.60	1.5	Round	7.66	45.12
		9.0	3.25	1.25	1.5	20.47
1	Elevating-bar.................. {	42.0	1.5	Round	3 5	20.61
		9.0	2.5	1.0	.75	6.3
1	Pair wrenches............... {	21.0	2.25	1.0	.17	13.23
		18.0	1.0	Round	1.5	3.91
	Amount	....	....	....	....	2722.59

Bills of Iron for one 8-inch Barbette-Carriage.

CHASSIS, FRONT PINTLE.

No. of pieces.	Names of parts.	Dimensions of each piece. In.	In.	In.	Total length. Feet.	Total weight. Lbs.
2	Rails (15-inch I-beams)...	171.0	5.375	9.	28.5	1911.78
1	Hurter-bar	36.0	6.0	1.0	3.0	60.48
2	Counter-hurters	7.0	5.25	1.0	1.16	20.46
8	" " rivets........	3.0 or 3.0	0.875 .75	Round Round	2.0	4.00
1	Front transom..................	36.6	18.0	0.5	3.05	92.23
1	" " collar.........	7.0	7.0	.75	1.58	27.87
2	" " bolster, (cast iron.)					
3	Transoms........................	40.0	5.5	.75	10.0	138.60
2	Diagonal braces,—1 58 in., the other 64 in. long......	61.0	5.5	.75	10.16	140.82
2	Traverse-wheel forks (shapes)....................or	48.0	5.5	1.5	8.0	221.76
2	Side steps.....................	27.0 10.5	1.5 6.0	.75 .25	4.5 1.75	17.01 8.82
2	Rear steps......................	43.0 27.0 16.0	2.0 2.0 3.5	.75 .75 .25	7.16 4.5 2.66	36.09 22.68 7.42
10	Bolts for transoms............	2.75	1.5	1.5	2.3	17.39
4	" " hook-heads	4.75	1.25	Round	0.8	4.36
6	" front transoms.....	3.0	1.5	1.5	1.5	11.34
6	" " "	3.5	.75	Round	1.75	2.57
2	" " " and diagonal brace..	3.25	1.5	1.5	0.54	4.08
6	" diagonal brace.....	2.75	1.5	1.5	1.37	10.36
4	" hurter-bar..........	3.0	1.5	1.5	1.0	7.56
16	" traverse-forks......	3.0	1.5	1.5	4.0	30.24
2	" traverse-wheels....	5.5	2.5	Round	0.92	15.05
4	" steps..................	2.5	1.5	1.5	0.83	6.27
16	" front trans. & rails	2.5	1.25	1.25	3.33	17.48
4	Hooks for handspikes........	4.0	1.25	Round	1.33	5.44
	or	4.0 2.0	1.75 .75	0.5 Round		
78	Nuts (hexagonal)............	1.5	1.5	.75	9.5	35.91
2	Nuts for traverse-wheel bolts	2.75	2.25	.75	0.46	2.60
2	Traverse-wheels, (cast iron.)					
2	Manœuvring-bars...........	46.0 9.0	1.5 3.25	Round 1.25	7.66 1.5	45.12 20.47
1	Elevating-bar................	42.0 9.0	1.5 2.5	Round 1.0	3.5 .75	20.61 6.3
1	Pair wrenches,—1 single, 14 in. l'g; 1 double, 18 in.	21.0 18.0	2.25 1.0	1.0 Round	1.75 1.5	13.23 3.91
	Amount....................	....	....	....	....	2989.31

Bill of Iron for one 10-inch Barbette-Carriage.

TOP CARRIAGE.

No. of pieces.	Names of parts.	Dimensions of each piece.			Total length.	Total weight.
		In.	In.	In.	Feet.	Lbs.
2	Cheek-plates (see drawings)	74.0	39.6	.4		472.00
2	Front braces	41.25	6.0	2.75	24.25	436.50
2	Middle braces	39.25	6.0	2.75		
2	Rear braces	65.0	6.0	2.75		
2	Sub " (ang. iron) front	21.0	3.25	2.75	10.46	93.26
	rear	41.75	3.25	2.75		
2	Ends for rear brace	6.0	3.0	.5	1.0	5.04
2	Diagonal braces	54.75	3.5	.5	9.12	53.62
2	Shoes ......(shapes)......or	16.0	3.75	2.25	2.66	75.41
		69.0	4.25	1.0	11.5	164.22
1	Fulcrum for handspike	6.0	2.5	1.5	.5	6.30
2	Transoms	44.0	4.5	.75	7.33	82.97
2	Brace-transoms	40.75	4.5	.75	6.8	76.97
		10.0	5.5	.75	1.66	22.01
2	Rear transoms, 5-in. trough-beams	35.5	6.0	5.0	5.91	191.70
2	Rear transom ends	6.0	3.25	.5	1.0	16.38
2	Trunnion-plates	33.0	3.25	.75	5.5	45.04
1	Axle, hammered (shapes) or	44.0	3.125	Round	3.66	93.55

The remainder of the bill the same as for the 8-inch columbiad.

CHASSIS.

The same as 8-*inch*, except as follows:

The length of the *hurter-bar* is 43.25 in.; of the 4 *transoms*, 46.00 in.

42-pounder Barbette-Carriage.

The same as the 8-inch, with the addition of 2 pieces, 12 in. long, 4.875 wide, .5 in. thick; omit *one piece* of the rear transom of top carriage.

32-pounder Barbette-Carriage.

The same as the 8-inch, except as follows:

TOP CARRIAGE.

The length of the 2 *transoms* is 33 inches; of the *rear transom*, 24.5 inches, (omit *one piece;*) of the *axle*, 33 inches.

CHASSIS.

The length of the *hurter-bar* is 31 inches; of the *front transom*, 31.6 inches; of the 3 *transoms*, 35 inches.

24-pounder Barbette-Carriage.

Add to the bill of iron for a 32-pounder, 2 pieces, 12 inches long 5.25 inches wide, 1.25 inches thick.

Bills of Iron for one 8-inch Casemate-Carriage.

TOP CARRIAGE.

Number of pieces.	Names of parts.	Dimensions of each piece.			Total length.	Total weight.
		In.	In.	In.	Feet.	Lbs.
2	Cheek-plates	64.0	32.0	0.4	....	363.00
2	Front braces } ⊔ beams	33.5	6.0	2.75	} 20.12	362.25
2	Middle braces } ⊔ beams	32.5	6.0	2.75		
2	Rear braces } ⊔ beams	54.75	6.	2.75		
2	Sub-braces (angle-iron) } front..	16.5	3.25	2.75	} 8.83	78.76
	Sub-braces (angle-iron) } rear...	36.5	3.25	2.75		
2	Ends for rear brace	6.0	3.0	0.5	1.0	5.04
2	Diagonal braces	42.0	3.5	0.5	7.0	41.16
2	Shoes.........shapes, or {	32.0	3.5	2.25	5.33	130.03
		38.0	3.25	1.0	6.33	69.12
1	Fulcrum for handspike	6.0	2.5	1.5	.5	6.30
2	Transoms	38.0	4.5	.75	6.33	71.65
2	Brace transoms {	38.0	4.5	.75	6.33	71.65
		10.0	5.5	.75	0.83	11.50
1	Rear transom (5-in-trough-beam)	30.5	6.0	5.0	2.54	82.35
2	" " ends	6.0	3.25	1.5	1.0	16.38
2	Trunnion-plates	34.0	3.25	.75	5.66	46.35
1	Axle (hammered),...shapes, or	38.0	3.125	Round	3.16	80.77
2	" stops	4.25	1.0	Round	0.71	1.83
2	Linch-pins	3.5	1.25	.5	0.58	1.24
2	Axle-boxes, (brass,) see drawing	....	....	....	....	....
2	" washers (cast iron)	....	....	....	....	....
2	Arc-supports	6.0	1.75	.375	1.0	2.20
1	Elevating-arc (brass)	30.0	....	.2	....	....
1	Elevating-screw	13.0	2.375	Round	1.08	15.54
1	Elevating-screw box (brass)	....	....	....	....	....
					Total....	1585.70
					Cast iron	
					" brass	

The rest of the bill is the same as for the 8-inch Barbette, omitting 4 transom-bolts, 4 elevating-bed bolts, and 8 nuts.

42-pdr. Casemate-Carriage.

The same as the 8-inch, with the addition of 2 pieces, 12 inches long, 4.875 wide, and 0.5 thick.

32-pdr. Casemate-Carriage.

The same as the 8-inch, except the lengths of the following pieces:

TOP CARRIAGE.

2 transoms, 33 inches; 1 rear transom, 25.5 inches; 1 axle, 33.0 inches

Bills of Iron for one 8-inch Casemate-Carriage.

CHASSIS.

Number of pieces.	Names of parts.	Dimensions of each piece.			Total length.	Total weight.
		In.	In.	In.	Feet.	Lbs.
2	Rails 9-in. H-beams	162.0	5.375	9.	27.0	1338.00
1	Hurter-bar	36.0	4.0	1.0	3.0	13.44
2	Counter-hurters	7.0	5.25	1.0	1.16	20.46
8	" " rivets	3.0	.875	Round	2.0	4.00
	or	3.0	.75	Round	....	....
1	Front transom	36.0	6.0	1.0	3.0	20.16
3	Transoms	40.0	5.5	.75	10.0	138.60
2	Diagonal braces	57.0	4.0	.625	9.5	79.80
2	Front traverse-wheel forks, shapes, or	11.5	5.5	1.5	1.91	52.94
		16.0	5.5	1.25	2.66	61.45
2	Rear traverse-wheel forks, shapes, or	38.0	5.5	1.25	6.33	145.22
1	Tongue............shape, or	65.0	6.5	1.0	5.41	118.15
12	Bolts for transoms	2.75	1.5	1.5	2.75	20.79
8	" " front transom	3.25	1.5	1.5	2.16	16.33
4	" " diagonal brace	2.5	1.5	1.5	.83	6.27
4	" " hurter-bar	3.0	1.5	1.5	1.0	7.56
4	" " tongue and transom	3.25	1.5	1.5	1.08	8.16
28	" " traverse-fork	3.0	1.5	1.5	7.0	52.92
4	" " traverse-wheel	5.5	2.5	Round	1.83	29.94
8	Hooks for handspikes	4.0	1.25	Round	2.66	10.88
2	or	4.0	1.75	.75	......	....
		2.0	.75	.75	......	....
68	Nuts, (hexagonal,)	1.5	1.5	.5	8.5	32.13
4	Nuts for traverse-wheel bolts	2.75	2.25	Round	0.46	2.60
2	Front traverse-wheels (cast iron:)					
	Rear traverse-wheels (cast iron:)					
2	Manœuvring-bars	46.0	1.5	Round	7.66	45.12
		9.0	3.25	1.25	1.5	20.47
1	Pair wrenches	21.0	2.25	1.0	1.75	13.23
		18.0	1.0	Round	1.5	3.91
					Amount,	2262.53

32-pdr. Casemate-Carriage.

The same as the 8-inch, except the lengths of the following pieces:

CHASSIS.

1 hurter-bar, 31 inches; 1 front transom, 31 inches; 3 transoms, 35 inches.

24-pdr. Casemate-Carriage.

The same as the 32-pdr. with the addition of 2 pieces, 12 inches long. 3.25 wide, 1.25 thick.

CHAPTER FOURTH.

MACHINES, ETC., FOR SIEGE AND GARRISON SERVICE.

Field and Siege Gin. (Plate 16.)

WOOD.—2 *legs;* 1 *pry-pole;* 3 *braces;* 6 *assembling-pins;* 1 *windlass;* 5 *handspikes.*

IRON.—6 *rivets and burrs* No. 2 B, for the tenons of the braces.

1 *tongue,* fastened to the head of the left leg by 3 *rivets.*

2 *head-straps,* fastened over the head of the legs by 4 *rivets* No. 3, 8 *screws* 2 inch No. 14.

1 *assembling-bolt* No. 4 A, for the head of the legs; 2 *washers,* fastened on the outside; that on the left leg by the tongue-rivets; that on the right by 2 screws $1\frac{1}{2}$ inch No. 14.

2 *sheaves,* (cast brass;) 1 *sheave-bolt;* 1 *key;* 2 *oval washers,* fastened to the legs by 4 *screws* $1\frac{1}{2}$ inch No. 14.

1 *key-bolt* for pry-pole; 1 *chain,* 8 *links* No. 2; 2 *rings* No. 2 A.

1 *eye-pin* No. 2, screwed in the right side of the right leg.

2 *journal-boxes,* (brass;) 4 *bolts* No. 4 A; 2 *screws* $2\frac{1}{2}$ inches; 2 *pawls,* held by the upper journal-box bolt; 4 *washers;* 4 *nuts.*

2 *gudgeons,* let in the ends of the windlass, fastened by 2 *iron pins.*

2 *bands* for windlass, fastened by 6 *screws.*

2 *handspike-sockets,* (brass;) 2 *pawls;* 2 *springs,* held in place by 2 *plates* fastened to the socket by 6 *screws.* The socket turns freely on the gudgeons.

2 *ratchet-wheels,* fastened to the gudgeons by 2 *keys.*

2 *bands* for the foot of the legs; 4 *nails* No. 1 C.

3 *bands* for the pry-pole,—1 on the foot, 2 on the head; 6 *nails* No. 1 C.

3 *points,* driven into the lower ends of the legs and pry-pole.

1 *handle* for the pry-pole; 2 *washers,* let in and held by 6 *screws* $1\frac{1}{4}$ inches No. 14.

1 *tongue* for the pry-pole, fixed in the head by 2 *rivets and burrs* No. 3 B.

Single Pulley and Block.

1 *sheave;* 2 *straps;* 1 *cross-head;* 1 *hook;* connected by 2 *bolts* No. 4 A, and 1 *bolt* No. 5 A; 3 *nuts.*

Garrison-Gin.

WOOD.—2 *legs;* 1 *pry-pole;* 11 *cleats* for pry-pole, fastened by 22 *nails* No. 2 C; 1 *windlass.*

IRON.—6 *bands*, one for each end of the legs and pry-pole, fastened by 18 *nails* No. 3 C.

2 *braces*, fastened to the legs by 4 *bolts* No. 5, and 4 *keys;* 8 *washers*, fastened to the legs by 32 *nails;* 4 *key-chains*, each of 4 *links* No. 1, and 2 *rings* No. 1 B.

4 *eye-pins* No. 1, screwed into the legs above the bolt-holes.

1 *clevis;* 1 *clevis-bolt* No. 10, fastened to the head of the pry-pole by 1 *iron pin;* 2 *keys;* 2 *chains;* 12 *links* No. 1, and 2 *rings* No. 1 B each; 2 *eye-pins* No. 1.

2 *journal-boxes*, (brass,) let into the legs and fastened by 2 *bolts* No. 4 A, and 2 *bolts* No. 4½ A; 4 *washers;* 4 *nuts;* 4 *screws*, 2½ inches.

2 *pawls*, held by the upper journal-box bolts.

2 *gudgeons*, let into the ends of the windlass; 2 *iron pins.*

2 *bands* for windlass; 6 *screws.*

2 *handspike-sockets*, } Same as those for the field-gin.
2 *ratchet-wheels*, }

3 *points*, driven into the lower ends of the legs and pry-pole.

1 *handle* for the pry-pole; 2 *washers*, let in the pry-pole and held by 8 *screws* 1¼ inch No. 14.

Pulley-Blocks.

They are made with one, two, three, or four sheaves.

IRON.—2 *straps;* the ends are bent over the cross-heads.

2 *cross-heads;* 2 *eyes*, riveted in the cross-heads: the ends of the cross-heads are cut with a screw-thread; 4 *nuts.*

1 *hook*, welded into the eye of one of the cross-heads.

The partition has two tenons on each end, which are let into the cross-heads.

The sheaves, of cast brass.

1 *sheave-bolt* No. 5 A; 1 *nut.*

Casemate-Gin. (Plate 17.)

It is made like the garrison-gin, differing from it only in the dimensions of some parts. The pry-pole has but 6 *cleats* for steps. The handspike-socket, ratchet-wheel, pawl-bolt, and pry-pole handle are the same as those of the garrison-gin.

Sling-Cart. (Plate 18.)

WOOD.—1 *axle-tree;* 1 *bolster;* 1 *pole;* 2 *hounds;* 1 *pole-prop.*

IRON.—1 *lower axle-skean;* 2 *upper axle-skeans*, let into the axle-tree and axle-arms, and fastened by 6 *rivets* No. 3, and 2 *bands* on the ends of the axle-arms.

2 *washer-plates* for axle-hooks, let into the rear of the axle-tree, and fast-

ened by 8 *nails* No. 3 C, $2\frac{1}{2}$ inches; 2 *axle-hooks* pass through the axle-tree from the rear; 2 *nuts;* 2 *washers.*

2 *washer-plates* for bolster-hooks, let into the front of the bolster and fastened by 8 *nails* No. 3 C, 2 inches; 2 *bolster-hooks** pass through the bolster from the front; 2 *nuts* and 2 *washers.*

2 *stirrups,* let in the bolster and axle-tree, which they hold together by 2 *bridles* and 4 *nuts* No. 4.

1 *bed-plate* for the screw, (cast iron,) let into the top of the bolster and held by 2 *bolts* No. 4 C; 2 *nuts.*

1 *hoisting-screw:* the lower end is square, and has 2 hooks.

1 *nut* for the screw, (brass,) round, with 2 square feathers on opposite sides.

1 *handle* for the screw, fits on the nut, and has 2 *round branches:*

2 *rivets and burrs* No. 3 B, for the small end of the pole.

1 *pole-strap,* fastened to the end of the pole by 12 *nails* No. 3 C, 2 inches, and 3 *bolts* No. 2 A; 3 *nuts.* The strap forms an eye for attaching the pole to a limber.

2 *bolts* No. 5 B, for connecting the hounds with the bolster and axle-tree; 2 *nuts.*

3 *bands* for the hounds and pole, fastened by 18 *nails* No. 3 C, $2\frac{1}{2}$ inches.

2 *bolts* No. 4 A, for the hounds and pole; 4 *washers;* 2 *nuts.*

1 *pole-staple* passes through the pole from the under side, and is held by 2 *nuts* No. 7; 2 *washers;* and, at its middle, by 1 *eye-bolt* No. 4; 1 *nut.*

1 *cascable-chain;* 16 *links* No. 5; 1 *ring;* 1 *hook:* the ring traverses on the bar of pole-staple.

1 *eye-pin* for pole-prop socket, passes through the pole from the under side, and held by 1 *washer* and 1 *nut* No. 3; 1 *pole-prop socket;* 1 *ferrule,* fastened to the prop by 2 *rivets* No. 2.

1 *pole-prop chain;* 16 *links* No. 1; 1 *ring* No. 1 A; 1 *toggle;* 1 *eye-pin* No. 1, screwed into the pole.

2 *shoulder-washers* for axle-tree.

2 *linch-washers,* with drag-hooks.

2 *linch-pins.*

1 *sling-chain;* 2 *trunnion-chains*

Sling-Cart Wheel. (Plate 18.)

Wood.—1 *nave;* 16 *spokes;* 8 *fellies;* 8 *dowels.*

Iron.—4 *nave-bands,* fastened by 12 *nails* No. 3 C, 2 inches long.

1 *tire,* made in one hoop; 8 *tire-bolts* No. 4 C; 8 *washers;* 8 *nuts.*

2 *nave-boxes,* (cast iron.)

---

* The axle and bolster hooks serve for fastening the lashing chains or ropes to relieve the strain on the screw when the weight is slung.

The sling-cart is capable of transporting a 10-inch columbiad. It is used with a field-limber.

Trunnion-Chains. (Plate 18.)

The trunnion-chains are three in number, for light or heavy weights. They are made of the patent looped-link chain. A *pair* is required to carry a gun. One is passed under each trunnion and hooked on the head of the screw of the sling-cart.

No. 1. Composed of 1 *chain* 59 inches long, the ends joined by 1 *ring.*

No. 2. Composed of 2 *chains*, each 59 inches long, the ends joined by 1 *ring.*

No. 3. Composed of 2 *chains*, each 47 inches long, the ends joined by 1 *ring*, having 3 *branches*, two for the ends of the chains composing the pair, and the third for the hook of the screw.

Thickness of the iron composing the link, .5 inch.

Length of iron for the connecting-ring, 23 inches for No. 1, 24 inches for Nos. 2 and 3.

Size of iron for connecting-ring, 1.375 inch round.

WEIGHTS.—No. 1, 27 lbs.; No. 2, 53 lbs.; No. 3, 61 lbs.

Sling-Chain.

The sling-chain is composed of 69 *links*, 1 *ring* at one end, and 1 *hook* at the other. The links are made of .75-inch round iron, and are 5 inches long. The ring is of 1-inch iron, and 6 inches diameter, (exterior.) Whole length of chain, 256.25 inches.

Hand Sling-Cart.

This cart is convenient for the transportation of light weights to short distances. It should not be used habitually for weights of more than 4000 lbs.; but a 24-pdr. or 32-pdr. gun may occasionally be transported a short distance. It is made entirely of iron, except the pole, which is of *oak*.

BODY.

1 *axle-tree;* 1 *upper pole-strap*, welded to the middle of the axle-tree.

1 *under-strap* for the pole, fastened to the axle-tree by 1 *bolt* No. 2 E.

3 *bolts* No. 3 D, for connecting the pole with the upper and lower strap; 3 *nuts.*

2 *rivets* No. 3 B, for the rear end of the pole.

1 *pole-strap and eye*,* fastened to the small end of the pole by 6 *rivets* No. 3.

1 *handle*, held in place in the hole by a shoulder on one side and 1 *key* on the other.

---

* The eye is used for connecting the sling-cart occasionally with a limber, or for attaching a horse to it, whilst the pole is held up by hand.

2 *braces*, fastened to the pole by 1 *bolt* No. 2 A and 1 *nut*, and to the axle-tree by 2 *nuts* No. 3.

1 *hook*, fastened to an eye in the axle-tree by 1 *bolt* No. 4 A; 1 *nut*.

2 *shoulder-washers;* 2 *linch-washers;* 2 *linch-pins.*

WHEEL.

1 *nave*, (cast iron;) 10 *spokes*, with a round tenon for the nave, and a flat bearing for the tire.

1 *tire*, shrunk on the ends of the spokes and fastened by 40 *rivets* No. 3.

Casemate-Truck.

The casemate-truck is designed for transporting guns in casemate-galleries or through posterns.

Wood.—2 *rails;* 3 *transoms*, framed to the rails by tenons and mortises. 1 *handle.*

Iron.—1 *rear transom-plate and ring* for drag-ropes, let into the under side of the transom and rails, and fastened by 4 *nails* No. 2 C, 3½ in.

1 *front transom-plate and ring* for drag-ropes, fastened by 6 *nails* No. 2 C, 3½ in.

6 *bolts* for the rails and transoms, No. 4 B; 6 *nuts.*

2 *rear fork-plates,* fastened to the under side of the rails by 4 *nails* No. 2 C, 3½ in.

2 *forks;* 2 *bolts* for rear wheels; barbette chassis traverse-wheel forks.

1 *fork-socket* for front wheel; is round, and let in the front transom.

1 *fork;* 1 *bolt* for front wheel, the same as for the rear wheels, the upper part of the stem made conical.

1 *fork-plate* for front wheel: it has an eye to connect it to the tongue.

1 *tongue;* 1 *tongue-bolt* No. 4 A; 1 *nut.*

3 *truck-wheels:* the traverse-wheels of the barbette chassis.

Hand-Cart.

It is used for the transportation of light stores to short distances.

Wood.—1 *bolster* for axle-tree; 2 *lower side rails;* 3 *cross-bars*, framed into the side rails: the front bar is round, and serves for a handle; 2 *upper side rails;* 2 *end rails*, halved into the side rails and fastened by 4 *screws;* 6 *side studs;* 6 *end studs*, framed into the rails and cross-bars, and fastened by wooden pins; 5 *boards* for bottom, sides, and ends.

Iron.—18 *screws* No. 14, 1½ inch, to fasten the bottom boards to bolster and cross-bars; 48 *screws* to fasten the side and ends to the studs.

1 *axle-tree*, fastened to the bolster by 2 *bolts* No. 2 B; 2 *nuts.*

2 *props*, fastened to the side rails by 4 *bolts* No. 1 D; 4 *nuts.*

2 *shoulder-washers*, let into the ends of the naves.

2 *linch-washers;* 2 *linch-pins.*

WHEEL.

WOOD.—1 *nave;* 12 *spokes;* 6 *fellies.*

IRON.—2 *nave-bands,* fastened by 6 *nails.*

1 *tire,* held by 6 *tire-bolts* No. 1 C; 6 *washers;* 6 *nuts.*

1 *nave-box,* wrought iron, welded.

Store-Truck.

This truck is used for moving boxes in store-houses and in embarking and disembarking stores.

WOOD.—2 *rails,* rounded at the ends for handles.

4 *cross-bars,* framed into the rails and fastened by *wooden pins.*

2 *bolsters,* nailed to the under side of the rails.

IRON.—1 *shoe,* fastened to the upper side of the rails by 4 *bolts* No. 1 C; 4 *washers;* 4 *nuts.*

1 *axle-tree,* fastened to the rails by 2 *bolts* No. 1 C; 2 *nuts.*

2 *guard-plates,* let into the rails under the shoe and held by the axle-tree bolts.

2 *truck-wheels,* (cast iron.)

2 *shoulder-washers.*

2 *linch-washers.*

2 *screws* with square heads for the ends of the axle-tree, to hold the wheels on.

2 *props,* fastened to the rails by 4 *bolts* No. 1 B; 4 *nuts.*

Lifting-Jack.

The lifting-jack is a geared screw with a projecting foot at its lower end, for lifting heavy weights.

WOOD.—1 *bed;* 1 *handle.*

IRON.—2 *rivet-bolts* No. 2 A, to strengthen the bed; 4 *washers;* 2 *nuts.*

2 *eye-plates* for the braces, let into the ends of the bed, and fastened by 4 *screws,* 2-inch, and 1 *screw,* 1-inch, No. 16.

1 *stand,* (cast iron;) 4 *steadying-points,* screwed into the bottom of the stand.

2 *braces,* fastened to the stand, at the upper end, by 2 *bolts* No. 2.

1 *screw,* same size and pitch as the elevating-screw for casemate-carriage; 1 *foot;* 1 *plate,* fastened to the foot by 3 *screws,* 1½ inch, No. 14.

1 *nut;* 1 *pinion* for the hoisting-screw, (brass,) like those for the casemate elevating-screw.

1 *shaft* for pinion: is kept in place by 1 *screw-pin,* let in the stand.

1 *crank,* held to the shaft by 1 *nut* No. 4; 1 *wooden handle,* fastened by 1 *washer;* 1 *nut* No. 2.

1 *cap-plate,* let into the head of the stand one-eighth of an inch, and fastened by 4 *bolt-screws* No. 1.

Hydraulic Jack.

The hydraulic jack is used for the same purposes as the lifting-jack, and may replace it to great advantage, being much more powerful, more portable, and more convenient in use. Being a patented invention, it is procured ready-made. The most convenient size is that of 10 tons' capacity, of which the following are the

Dimensions.—Height, 25.5 inches; lift, 10 inches; largest diameter, 9 inches; length of foot, 4 inches; length of lever, 26.5 inches.

Weight of jack, without lever..................112.5 pounds.
" lever ....4.75 "

Lever-Jack.

The lever-jack is an adjustable fulcrum, with a long lever.

Wood.—1 *stand;* consists of 2 *uprights* framed into 1 *bed,* and fastened by 2 *wooden pins;* 1 *transom;* 1 *long lever,* 15 feet long.

Iron.—1 *transom-bolt* No. 4 A connects the transom and uprights; 2 *washers;* 1 *nut.*

1 *fulcrum-pin,* inserted in holes in the uprights at any required height.

1 *chain,* 15 *links* No. 4 and 3 *rings* No. 2 A; 1 *eye-pin* No. 1 fastens the fulcrum-pin to the stand.

2 *lever-plates,* (cast brass,) fastened to the large end of the lever by 6 *screws* No. 16, 2½-inch, to prevent the lever from slipping on the fulcrum-pin.

Platform for Siege-Mortars.

Wood.—6 *sleepers;* 18 *deck-plank,* held together by 72 *dowels.* There are 4 dowels in one edge of each plank, fitting into 4 holes in the edge of the next plank. The dowels are held fast by *fox-wedges.*

Iron.—12 *eye-bolts* fit into holes in the front and rear planks, passing through the sleepers, to prevent the planks from slipping on the sleepers.

Platform for Siege-Guns.

Wood.—12 *sleepers;* 36 *deck-plank,* held together by 174 *dowels;* 1 *hurter;* 6 *stakes.*

Iron.—12 *eye-bolts* fit into holes in the front and rear planks, passing through the sleepers, to prevent the planks from slipping on the sleepers.

Hand-Barrow.

Wood.—2 *side rails:* the ends are rounded and form the handles.

Rope netting joins the side rails, passing through holes in the side rails.

Pintle-Cross, for Temporary Batteries.

Wood.—2 *cross-pieces,* halved into each other in their middle at right angles to each other; 1 *pintle-bolster*, fastened to the cross by 4 *octagonal pins*, 1 inch thick.

IRON.—1 *bolster-plate*, (cast iron,) fastened to the bolster by 4 *bolts;* 4 *washers;* 4 *nuts;* 1 *pintle.*

A circular platform of planks is required for the wheels of the chassis to traverse on.

Pent-Houses for Barbette-Carriages.

The *pent-house* is a covering of thin boards, framed together, to protect the wooden barbette-carriages from the weather.

It is made in several separate pieces, which can be readily put together or taken apart.

The pent-houses for the columbiad barbette-carriages are similar to each other, differing only in their dimensions. Those for the other barbette-carriages are of a different pattern, but similar to each other.

Pent-Houses for the Columbiad-Carriages.

WOOD.—1 *body*, composed of 2 *sills*, 2 *sides*, 1 *roof*, 1 *rear* and 1 *front end.*

1 *front chassis-cover* and 1 *rear chassis-cover*, each in one piece.

IRON.—8 *eye-pins;* 8 *eye-pin washers;* 8 *keys;* 8 *chains;* 8 *wire staples;* 4 *long hooks;* 14 *hooks*, (short;) 36 *staples;* 4 *handles* for ends.

Pent-Houses for the other Barbette-Carriages.

WOOD.—1 *body*, composed as for the columbiad barbette.

1 *chassis-cover;* 1 *tongue-cover.*

IRON.—4 *long hooks;* 2 *short hooks;* 12 *staples;* 8 *eye-pins;* 8 *eye-pin washers;* 8 *chains;* 8 *keys;* 8 *wire staples;* 4 *handles* for ends.

TO PUT ON THE PENT-HOUSE.

On the columbiad-carriage.—Place the gun over the pintle; depress the muzzle about five degrees, so that the chase shall fit in the circular cut made in the front end and roof. Lay the sills across the chassis in front and in rear of the top-carriage; place the tenons of the sides in the mortises of the sills; put on the roof and hook it to the sides; place the ends and key them; put on the chassis-covers and hook them.

On the other barbette-carriages.—Run the gun "in battery;" remove the wheels; place them upon the chassis in rear of the axle and resting against the top carriage; chock them with their linch pin and washer, and proceed to put on the body as on the columbiad-carriage.

PRINCIPAL DIMENSIONS AND WEIGHTS OF MACHINES, ETC., FOR SIEGE OR GARRISON SERVICE.

Sling-Carts and Trucks.

	Large Sling-Cart.	Hand Sling-Cart.	Hand-Cart.	Casemate-Truck.	Store-Truck.
Length from rear of wheel to front end of pole ......in.	242.4	160.75	*74.75	*141.5	*66.5
Length of axle-tree ......in.	92.	75.50	45.5	†42.5	24.15
Height of wheels ......in.	96.	72.0	36.5	15.0	12.0
Distance between the wheels on the ground ......in.	62.75	60.4	36.35	29.6	19.75
Weight of: one wheel ......lbs.	714	440	34.	......	18.5
body ......lbs.	700	240	113	......	42.
screw ......lbs.	98	......	......	......	......
handles ......lbs.	77	......	......	......	......
cart complete, without sling-chains ......lbs.	2302	1115	181	600	80
trunnion-chain and rings ......lbs.	61 53	27	......	......	......
sling-chain ......lbs.	84	......	......	......	......

* Whole length of body and handles. † Width of body.

Gins.

	Field and Siege.	Garrison.		Casemate.
Length of legs ......in.	175.5	256.5		172.5
Weight of: 1 leg ......lbs.	148.	280.	272.	213
1 pry-pole ......lbs.	71.	293.	292.	208
1 windlass, oak ......lbs.	187.	310.	310.	264
braces ......lbs.	33.	104.	104.	82
gin, complete ......lbs.	615	1267.	1250.	979
1 single block ......lbs.	35	Ash.	Pine.	......
1 double block ......lbs.	......	72		......
1 triple block ......lbs.	......	90		......
1 fall ......lbs.	32	*110		†83

* 120 feet, 5-inch hemp rope. † 90 feet.

Lifting-Jack and Lever-Jack.

	Lifting-Jack.	Lever-Jack.	
		Stand.	Lever.
Length ....inches.	20.	24.	180.
Breadth .... "	12.	14.	6.5.
Height .... "	29.2	30.	......
Weight ....lbs.	160.	100.	150.

DIMENSIONS AND WEIGHTS OF PLATFORMS.

For Guns and Howitzers.

NAMES OF PIECES.	Siege.					Ricochet.				
	No. of Pieces.	Length.	Width.	Thickness.	Weight.	No. of Pieces.	Length.	Width.	Thickness.	Weight.
		In.	In.	In.	Lbs.		In.	In.	In.	Lbs.
Hurter	1	108.	6.0	3.6	61	1	96.	8.	8.	174
Sleepers	12	108.	6.0	3.5	608	3	108.	6.5	6.6	147
Deck-planks............	36	108.	6.0	3.5	1854	...	...	...	...	...
Planks	...	...	...	...	...	2	128.	13.	2.25	166
Plank....................	...	...	...	...	...	1	84.	13.	2.25	60
Pieces of plank.......	...	...	...	...	...	1	30.	13.	2.26	21
Stakes (securing).....	6	48.	3.5	2.0	70	18	48.	1.25	1.25	32
Stakes (implements)	4	32.	2.0	1.0	10	4	32.	2.0	1.0	10
Eye-bolts (iron).......	4	14.	0.75	Round	8.6	...	...	...	...	...
Platform, complete..	...	...	...	...	2601.6	...	...	...	...	600

For Mortars.

NAMES OF PIECES.	Siege.					Rail.				
	No. of Pieces.	Length.	Width.	Thickness.	Weight.	No. of Pieces.	Length.	Width.	Thickness.	Weight.
		In.	In.	In.	Lbs.		In.	In.	In.	
Sleepers	6	96	5.0	3.6	230	3	60	11.5	.85	...
Deck-planks............	18	108	6.0	3.5	927	...	...	...	...	...
Rails......................	...	...	...	...	...	2	84	10.0	10.0	...
Stakee (securing)....	6	48	3.5	2.0	70	14	48	3.6	3.0	...
Stakes (pointing) ...	4	48	1.0	1.0	...	4	48	1.0	1.0	...
Eye-bolts	12	11	0.75	Round	...	...	...	...	...	...
Platform, complete..	...	...	...	...	...	...	...	...	...	...

Wooden platform for columbiad-carriages weighs 3904 lbs.

Traverse-Circles.

	No. of Pieces in the		Size of Pieces.				Bolts.		Weights of			
			Outer or Rear.		Inner or Front.							
	Inner or Front.	Outer or Rear.	Width.	Thickness.	Width.	Thickness.	No.	Kind.	Inner Circle.	Outer Circle.	Bolts and Nuts.	Total.
			In.	In.	In.	In.			Lbs.	Lbs.	Lbs.	
For barbette-carriage, centre pintle............	2	8	5.	1.	2.25	1.75	32	No. 4 H.	152	547	23.	722.
For barbette-carriage, front pintle.............	...	3	3.5	.5	...	...	18	"	...	145	16.5	161.5
For casemate-carriage...	2	3	3.5	.5	...	...	21	"	57	123	15.	195.

Dimensions and Weights of Blocks, Rollers, etc., for Manœuvres.

Names.	No.	Length.	Width.	Thickness.	Weight.	Total Weight.	Remarks.
		In.	In.	In.	Lbs.	Lbs.	
Long roller....	2	42.	6.	Round	25.0	50.0	A groove .25 in. deep in the middle.
Short roller ...	3	12.	7.	Round	12.0	36.0	
Half roller	2	46.	6.	6.	31.0	62.0	Top rounded 3 in.
Block............	16	20.	8.	8.	26.0	416.0	
Half block	6	20.	8.	4.	13.0	78.0	
Quarter block.	2	20.	8.	2.	6.5	13.0	
Gun-chocks ...	6	3.6	2.75	2.5	0.375	2.25	Wedge-shaped.
Wheel-chocks.	6	7.	6.	3.	2.25	13.5	Section a triangle. Top rounded ¼ in.
Roller-chocks	6	7.	5.	2.	1.0	6.0	
Skid.............	2	72.	8.	8.	97.	194.	
Shifting-plank	1	67.	12.	2.25	48.	48.	Ends bevelled on opposite sides.
Trace-rope	1	360.	2.25	Round	7.5	7.5	
Trunnion-loops	2	18.	1.5	Round			End spliced.

Bills of Timber for Gins and Sling-Cart.

Names of Parts.	No. of pieces.	Rough dimensions of each piece. Long.	Wide.	Thick.	Contents. Each piece.	Total.	Kind of Wood.
FIELD AND SIEGE GIN.		In.	In.	In.	Sup. ft.	Sup. ft.	
Legs	2	180	6.5	5.5	44.69	89.38	Spruce or ash.
Pry-pole	1	180	5.5	5.5	37.81	37.81	
Windlass	1	68	9.	9.	38.25	38.25	Oak.
Braces, Upper	1	48	4.75	2.75	4.35	4.35	Oak plank.
Braces, Middle	1	72	4.75	2.75	6.53	6.53	
Braces, Lower	1	102	4.75	2.75	9.25	9.25	
						185.57	
GARRISON-GIN.							
Legs and pry-pole, Large end	3	264	9.	9.	113.21	339.63	Spruce.
Legs and pry-pole, Small end			6.5	6.5			
Two bevel-blocks	1	40	10.	9.	25.	25.00	
Windlass	1	104	11.	11.	87.39	87.39	Oak.
Cleats	11	12	4.25	3.	1.06	11.66	Oak plank.
						463.68	
CASEMATE-GIN.							
Legs, Large end	2	180	9.0	9.0	100.33	200.66	Spruce.
Legs, Small end			6.5	6.5			
Pry-pole, Large end	1	180	9.	9.	77.03	77.03	
Pry-pole, Small end			6.5	6.5			
Windlass	1	101	11.	11.	84.88	84.88	Oak.
Cleats	6	12	4.25	3.	1.06	6.36	Oak plank.
						368.93	
SLING-CART.							
Axle-tree	1	102	11.	9.	70.13	70.13	Oak.
Bolster	1	66	9.	9.	37.13	37.13	Do.
Hounds	2	80	9.	5.	25.	50.	Do.
Tongue, Large end	1	198	7.5	6.	48.13	48.13	Do.
Tongue, Small end			5.	5.			
Two wheels, Naves	2	21	19.	Round	41.34	82.68	Do.
Two wheels, Spokes	32	48	5.25	2.75	4.81	153.92	Do.
Two wheels, Fellies	16	39	9.	5.5	13.4	214.4	Oak plank.
						656.39	

Bills of Lumber for Platform for Siege Guns and Mortars.

For one siege gun or howitzer, yellow pine or oak:

49 pieces, 114 in. long, 6 in. wide, 4 in. wide, 19 ft. each .... 931 ft.

For one siege mortar, yellow pine or oak:

6 pieces,	102 in. long,	6 in. wide,	4 in. thick,	17 ft. each	....	102 ft.
18 "	114 "	6 "	4 "	19 ft. "	....	342
				Total	....	444 ft.

Bill of Iron for Field and Siege Gin.

Parts.	Width.	Thickness.	Length.	Weight.	Remarks.
	In.	In.	In.	Lbs.	
Chain, No. 2	0.2	Round	42.	0.36	
Rivets and nails	.375	Round	129.	3.95	
Bolts, No. 3, and keys for gudgeons	.625	Round	71.	6.03	
Key-bolt	.75	Round	10.	1.22	
Bolts, No. 5, eye-pin, and handle	1.	Round	27.	5.87	
Sheave-bolt	1.25	Round	16.	5.45	
Bolts for pulley-block	1.5	Round	8.	3.92	
Cross-head for pulley-block	2.5	Round	3.5	4.77	
Nuts, No. 3	1.25	.625	10.	2.18	
Bands	1.5	.25	212.	22:26	
Nuts, No. 4	1.5	.75	5.	1.57	
Hook for pulley-block	1.75	1.75	12.	10.29	Hammered.
Washers, No. 3	2.	0.125	18.	1.26	
Bevel washer	2.	.625	3.	1.05	
Gudgeons and points	2.	2.	14.	15.68	
Oval washers	2.5	0.125	13.	1.14	
Head-straps	2.5	.31	32.	7.	
Straps for pulley-block	2.5	.5	30.	10.50	
Pry-pole tongue	3.5	1.	12.	11.76	Hammered.
Journal-boxes	3.5	1.75	24.	41.16	
Tongue-plate	5.5	0.5	16.	12.32	Hammered.
Journals	3.0	Round	18.	35.34	
Bands for windlass	4.0	0.375	64.	26.88	
Pry-pole handle	1.125	Round	22.	6.07	
Pawls	1.25	1.25	24.	10.50	
Ratchets	8.0	1.25	16.	44.80	Or 2 round shapes, hammered.
Three sheaves for pulleys	....	....	....	24.	Brass.

Bill of Iron for one Garrison or Casemate Gin.

Parts.	Width.	Thickness.	Length.	Weight.	Remarks.
	In.	In.	Feet.	Lbs.	
Key-chains, No. 1	0.15	Round	7.5	0.52	This bill includes the materials for one double and one triple pulley-block
Rings	0.2	Round	2.5	0.27	
Rivet-bolts, No. 1	0.5	Round	1.66	1.08	
Pin for clevis-bolt	0.75	Round	0.41	0.60	
Eye-pins	0.875	Round	0.83	1.66	
Bolts, No. 5	1.	Round	3.33	8.69	
Bolts, No. 3, for pawls	1.25	Round	0.70	2.86	
Braces and clevis	1.5	Round	22.5	132.52	
Clevis-bolt	1.75	Round	2.25	18.02	
Bolt-heads, No. 5, and points for legs	2.	Round	4.	41.88	
Nails, No. 3	0.375	0.375	9.41	4.42	
Nuts, No. 1	1.	0.5	0.16	0.26	
Keys for braces	1.25	0.125	1.16	0.60	
Nuts, No. 3	1.25	0.625	2.54	6.65	
Eyes for pulley-blocks and pawls	1.25	1.25	4.	21.0	
Keys for clevis-bolt	1.5	0.125	1.16	0.73	
Nuts, No. 4	1.5	0.75	0.75	2.83	
Hooks for blocks	1.75	1.75	1.83	18.83	Hammered.
Washers, No. 3	2.	0.125	0.33	0.27	
Collars for points	2.	1.	2.	13.44	
Journals	3.	Round	1.5	35.34	
Washers for handle	3.	0.188	0.5	0.94	
Washers, No. 5	3.25	0.188	2.16	4.40	
Bands for windlass	4.	0.375	5.33	26.86	
Lower bands for legs	4.	0.25	5.08	17.06	
Cross-heads for blocks	4.	1.25	2.33	39.14	Hammered.
Upper bands for legs	6.	0.25	4.12	20.76	
Partitions for blocks	8.	0.25	2.75	18.48	
Straps for blocks	8.	0.37	5.	50.40	
Pry-pole handle	1.125	Round	1.8	5.96	
Two ratchets	8.0	1.25	1.33	44.80	Or 2 round shapes, hammered.
				541.37	
Two journal-boxes	....	....	....	13.	Cast brass.
Five sheaves	....	....	....	60.	
				73.	

Bill of Iron for one Sling-Cart.

Parts.	Width.	Thickn.	Length.	Weight.	Remarks.
	In.	In.	Feet.	Lbs.	
Pole-prop chain, No. 1	0.15	Round	3.75	0.26	
Rings, No. 1	0.2	Round	0.31	0.03	
Rivets, No. 2	0.25	Round	0.50	0.08	
Chain, No. 5, and rivets, No. 3	0.375	Round	9.06	3.33	
Pole-rivets	0.5	Round	0.50	0.32	
Bolts, No. 4	0.75	Round	4.42	6.50	
Eye-pin, No. 1	0.875	Round	0.14	0.28	
Bolts, Nos. 2 and 5, and rings	1.	Round	9.91	25.86	
Pole-staple	1.25	Round	4.5	18.41	
Bolt-heads, No. 4, and eye-pin*	1.5	Round	1.	5.86	*Pole-prop.
Screw-handle	1.75	Round	5.33	42.69	
Bolt-heads, No. 5	2.	Round	0.50	5.23	
Nails, No. 3	0.375	0.375	12.04	5.66	
Toggle for pole-prop chain	0.5	0.25	0.16	0.06	
Axle-washers, upper skeans, nuts, No. 2, and chain-hook	1.	0.5	11.25	18.90	
Burrs for pole-rivets	1.125	0.25	0.18	0.17	
Nuts, No. 3	1.25	0.625	0.10	0.26	
Bolster-hooks	1.25	1.25	2.33	12.23	
Axle-bands	1.3	0.2	2.50	2.17	
Nuts, No. 4	1.5	0.75	3.25	12.28	
Hook for sling-chain	1.5	1.	1.33	6.70	Hammered.
Axle-hooks	1.5	1.5	2.50	18.90	
Pole-prop ferrule	1.75	0.375	0.66	1.45	
Linch-pins	1.75	0.625	0.83	3.04	
Washers, No. 3	2.	0.125	0.33	0.27	
Bands for hounds and pole	2.	0.25	10.	16.80	
Brow-bands for naves	2.	0.375	16.33	41.00	
Lower skean and stirrups (in part)	2.	0.5	10.	33.60	
Bridles	2.	0.625	1.58	6.63	
Stirrups and pole-straps	2.	0.75	4.83	24.34	
Nuts, No. 5	2.	1.	0.66	4.43	
Upper skeans	2.25	0.5	0.66	2.49	
Nuts, No. 7	2.25	1.25	0.37	3.49	
Washers, No. 4	2.5	0.188	4.58	7.19	
End bands for naves	2.5	0.375	13.82	43.52	
Lower axle-skean—body	3.	0.5	3.41	17.18	
Hoisting-screw (in one piece)	3.	3.	3.83	115.81	Hammered.
Washers, No. 5	3.25	0.188	0.54	1.10	
Pole-prop socket	3.5	0.625	1.25	9.18	
Socket of screw-handle	3.5	2.25	1.	25.88	Hammered.
Washers, No. 7	4.	0.25	0.66	2.21	
Washers for axle and bolster hooks	4.5	0.375	2.33	13.18	
Two wheel-tires	4.5	0.875	50.	661.00	In 4 pieces.
Lower axle-skean—middle part	6.	0.5	1.	10.08	
				1230.04	
Bed-plate for screw	....	....	....	42.	} Cast iron.
Nave-boxes for two wheels	....	....	....	60.	
				102.	
Nut for hoisting-screw	....	....	....	14.	Cast brass.

Bill of Lumber for one 32-Pdr. Gun or 8-in. Sea-Coast Howitzer Pent-House.

Names of Parts.	No. of pieces.	Rough dimensions of each piece. Long.	Wide.	Thick.	Contents. Each piece.	Total.	Kind of wood.
MAIN HOUSE.		In.	In.	In.	Sup. ft.	Sup. ft.	
Sides	32	74	6.	.75	3.08	98.56	White pine or cypress.
Roof	32	25	6.	.75	1.04	33.28	
Front door	12	68	6.	.75	2.83	33.96	
Rear door	10	49	6.	.75	2.04	20.40	
Side and roof strips	9	87	3.	1.5	2.72	24.46	
Door-strips	4	62	3.	1.25	1.61	6.46	
Rafters	3	39	7.	1.5	2.84	8.53	
Roof front-piece	1	42	18.	1.25	6.56	6.56	
Roof back-piece	1	39	6.	1.	1.67	1.67	
Fascias	2	86	7.	1.	4.18	8.36	
Axle pocket-sides	4	26	6.	1.	1.08	4.33	
" " fronts	2	24	10.	1.	1.66	3.33	
" " caps	2	11	8.	1.	.61	1.22	
Sills	2	62	3.	4.	5.17	10.34	Yellow pine, chestnut, or oak.
Front posts	2	78	3.	3.	4.87	9.75	
Back and middle posts	4	60	3.	3.	3.75	15.	
						286.21	
REAR HOUSE.							
Sides	10	57	6.	.75	2.37	23.70	White pine or cypress.
Roof	22	34	6.	.75	1.41	31.02	
Back	5	66	6.	.75	2.75	13.75	
Roof-strips	4	56	4.	1.25	1.94	7.77	
Back strips and braces	2	120	3.	1.25	3.12	6.24	
Front rafter	1	61	9.	1.25	4.76	4.76	
Rear rafter	1	62	16.	1.25	8.61	8.61	
						95.85	
TONGUE-COVER.							
Sides	8	50	6.	.75	2.08	16.64	White pine or cypress.
Side strips	1	120	3.	1.25	3.12	3.12	
Roof	2	51	9.	1.	3.19	6.37	
Rafters	2	14	9.5	1.25	1.15	2.31	
Back	1	19	17.	1.25	2.80	2.80	
						31.24	

Bill of Lumber for one 8-in. Columbiad Barbette Pent-House.

Names of Parts.	No. of pieces.	Rough dimensions of each piece. Long.	Wide.	Thick.	Contents. Each piece.	Total.	Kind of wood.
MAIN HOUSE.		In.	In.	In.	Sup. ft.	Sup. ft.	
Sides	32	75	6	.75	3.12	99.84	White pine or cypress
Roof	32	31	6	.75	1.29	41.28	
Doors	24	49	6	.75	2.04	48.96	
Side strips	6	86	3	1.5	2.69	16.13	
Roof-strips	4	86	4	1.25	2.99	11.94	
Door-strips	4	62	3	1.25	1.61	5.45	
Rafters	3	52	9	1.25	4.06	12.18	
Fronts	2	54	12	1.	4.5	9.	
Fascias	2	86	7	1.	4.18	8.36	
Sills	2	66	3	4.	5.5	11.	Yellow pine, chestnut, or oak.
End posts	4	62	3	3.	3.875	15.5	
Middle posts	2	80	3	3.	5.05	10.10	
						289.74	
FRONT AND REAR HOUSES.							
Sides	36	28	6	.75	1.17	42.12	White pine or cypress.
Roofs	36	37	6	.75	1.54	55.44	
Ends	12	70	6	.75	2.91	34.92	
Roof-strips	8	45	4	1.25	1.53	12.23	
End strips	2	32	3	1.25	1.10	2.20	
Side strips	12	28	3	1.25	.94	11.25	
" "	4	45	3	1.25	1.56	6.25	
Braces	2	72	3	1.25	2.50	5.	
Front roof-rafters	2	66	17	1.25	9.74	19.47	
Back roof-rafters and ends	6	66	12	1.25	6.87	41.25	
						230.13	

Note.—An allowance of $\frac{1}{8}$ should be made for waste, and $\frac{1}{6}$ for small bills.

Bill of Iron for one Barbette Pent-House.

Size of Iron. Wide.	Thick.	Number of pieces.	Length of each piece.	Total length required.	Weight.	Remarks.
In.	In.		In.	In.	Lbs.	
1.25	.375	8	4.5	36	4.71	Eye-bolts.
2.	.125	8	2.	16	1.12	Eye-bolt plates.
.625	Round.	8	7.25	58	4.92	Door-handles.
.375	"	6	7.	42	1.29	Long hooks.*
.375	"	2	5.	10	.31	Short hooks.
.25	"	16	4.	64	.92	Staples.†

* 8 additional pieces for columbiad-carriages. † 16 additional pieces for columbiad-carriages

CHAPTER FIFTH.

ARTILLERY IMPLEMENTS AND EQUIPMENTS.

NOMENCLATURE, DIMENSIONS, WEIGHTS.

Rammer-Heads.

RAMMER-HEADS are made of ash, maple, birch, beech, elm, gum, or other tough woods; the head is bored $\frac{2}{3}$ of its length with a hole 0.25 inch less than the diameter of the staff, which enters with a tenon. The staff is driven into the head and fastened with a *pin* of hard wood 0.3 inch diameter: the neck has a *copper band* 0.5 inch wide and 0.05 inch thick, fastened with 3 *copper nails*. For dimensions, see page 138.

Sponge-Heads.

Sponge-heads are made of elm or poplar, &c. The head is bored $\frac{2}{3}$ of its length with a hole 0.25 inch less than the body of the staff, which is inserted in a tenon and fastened by 2 hard-wood *pins* 0.3 inch diameter.

Rammer, ladle, and sponge heads should be saturated, when new, with linseed oil, to prevent splitting from alternate wetting and drying in service.

For the woven woollen sponge the diameter of the head is 1 inch less than the calibre of the piece.

Sponges.

Sponges are made of coarse, well-twisted woollen yarn, woven into a warp of strong hemp or flax thread, after the manner of Brussels carpet; the loops are 0.75 inch long.

They are woven in webs with selvages between them, which being cut, the sponges are sewed to fit formers of the same dimensions as the sponge-heads. One end of the sponge is drawn together with strong twine, and a tuft of woollen yarn is inserted at the centre of the gather or folds; a circular piece of strong canvas is stitched inside of the bottom; the other end, after receiving the sponge-head, is nailed to it around the staff with 6 *copper nails*, 1 inch long; 3 *copper nails* should also be driven into the bottom of the sponge, to secure it to the head.

Similar sponges are made by working the yarn with needles into canvas bags; but the wove sponges are equally good, and less expensive.

Sponges are likewise made of sheep-skin alum-dressed, with the wool on; but they are inferior to those made of yarn.

For dimensions of sponges, see Table of sponge-heads, page 138.

Sponge-Covers.

They are made of Russia duck.

The interior diameter is equal to the calibre of the piece. A *hem* 0.5 inch wide around the top, receives a *cord* 0.2 inch diameter, by which the mouth is drawn together and tied around the sponge-staff: a *loop* of canvas 0.75 inch wide is sewed on the end of the cover, to draw it off by.

The covers are marked in *black* with the calibre of the gun.

Ladle-Heads.

Ladle-heads are made of the same kinds of wood, and are fastened to the staves in the same manner, as rammer-heads.

Ladles.

Ladles are used for siege, garrison, and sea-coast guns only. They are made of sheet copper No. 18.

Towards the mouth of the ladle the copper is spread a little, so as to increase the diameter of the ladle 0.3 inch: the corners are rounded with a radius of from 2 inches to 3.5 inches. To stiffen the ladle, the copper is *planished* after being bent and brazed. The ladle is attached to the head by 6 to 10 *copper nails*, 1 inch long, driven in two rows around the body, about 1 inch apart.

Worms.

There are two sizes of worms, one for siege or garrison guns, and the other for field guns. They are fastened to their staff by 2 *iron rivets*, .25 inch in diameter.

Staves.

Staves for implements are made of tough ash.

The diameter of the tenon is 0.25 inch less than that of the staff; its length, $\frac{2}{3}$ of that of the head into which it is inserted. For worms it is pointed to fit the conical form of the socket.

For field-guns, field, siege, and mountain howitzers, and mortars, the rammer and sponge heads are on the same staff; for other pieces, on separate staves.

For the coehorn mortar, the body of the staff forms the rammer and sponge-head.

For lengths of staves, see page 138.

For other cannon than those of the patterns described in Chapter I., staves may be made of such a length that the finished implement shall be 18 inches longer than the bore of the piece.

Anvil-block, for portable forge, is of tough oak or other hard wood: it has 1 *band*, 8 inches wide around the top: 1 *iron* pin fastens the anvil to the block: 2 *rings* fastened by 2 *staples* serve for handles. Dimensions, 19 inches high, 4.4 inches diameter at top; 10.5 inches by 7.5 inches at bottom. Weight 19 lbs.

Axe, felling:—blade with steel edge, length 7.25 inches; width of top 3.5 inches, of edge 4.75 inches; thickness at top 0.75 inch, at the eye 1.25 inch; size of the eye 2.25 inches by 0.75 inch; *handle* (hickory) 27 inches long. Weight 6 lbs.

Basket, for mortar-implements; of strong wicker-work, 18 inches in diameter, 12 inches deep. Weight 4 lbs.

Breech-sight: the base is a plate of brass 4.5 inches long, 0.6 inch wide, curved to fit the base-ring; the scale and slider are similar to those of the pendulum hausse, except that a hole .05 inch diameter is made in the plate instead of a notch to sight through; the brass is .1 inch thick when finished, made of No. 10 or 11 sheet brass; the sights are graduated for *no disparts*, a *front sight* equal in height to the dispart being screwed into the swell of the muzzle; in columbiads, into the seats provided for the purpose between the trunnions; the scales are computed for the patterns of guns having a base-ring; in the 24, 32, and 42 pdrs. mounted in casemate (a muzzle-sight being inadmissible) the scale is computed for a sight placed at the front end of the second reinforce. Weight 0.3 lb.

Bill-hook, (iron, with steel edges;) *blade*, whole length, 8.25 inches; width in the middle 3 inches, near the shank 2.7 inches; thickness 0.25 inch; *hook* 1 inch long; *shank* 8 inches long; *handle* (hickory) 7.5 inches long. Weight 2 lbs.

Broom, for mortar-batteries, (hickory or birch.) Weight 3.75 lbs.

Budge-barrel, for use in forts and batteries; *staves* (oak) 0.4 inch thick; *bottom* (oak) in 1 or 2 pieces, 0.4 inch thick; 4 *hoops* (sheet copper No. 18) 48 inches long, 1.1 inch wide, and confined to the barrel each by 5 *rivets* 0.2 inch diam.; they are joined by 2 *rivets*, or brazed together; height of barrel 20 inches; exterior diameter,—at ends 13 inches, at bilge 15 inches; *cover* (bag leather) 18 inches high and 40 inches wide, secured to the barrel under the upper hoop by 5 *nails* and by the 5 *rivets* through the hoop; 2 *cords* 0.6 inch diam., 6 feet long, passing through holes in the cover at 1.5 inch from the top, to draw the mouth together; the ends of the cords pass through a *cap* or *hood* 9 inches deep, sliding on the cords. Weight 15.5 lbs.

Coal-sack, for portable forge, is made of strong leather; it is closed at the top by a leather strap passing through slits in the sack; diameter 14 inches, height 18 inches.

Chock, for casemate-carriage; small wedge, with a handle on one side Weight 1.4 lb.

Drag-rope: 4-inch rope, 28 feet long, with a *thimble* worked in a loop at one end, and a *thimble* and *hook* at the other end; 6 *handles*, wood, 12 inches long, 1.5 inch in diameter, fastened in the ropes at the distance of 4 feet apart, and at the same distance from the ends of the rope. Weight 16.5 lbs.

Forge-bucket, for the portable forge, is of sheet iron stiffened at top by 1 *band* .5 inch wide; it is furnished with 1 *handle* fastened into 2 *ears* 1.6 inch long; 7 inches high, 6.8 inches diameter.

Fuze-cutter: a steel chisel, with wooden handle, for cutting the Bormann fuze.

Fuze-extractor: the inner *screw* and its *stem* are made of steel, and riveted into the *handle*, which is of iron; the stem is contained in a *hollow screw* of steel, which is worked up and down by means of an iron *nut* with 2 *handles*,—the screw being prevented from turning by a slot and a *feather* in the frame; the nut is kept in place by 4 *iron set-screws*, the points of which enter into a groove in the nut; the *frame* is of cast brass. Weight 3.53 lbs.

In using this fuze-extractor, the inner stem is screwed into the fuze or plug to be extracted, by means of the upper handle, and it is lifted out by turning the nut of the hollow screw.

Fuze-setter, (brass;) the *handle*, upper end slightly rounded; the *cup* 2.1 inches diameter; depth 0.3 inch; whole length 5 to 6 inches. Weight 2.66 lbs.

Fuze-mallet, (dog-wood or oak,) in one piece; *head* 5.5 inches long, 4 inches diameter; *handle* 7.5 inches long, 1.25 inch diameter. Weight 2.75 lbs.

Fuze-saw, (tenon saw;) 10-inch blade. Weight 0.75 lb.

Funnel, for filling shells, (copper or tin;) diameter of *funnel* 3.3 inches; diameter of *pipe* 0.7 inch; length of pipe 2 inches. Weight 0.32 lb.

Gunner's gimlet: iron wire 0.175 inch diameter, formed with a ring 2 inches diameter at the head; the other end terminating in a gimlet-point. Weight 0.08 lb.

Gunner's callipers: made of sheet brass, with steel points; the graduations show the diameters of guns and of shot, linear inches, degrees of the circle, &c. Weight 0.5 lb.

Gunner's haversack, (bag-leather;) 2 *sides* 13 inches high, 13 inches wide at bottom, 14 inches at top of flap; end and bottom *gussets* 5 inches wide; *flap* 8 inches deep, with a *strap* 7 inches long passing through a *buckle* sewed to the front side; *shoulder-belt* 1.5 inch wide, one part 12 inches long, with a *buckle* No. 4 and *loop;* the other 36 inches long. Weight 1.86 lb.

Gunner's perpendicular: this is made of sheet brass; the lower part is cut in the form of a crescent, the points of which are made of steel; a small spirit-level is fastened to one side of the plate, parallel to the line joining the points of the crescent, and a slider is fastened to the same side of the plate, perpendicular to the axis of the level. The instrument is useful in marking the points of sight on siege guns and mortars, when the platform is not perfectly level. Weight 0.6 lb.

Gunner's pincers: made of iron, with steel jaws 1 inch wide; whole length 10.5 inches. Weight 0.85 lb.

Gunner's quadrant, (wood;) a graduated *quadrant* of 6 inches radius, attached to a rule 23.5 inches long; it has a *plumb-line* and *bob,* which are carried, when not in use, in a hole in the end of the rule, covered by a brass plate. Weight 0.84 lb.

Gunner's quadrant, (brass;) a graduated *quadrant,* 6 inches radius, attached to a rule 22 inches long; it has an *arm* carrying a *spirit-level* at its middle, and a vernier at its movable end; the other end is secured to the centre of the quadrant by a rivet, around which the arm moves. Weight 2.25 lbs.

Gunner's sleeve, for mortars, (serge or flannel.) Weight 0.25 lb.

Lanyard: the lanyard, for pulling off the primers, is a piece of strong cod-line (about .2 inch diam.) 12 feet long; to one end is attached a small *iron hook,* with an eye for the line, and to the other end a *wooden toggle* .75 inch diameter, and 4 inches long. Weight 0.1 lb.

Maul, for driving pickets; *head* (elm or hickory) 6 inches diameter, 8 inches long; *handle* (ash) 1½ inch diameter, 24 inches long, with an iron band on each end, 1 inch wide, ¼ inch thick. Weight 10 lbs.

Men's harness: 4-inch rope, 18 feet long, with *thimbles* and a *hook* like the drag-rope; instead of handles, 10 *loops* made of strips of bag-leather 5 feet long, 2.75 inches wide, are fastened to the rope in pairs, each pair being secured in place by two knots worked on the rope; the first pair of loops at 3 feet from the hook, the others at a distance of 3½ feet apart. Weight 23 lbs.

Pass-box, (white pine, 0.75 inch thick;) interior dimensions 7 inches square by 14 inches long; one side turns on 2 *hinges,* and is fastened with a brass *hook* and a *staple;* a wooden *handle* is set diagonally on one end. Weight 7 lbs.

Pickaxe; iron, pointed at both ends with steel; length of each blade 6.5 inches; width of edge of axe 3 inches; *handle* (hickory) about 1.5 inch by 1.25 inch, and 30 inches long. Weight 6.5 lbs.

Pendulum hausse.

The *scale* is made of sheet brass No. 13. At the lower end is a brass bulb, filled with lead. The *slider* is of thin brass, and is retained in any desired position on the scale by means of a brass set-screw with a milled head. The scale is passed through a slit in a piece of steel, with which it is connected by a brass screw, forming a pivot on which the scale can vibrate laterally; this slit is made long enough to allow the scale to take a vertical position in any ordinary cases of inequality of the ground on which the wheels of the carriage may stand. The ends of this piece of steel form two journals, by means of which the scale is supported on the seat attached to the gun, and is at liberty to vibrate in the direction of the axis of the piece.

The *seat* is of iron, and is fastened to the base of the breech by 3 *screws*, in such a manner that the centres of the two journal-notches shall be at a distance from the axis equal to the radius of the base-ring.

A *muzzle-sight*, of iron, is screwed into the swell of the muzzle of guns, or into the middle of the muzzle-ring of howitzers. The height of this sight is equal to the dispart of the piece, so that a line from the top of the muzzle-sight to the pivot of the hausse is parallel to the axis of the piece; consequently, the vertical plane of sight passing through the centre line of the scale and the top of the muzzle-sight will be also parallel to the axis, in any position of the piece; the hausse will, therefore, always indicate correctly the angle which the line of sight makes with the axis.

The seat for suspending the hausse on the gun is adapted to each piece, according to the varying inclination of the base of the breech to the axis. The hausse, the seat, and the muzzle-sight, are marked for the kind of gun to which they belong. The hausse, when not in use, is carried in a leather pouch suspended to a shoulder-strap.

The graduations on the scale are the sines of each quarter of a degree, to a radius equal to the distance between the muzzle-sight and the centre of the journal-notches, which are, in all cases, one inch in rear of the base-ring. Weight of hausse and case .65 lb.

Graduations.

	FOR GUNS.			FOR HOWITZERS.			
	6-Pdr.	12-Pdr.	12-Pdr. Model 1857.	12-Pdr.	24-Pdr.	32-Pdr.	12-Pdr. Mountain.
	In.	In.	In.	In.	In.	In.	In.
Radius of base-ring...	5.15	6.5	5.5	5.0	6.0	6.9	3.8
Height of muzzle-sight	1.025	1.33	1.25	0.9	1.125	1.3	0.35
Distance between the muzzle-sight and the centre of the journal-notches ...	59.7	77.3	66.0	53.35	65.2	75.05	33.41
1°........................	1.042	1.349	1.152	0.931	1.138	1.310	0.583
2°........................	2.084	2.698	2.303	1.862	2.275	2.619	1.166
3°........................	3.124	4.046	3.454	2.792	3.412	3.928	1.753
4°........................	4.164	5.392	4.604	3.722	4.548	5.235	2.331
5°........................	5.203	6.737	5.752	4.650	5.683	6.541	2.912

Priming-wire; iron wire 0.175 inch diameter, formed with a ring 2 inches diameter at the head, and pointed; length of stem, for siege and garrison guns, 14 inches; length for field-guns, 8 inches. Weight 0.08 lb. for garrison guns.

Powder-measures; they are made of sheet copper, from No. 16 to No. 20. The bottom is made with a flanch .1 inch deep, turned downwards, and it is brazed or soldered to the sides.

Interior Dimensions.

Contents.		Diameter and height.	Weight.	Contents.		Diameter and height.	Weight.
Lbs.	oz.	In.	Lbs.	Lbs.	oz.	In.	Lbs.
0	1	1.337		2	0	4.240	
0	2	1.685		2	8	4.571	
0	4	2.122	0.3	3	0	4.857	1.6
0	8	2.673	0.5	4	0	5.346	
1	0	3.368	0.75	4	8	5.560	
1	4	3.628		6	0	6.120	
1	8	3.855		8	0	6.736	

Prolonge; 3.5 inch hemp rope of 4 strands; on one end, a *toggle* and 3 *round links* in a *thimble;* on the other end, a *ring-link* and *thimble;* whole length of rope 18 feet; the *toggle* of round iron 0.75 inch diameter, 7.5 inches long, with an eye in the centre; *toggle-rings* of 0.5 inch round iron; the ring that enters the thimble is 3 inches, the other two 3.1 inches exterior diameter; *thimbles* 1.1 inch interior diameter; *prolonge-rings* of 0.6 inch round iron, 4.5 exterior diameter; the link 3 inches exterior diameter; the iron for link is 0.5 inch diameter. Weight 12.5 lbs.

Plummet, for mortars; *line* and *bob.* Weight 1 lb.

Pointing-wire, for mortars, (iron wire No. 7,) 20 inches long. Weight .08 lb.

Quoin, for siege-mortars, (oak;) length 19.5 inches; height 7.85 inches; *handle* 6 inches long. Weight 7 lbs.

Scraper, for siege-mortars, (iron;) *handle* 0.5 inch by 0.3 inch square, 27 inches long; one end formed like a *spoon;* the other, a *scraper.* Weight 2.3 lbs.

Spatula, for mortars, (ash or hickory;) *handle* 16.5 inches long; *blade* 6 inches; *square end* 3 inches long. Weight 0.75 lb.

Shell-hooks, (iron;) 2 *branches* 0.5 inch diameter, in shape of an *S*, joined by a *rivet;* upper end of the branches connected by 2 *small rings,* 1.25 inch diameter, and 1 *large ring* 3.4 inches diameter; straight *points,* to insert into the ears of the shell, 0.5 inch diameter, 0.75 inch long; whole length of branches 12.48 inches. Weight 2 lbs.

Screw-jack, for field service; the *stand,* (cast iron;) the *hoisting-screw;*

the *nut;* 2 *handles;* the *cap-plate,* fastened on the top of the stand by 4 *screws;* height of the stand 19 inches; length of screw 15 inches; handles 7.25 inches each. Weight 25 lbs.

Shovel; blade sheet iron, pointed with steel; length 12 inches; width 10.5 inches; *handle* (ash) 1.5 inch thick at bottom, and 1.25 inch at top; length 45 inches; *ring* 1.5 inch diameter, secured by a *strap* to the handle at 9 inches from the upper end. Weight 4.75 lbs.

Sponge-bucket, for field-gun carriages; it is made of sheet iron No. 13; the top and bottom are turned over the sides and fastened each by 4 *rivets;* diameter 7.8 inches; height 9 inches.

The *float* is of wood, fastened by 2 *rivets* to a cross-bar; it is put in before the top is fastened on; the *handle* of the float is fastened to it with 2 *rivets,* and it is connected with the bail of the bucket by a *chain;* the *bail* is fastened to the bucket by 2 *ears,* each held by 3 *rivets;* a *toggle,* which is fastened to the bail by 2 *links* and a *swivel,* serves to attach the bucket to the eye of the axle-strap on the gun-carriage. Weight 10 lbs.

Tar-bucket; the bucket is made of sheet iron No. 13, like the sponge-bucket; the *cover* is fastened to the top by a rivet on which it turns, and it is kept closed by shutting over a stud riveted into the top; the *ears* are fastened to the bucket each by 3 *rivets;* a *ring,* for suspending the bucket on its hook, is connected with the ears by 2 *chains;* diameter of bucket 7.2 inches; height 8 inches. Weight 7 lbs.

Tarpaulins are made of cotton duck, not painted; they are of three sizes; large, 15 feet by 12 feet; small, 6 feet by 10 feet, and 5 feet square. Weight 35.75 lbs., 12.25 lbs., and 5.25 lbs., respectively.

Tompions, for 8-inch siege-howitzers and mortars, and 10-inch mortar.

Thumbstall, (buckskin;) *cushion,* stuffed with hair, 2.5 inches long, 1 inch thick; the *strap* 3 inches long; the *string* 12 inches. Weight .003 lb.

Tow-hook, (iron;) *handle* 0.4 inch diameter, 13 inches long; *hook* 1 inch; the other end forms a *hammer* 0.6 inch diameter, 2 inches long. Weight 0.6 lb. Used for unpacking ammunition-chests.

Tube-pouch; the sides 4.25 inches high, 7.25 inches long; 2 *ends* 0.9 inch wide at bottom, 2 inches at top; the inner *cover;* the *flap,* 8 inches deep, with its *strap,* and brass *button* attached to the bottom of the pouch; 2 *loops* for the belt to pass through; the *belt* 1.37 inch wide and 42 inches long, with a *buckle* No. 6 and *loop* at one end; the priming-wire and gunner's gimlet are carried with the tube-pouch in the loops, attached by a twine, or in small loops on the inside of the flap. Weight 0.95 lb.

Vent-cover, for field-pieces without locks, (leather;) 6 inches long, 4 inches wide, with a *copper pin* riveted to it, 0.175 inch diameter, and 2 inches long; 2 *straps* 1 inch wide, with *buckles;* the length of the strap varies with the size of the piece; in permanent batteries sheet lead may be used for vent-covers. Weight 0.6 lb.

Vent-punch; the *body* (steel wire) 0.175 inch diameter, 4.3 inches long; *head* 0.175 inch thick, 1 inch octagonal, with a hole 0.2 inch diameter in the middle. Weight 0.08 lbs.

Watering-bucket, for field service, made of sole-leather; the bottom is of two thicknesses, fastened to each other with 25 *copper rivets,* and to the sides with 61 *rivets;* the side seams fastened with 28 *rivets,* all 0.5 inch long; a rim of sheet copper No. 24, is fastened on the upper edge with 14 *copper rivets;* 2 *ears* for the bail, fastened each with 4 *rivets* 0.62 inch long; the *bail* is of round iron 0.5 inch thick; interior diameter of the bucket at top 12 inches, at bottom 10 inches; height 9 inches. Weight 8 lbs.

Water-bucket, for the travelling-forge; the *staves* and the *bottom* are of oak; there are 16 staves, and the bottom is made of not more than 2 pieces; 3 *hoops,* made of hoop-iron No. 16; each hoop is joined together with 2 *rivets* No. 1, and fastened to the bucket with 2 *rivets;* 2 *ears* let into the sides, and fastened each by 1 *rivet;* the *bail* has a *link* connected with it by a *swivel;* diameter at top 11 inches, bottom 10.25 inches; height 11 inches. Weight 10 lbs.

Water-bucket, for garrison-service; it is made in a similar manner with the preceding, except that the bail has no link and swivel attached to it; diameter at top 10.25 inches, bottom 13.5 inches; height 11 inches. Weight 10 lbs.

Wiper, for the chambers of mortars; tow cloth, 1 yard square.

Handspikes.

Handspikes should be made of the best hickory, or, where it cannot be had, of the toughest young oak; it should be free from knots.

Trail handspike.—Irons: 1 *stop,* passing through the lower end, clinched and filed down smooth—it projects 0.3 inch; 1 *strap,* carrying 1 *ring* No. 2 A, fastened near the small end by 1 *rivet.*

Shod handspike.—Irons: 1 *shoe,* fastened to the lower end by 3 *rivets.* It is particularly useful in the service of mortars.

Manœuvring handspike is used for garrison and sea coast carriages. For mechanical manœuvres it is 84 inches long, and weighs 12 lbs.

Gin handspike is used in the service of gins. The large end is round, and fits into the socket of the windlass.

For *Mountain howitzer.—Irons:* 1 *stop,* like that for field-carriages; 1 *strap,* fastened at the small end by 2 *rivets,* forms a loop on the end; 1 *loop of rope,* 15 inches long, passing through 2 holes in the middle of the handspike, is useful in placing the gun on the pack-saddle.

Handspikes.

Dimensions.	Trail. For Field Carr'ge.	Trail. For Prairie Carr'ge.	Trail. Mount. Howitzer.	Manœuvring.	Shod.	Gin.
Length of whole ....inches	53.	36.	45.58	66.	62.	66.
Length of square part ....inches	....	....	....	19.	9.75	....
Length of conical part.......inches	9.5	....	....	35.	38.25	12.
Distance of farthest side of stop from the large end..................inches	9.0	....	8.9	....	....	....
Distance of middle of strap from the small end ....inches	9.0	....	....	....	....	....
Diameter upper end ....inches	1.5	1.3	1.65	1.8	1.75	1.6
Diameter lower end...........inches	2.2	....	1.65	....	....	2.78
Diameter largest ....inches	3.0	1.8	2.0	....	....	3.25
Diameter lower end of round ...in.	....	....	....	3.0	2.5	....
Size of lower end of square part ..in.	....	....	....	2.36	3×2.5	....
" upper end " " ..in.	....	....	....	3.0	3×2.5	....
Weight......... ....lbs.	7.25	2.25	5.0	8.25	12.0	11.25

Bars.

Dimensions.	For Iron Carriages. Manœuvring.	For Iron Carriages. Elevating.	For Iron Carriages. Pinch.	Wooden Casemate-Carriages. Truck.	Wooden Casemate-Carriages. Roller.
Length of whole ....inches	58.5	53.	54.	42.	34.
Length of square part..................inches	12.	12.	6.	....	....
Diameter of small end.................inches	1.	1.	1.25	1.1	0.85
Diameter of large end..................inches	....	....	....	1.1	1.
Width at large end.......................inches	1.	.9	1.25	....	....
Thickness " ....inches	1.25	1.5	2.0	....	....
Length of heel...........................inches	....	....	3.5	....	....
Weight...lbs.	30.75	19.	27.5	18.5	7.

Dimensions and Weights of Implements.

Kind of Implement.			Columbiads.			
			10-in.		8-in.	
			Bore.	Chamber.	Bore.	Chamber.
Finished Implements.	Sponge and Staff....	Length........in.	118.	128.	118.	128.
		Weight........lbs.	12.	11.	10.25	10.
	Rammer and Staff.	Length........in.	128.	......	128.	......
		Weight........lbs.	9.75	......	8.4	......
	Ladle and Staff......	Length........in.	......	......	......	......
		Weight........lbs.	......	......	......	......
	Worm and Staff.....	Length........in.	......	......	......	......
		Weight........lbs.	......	......	......	......
Staves.........	Diameter........in.		1.75	1.75	1.75	1.75
	Length for.........	rammer........in.	125.66	125.66	125.86	125.86
		sponge........in.	115.33	125.33	115.33	125.33
		ladle........in.	......	......	......	......
		worm........in.	......	......	......	......
Rammer-heads.		Length........in.	7.	......	6.4	......
	Diameter..............	Body........in.	6.13	......	5.6	......
		Neck........in.	3.	......	3.	......
Sponge-heads..........................		Length........in.	8.	8.	8.	8.
		Diameter........in.	9.	7.	7.	5.4
Sponges, woollen, weight........lbs.			......	......	......	......
Sponge-covers..........................		Length........in.	......	......	......	......
		Weight........lbs.	......	......	......	......
Duck, 30 in. wide, required for 100 covers........yds.			......	......	......	......
Ladle-heads.		Whole length........in.	......	......	......	......
	Diameter..............	above shoulder........in.	......	......	......	......
		below shoulder........in.	......	......	......	......
		neck........in.	......	......	......	......
Ladles.........	Whole length........in.		......	......	......	......
	Length of band, developed........in.		......	......	......	......
	Width of scoop, developed........in.		......	......	......	......
	Width of hand (included in whole length).....in.		......	......	......	......
					Casemate.	
			10-in.	8-in.	42-pr.	32-pr.
Height of front sight........in.			3.	3.	3.8	3.5
Breech-sight for guns of model of 1841 and 1844.	Radius of base-ring........in.		16.	13.	12.2	11.7
	Height for 0°........in.		1.75	1.78	1.85	1.15
	above 0°.	" 1°........in.	0.91	0.86	0.96	0.94
		" 3°........in.	2.73	2.6	2.88	2.83
		" 5°........in.	4.55	4.33	4.81	4.72

Dimensions and Weights of Implements.—Continued.

	Guns.					Howitzers.				Field-Guns and Howitzers.		
	42-pounder.	32-pounder.	24-pounder.	18-pounder.	12-pounder.	10-in. S. C.	8-in. S. C.	8-in. Siege.	24-pdr. Iron.	12-pdr. Gun. 24-pdr. How.	6-pdr. Gun. 12-pdr. How.	Mountain Howitzer.
......	128.	128.	128.	128.	128.	128.	128.	6.6	80.	......	......	49.0
......	10.25	10.	9.65	8.7	7.8	10.25	8.5	3.7	5.	......	.....	...
......	128.	128.	128.	128.	128.	128.	128.	......	......	95. 83.5	77.	...
......	9.75	8.4	8.15	8.	7.35	9.75	7.0	......	......	5.8‡	4.5	...
......	128.	128.	128.	128.	128.	......	......	......	......	......	......	...
......	13.75	13.15	12.4	10.	7.8	......	......	......	......	......	......	...
......	128.	128.	128.	128.	128.	......	......	......	......	87.	72.	...
......	7.5	7.5	7.5	7.5	7.5	......	......	......	......	4.25	3.6	...
......	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.5	1.5	1.5	1.5	1.65
......	125.66	125.86	126.07	126.23	126.17	125.66	105.86	51.67	75.67	91.67	73.17	40.0
......	125.33	125.33	125.33	125.33	125.5	125.33	105.33			78.17‡		
......	111.66	113.01	113.47	115.43	117.36	......	......	......	......	......	......	...
......	123.	123.	123.	123.	123.	......	......	......	......	82.5 69.‡	67.5	...
......	7.	6.4	5.8	5.3	5.5	7.	6.4	5.5	5.5	5.5*	4.†	4.0
......	6.13	5.6	5.1	4.64	4.	6.13	5.6	4.	4.	4.*	3.24†	3.24
......	3.	3.	3.	3.	2.5	3.	3.	2.5	2.5	2.5*	2.5†	2.5
......	8.	8.	8.	8.	7.6	8.	8.	7.6	7.5	7.5*	7.5†	5.
......	6.0	5.4	4.8	4.3	3.6	6.	5.4	3.6	3.6	3.6*	2.7†	2.5
......	0.7	0.65	0.5	0.4	0.35	......	......	......	......	0.35	0.25	...
......	12.	12.	12.	11.	11.	......	......	......	......	11.	9.	...
......	0.28	......	......	......	......	......	......	......	......	......	0.14	...
......	35.	32.	......	......	......	......	......	......	......	32.	20.	...
......	7.	6.4	5.8	6.3	4.6	......	......	......	......	......	......	...
......	6.7	6.1	5.5	5.	4.3	......	......	......	......	......	......	...
......	6.6	6.	5.4	4.9	4.2	......	......	......	......	......	......	...
......	3.	3.	3.	3.	2.5	......	......	......	......	......	......	...
......	16.5	15.35	14.1	13.1	11.2	......	......	......	......	......	......	...
......	20.75	18.85	16.95	15.4	13.2	......	......	......	......	......	......	...
......	14.	12.8	11.6	10.6	9.2	......	......	......	......	......	......	...
......	2.5	2.5	2.5	2.5	2.0	......	......	......	......	......	......	...
	Barbette.											
24-pr.	42-pr.	32-pr.	24-pr.	18-pr.	10-in. S.C.H.	8-in. S.C.H.	8-in. S.	24-pdr. how'r.	12-pr.	6-pdr.	12-pr. how.	
4.6	3.8	3.5	2.9	2.94	3.125	2.85	0.9	1.05	1.33	1.025	0.9	...
10.7	12.2	11.7	10.7	9.88	13.25	11.1	9.125	6.9	6.5	5.15	5.0	...
2.7	0	0	0	0	0	0	0	0	0	0	0	...
.93	2.0	1.96	1.94	1.95	1.91	1.61	0.886	1.07	......	......	......	...
2.8	6.02	5.87	5.82	5.85	5.74	5.03	2.64	3.21	4.046	3.124	2.792	...
4.68	10.06	9.8	9.71	9.76	9.58	8.4	4.44	5.35	6.737	5.203	4.65	..

* The same for 13-in. and 10-in. mortars, heavy.
† The same for 10-in. and 8-in. mortars, light.
‡ For the 12-pdr. gun, model 1857.

Worms.

Dimensions.	Siege and Garrison.	Field.
	In.	In.
Length of socket and neck	5.5	5.5
Length of one branch from neck to point (developed)	16.	13.
Depth of socket	4.5	4.5
Exterior diameter of socket at top	1.75	1.5
Diameter of neck	0.8	0.7
Thickness of the iron of the socket	0.125	0.125
Diameter of branches at the neck (tapering to a point)	0.6	0.5
Length of socket and worm, complete	9.5	9.
Diameter of worm, complete (exterior circle)	4.	3.
Size of iron for worms... Length	7.	6.
Size of iron for worms... Width	3.	3.
Size of iron for worms... Thickness	0.5	0.5
Weight of worm ... lbs.	1.75	1.5

Sponges for Mortars.

	13 and 10 in. Heavy Mortar.	10-in. and 8-in.	24-pdr. Coehorn.
Length of finished sponge and rammer ... inches.	44.	34.	18.
Weight " " " " " ... lbs.	3.2	2.	0.8
Length of staff, including tenon ... inches.	39.67	30.17	18.
Diameter of staff ... inches.	1.5	1.5	1.5

Preservation and arrangement in Store.

Implements collected together according to kind and calibre, in a dry place, arranged on shelves or racks, in bundles or bunches, or in boxes, according to their nature, with marks and labels showing the kind and number of the articles.

Sponges, rammers, ladles, and worms, complete, placed on pins in a vertical frame, or suspended vertically or horizontally, by racks or hooks, from the joists, supported so as not to bend. When in separate parts, the *heads* piled on shelves or on the floor, and the *staves* tied up in bundles, according to kind and calibre.

The *woollen sponges* should be preserved from moths by means of camphor, pepper, &c., or by being sealed up in strong paper bags.

Handspikes in square piles, heads and points alternating.

Leather equipments, hung on pins or hooks, in dry and cool rooms.

All wood painted, except tool-handles; iron either painted or oiled. See Chapter VII.

Bills of Timber for 100 *Implement-Heads.*

KIND.	RAMMER-HEADS.			SPONGE-HEADS.			LADLE-HEADS.		
	Square.	Length.	Contents.	Square.	Length.	Contents.	Square.	Length.	Contents.
	In.	Feet.	Sup. ft.	In.	Feet.	Sup. ft.	In.	Feet.	Sup. ft.
42-pounder.	6.625	66	241.40	6.5	72	253.5	7.25	66	289.09
32-pounder.	6.125	60	187.58	6.	72	216.0	6.5	60	211.25
24-pounder.	5.75	53	146.02	5.25	72	165.37	6.	53	159.0
18-pounder.	5.125	50	109.44	4.75	72	135.37	5.5	50	126.04
12-pounder.	4.5	50	84.37	4.125	68	96.42	4.75	50	94.01
6-pounder.	3.75	40	46.87	3.25	68	59.85			

Plank for 100 *Implement-Staves.*

KIND.	Number of planks.	DIMENSIONS.			CONTENTS.	
		Width.	Thickness.	Length.	Each plank.	Total.
		In.	In.	In.	Sup. ft.	Sup. ft.
Siege and garrison............	17	14.	2.	132	25.66	436.22
Field .... 12-pounder....	17	12.5	1.75	102	15.49	263.33
Field .... 6-pounder....	17	12.5	1.75	84	12.76	216.92

CHAPTER SIXTH.

ARTILLERY HARNESS AND CAVALRY EQUIPMENTS.

ARTILLERY HARNESS. (Plate 21.)

THE construction of the field-carriages requires a harness different, in some respects, from that of common wagons. The limber having no sweep-bar, the pole is supported directly by the wheel-horses, by means of a chain which connects the hames with the pole-yoke of the limber; and, in order to diminish the weight at the end of the pole, the leading-bars are dispensed with, the traces of the leaders being attached to those of the wheel-horses.

The same harness is perfectly adapted also to the siege-carriages; but, as these are arranged for draught in the ordinary manner, common wagon-harness may be used with them if necessary.

Leather.

Leather is generally divided into two kinds: 1st, that which is tanned and undergoes no further preparation; and, 2d, that which is tanned and is afterwards curried. The former includes all made from the heavier skins of the larger animals, as buffaloes, oxen, and cows, into thick, strong *sole-leather*, and the latter that made from the thinner skins of horses, cows, calves, sheep, etc., into *harness*, *bridle*, *upper*, *bag*, or *pouch* leather, which differ from each other only in thickness, the first being the thickest. There are other kinds besides these, designated from the mode of preparation, as *tawed* leather, such as white kid or sheep skin, prepared with alum and salt; *buckskin* and *buff* leather, so called from the fact that the buffalo and deer skins were first most commonly dressed in this way; *patent leather*, that which has been varnished. It is sometimes distinguished by its color, as *black*, *fair*, or *russet* leather. Leather which has been a long time in tanning is to be preferred to that which has been produced more rapidly. The quality is judged of by its appearance; a cross-section should be glistening and marbled, without any white streaks in the middle. It should be firm, compact, and pliant.

The actual strength of leather depends more on its quality than on its thickness. That made from bulls' hides should be rejected: it is thick and supple, but, like that made from the legs and flanks of other skins, it is spongy, without strength or endurance, and, if only slightly rumpled, the hair-side presents a shrivelled appearance, which it retains.

The different parts of harness, except straps and the like, are cut out by means of patterns. The seams are made with strong waxed thread, in double stitch, with about eight stitches to the inch: those along an edge are from 0.15 to 0.2 inch from the edge. The ends of the thread should be securely fastened before they are cut off. The awl used should be small for the thread.

Buckles, Loops, &c.

The buckles of the bridle and stirrup leather, and the loops for the cloak and valise straps on the driver's and valise saddles, are cast brass, with rollers; and the hook and loop on the pommel of the valise-saddle is brass-plated. They are designated by numbers. (See table, page 164.) All other buckles, loops, and staples are of wrought iron japanned, (black.) The iron buckles are all made with rollers; the tongues are the same size as the sides of the buckles.

Straps, or other pieces which have buckles or iron loops attached to them, are doubled on a length generally equal to twice their width, to receive the buckle or loop, which is fastened by two seams. The double end is shaved down.

Standing-loops are placed close to the buckles. Their ends are shaved down, brought together, and fastened between the two parts of the strap, if it is doubled, by the same seam. These loops are usually of the same leather as the strap.

The tongue-holes for buckles are made with a punch corresponding to the size of the tongue. Their distance apart is generally equal to the width of the strap, and the first hole is at double that distance from the end of the strap. This end is shaved down and reduced in width, to facilitate its entrance into the buckle.

Note.—A *layer* is a piece of leather sewed upon another piece, to strengthen it.

A *chape* is a piece used to fasten a buckle or loop to a strap or other piece of leather.

A *billet* is a strap which enters a buckle.

A *safe* is a piece of leather placed under a buckle, etc., to prevent it from chafing.

Composition.—A complete set of artillery harness is composed as follows:—

Head-gear. *Driver's saddles*, the same for all the near horses. *Valise-saddles* and *valise*, common for all the off horses. *Draught harness*, differing according as it is intended for the wheel or lead horses. *One whip* is allowed to each driver, and *one leg-guard* to each driver of wheel-horses

Head-Gear.

The head-gear is made of strong, *black bridle-leather,* not less than 0.1 inch thick. The buckles of the bridle are *brass-plated* or *cast brass*; of the halter, *iron.*

BRIDLE OF THE NEAR HORSE.—It is composed of the *headstall, bit,* and *pair of reins.*

HEADSTALL.—*One crown-piece,* the ends split form 2 *billets* for the buckles of the cheek-straps and 2 *billets* for the buckles of the throat-lash.

1 *brow-band:* the ends, doubled and sewed, form loops for the crown-piece to pass through; 2 *ornaments,* (brass,) circles 1.8 inch in diameter, raised in the centre, on a circle of leather 2.25 inches in diameter, fastened on the loop of the brow-band by passing the end of the brow-band, before being sewed, through an iron wire loop soldered to the ornament, the iron loop passing between the two billets of the crown-piece.

1 *throat-lash,* with 1 *buckle* No. 10 B and 1 *standing-loop* at each end. 2 *cheek-straps:* each has 1 *buckle* No. 8 B and 1 *billet* sewed to the lower end, flesh-side to flesh-side, with 2 *standing-loops,* to attach it to the bit; at the upper end 1 *buckle* No. 8 B, with one standing and one sliding loop to fasten it to the crown-piece.

BIT, (iron forged and brass-plated.)—2 *cheek-pieces,* curved in shape of **S**, and pierced at top with an *eye,* to receive the cheek-billet and a *hole* for the curb-chain: at its lower end an *eye* for the reins, and near the mouth-piece a *stud,* through which is inserted a *ring* No. 2 for the reins; 1 *mouth-piece:* its ends pass through the cheek-pieces, and are riveted and rounded; 1 *cross-bar,* riveted to the cheek-pieces; 1 *curb-chain,* (iron tinned,) of 13 *links,* diminishing in size from the middle towards the end: it is attached to the right cheek-piece by an **ꝏ**-coldshut, and to the left cheek-piece by a *hook.*

Bits are made of three sizes, in the width between the cheek-pieces,—viz., $4\frac{7}{8}$ inches, 5 inches, and $5\frac{1}{4}$ inches; about three-fifths being of the medium size.

REINS.—2 *reins:* each rein has a *buckle* No. 8 B and a *billet* sewed to one end, flesh-side to flesh-side, with 2 *standing-loops,* for attaching it to the bit; the reins are united by a *buckle* No. 8 B, with 1 *standing* and 1 *sliding loop* on the short rein, to receive the billet of the other; the near rein is shorter by 12 inches than the off one.

BRIDLE FOR THE OFF HORSE.—The same as the bridle for the near horse, with the addition of 1 *coupling-strap,* which has 1 *billet* and 1 *buckle* No. 8 B sewed on each end, with 1 *standing-loop* at one end and 2 *standing-loops* at the other; it is attached to the off ring of the bit, and passes through the near ring.

HALTER.—1 *crown-piece,* having a billet at each end for the buckles of the cheek-straps; 2 *cheek-straps,*—each has 1 *buckle* No. 6; 1 *standing* and 1 *sliding loop* at one end, the other end is sewed to 1 *iron loop* No. 3; 1 *brow-band,* the ends doubled and sewed, form loops for the crown-piece and throat-lash to pass through; 1 *nose-band,* the ends sewed to the same loops as the cheek-straps; 2 *chin-straps:* each is made of one piece doubled and sewed together with two seams the whole length: it holds in the fold at one end the square iron loop of the cheek-strap, and at the other, the rear, 1 *square iron loop* No. 3; 1 *throat-strap,* made of one piece doubled and sewed together with two seams the whole length, forming at the upper end a loop to receive the throat-lash, and holds in the fold at the other end the square iron loop of the chin-straps; 1 *throat-lash;* 1 *buckle* No. 8; 1 *standing* and 1 *sliding loop* at the end, on the near side: it passes through the loops in the brow-band and throat-strap.

1 *hitching-strap,* 6½ feet long; 1 *buckle* No. 6; 1 *standing-loop;* 1 *billet,* sewed to the buckle-end by the same seam which holds the buckle.

Driver's Saddle.

It is composed of 1 *saddle-tree;* 1 *seat; different parts of leather, etc., of the body of the saddle;* 2 *saddle-skirts;* 2 *stirrups;* 1 *girth.*

Saddle-Tree.—Wood, (beech or ash.)—The saddle-tree consists of 1 *pommel,* made of two pieces, notched or halved together at the top of the hollow of the pommel, and glued; 1 *cantle,* formed of two pieces in the same manner; 2 *side bars,* with notches to receive the pommel and cantle, to which they are nailed with 8 *nails,* each, 4-penny.

Before the irons are put on the tree, it is entirely covered with raw hide, applied green, sewed on with thongs of the same, and through the side bars near their junction with the pommel and cantle, in front and rear of each.

Grooves are made in the under side of the side bars to receive the thongs, that they may not project and chafe the horse's back.

Iron.—2 *stirrup-bars,* the front end riveted to the pommel and the rear end to the side bar; 2 *iron staples* No. 1, driven through, one from the front of the pommel, and the other from the rear of the cantle, and clenched.

Seat.—1 *girth-webbing,* the middle of its length nailed double on the pommel over the hollow: the two ends separated and stretched strongly and nailed on the front of the cantle. 1 *canvas,* (strong hemp,) to cover the webbing, stretched across the girth-webbing, the ends nailed on the side bars and on the edge of the pommel and cantle; 1 *cotton drilling,* drawn over the canvas and nailed in the same way; *cotton batting,* stuffed between the linen and the cotton drilling; 1 *leather lining,* pasted underneath the webbing and canvas

PARTS IN LEATHER, ETC., OF THE BODY OF THE SADDLE.—The front of pommel and rear of cantle are covered with leather glued to the wood and nailed close to the side bars. The ends of the side bars are covered with harness-leather, which is fastened by nails close to the pommel and cantle and by 2 finishing-nails on each end of side bar, driven through from the upper side; 1 *seat* of goat-skin morocco, lined with sheep-skin, stuffed with cotton, quilted, and bound round the edges with light morocco, fastened to the side bars by three finishing nails on each side; 1 *pommel-cover*, (bridle-leather,) sewed to the front of the seat, tacked to the lower part of the pommel, glued on the upper part, and sewed to the leather on the front of pommel by a seam along the top edge of pommel; 1 *cantle-cover*, sewed to the rear end of the seat, the lower part tacked to the side bars, the upper part glued to the cantle and sewed to the leather on the rear part of the cantle by a seam around the edge of the cantle; 1 *pommel-moulding*, (brass,) covering the seam, fastened by 2 *iron* and 2 *brass nails;* 1 *cantle-ornament*, (brass,) shape of a shield, fastened by 3 *brass nails;* 1 *pommel-ornament*, (brass,) shape of a shield, fastened by 3 *brass nails;* 2 *loops* No. 7 B, for cloak-straps, driven through the side bars in rear of the cantle, and riveted; 2 *billets* for trace-loop pass through the skirts and are nailed to the npper side of the side bars; 1 *collar-strap billet*, sewed to the loop on the front of the pommel.

SKIRTS.—2 *skirts*, (thick harness-leather,) fastened to the under side of the side bars with glue; the upper end is turned over the side bars and sewed at front and rear to the covering of ends of side bars.

STIRRUPS.—2 *stirrups*, (cast brass;) 2 *stirrup-straps* pass over the stirrup-bars; 1 *buckle* No. 4, with 3 *standing-loops*, sewed to the thin end of the strap, which is doubled and stitched on a length of 8 inches, where it passes through the eye of the stirrup.

GIRTHS.—1 *girth*, (light bridle-leather,) made in two parts of unequal lengths: each part is made of double thickness by folding the leather in the direction of its length, bringing the two edges together in the middle and fastening them with a seam the whole length. The long part has a *buckle* No. 4, and *chape*, with 3 *standing-loops;* it passes through the skirt from underneath, and is nailed to the upper side of the side bars on the off side. The short part has a billet sewed to it; it is nailed, in the same manner as the long part, on the near side.

Valise-Saddle

The valise-saddle, placed on the off-horse, is used to carry the driver's valise, but in case of emergency can be used to ride upon. It is composed of 1 *saddle-tree;* 1 *seat; different parts of leather, &c., of the body of the saddle;* 2 *saddle-skirts;* 1 *girth*

SADDLE-TREE.—WOOD.—The same as that of the driver's saddle, except in the dimensions.

IRON.—1 *hook* for the reins, (brass-plated,) with loop for billet of the collar-strap attached, is driven through the pommel from the front, and clenched; 1 *iron staple* No. 1, for the crupper-strap, driven in the cantle from the rear, and clenched.

4 *brass loops* No. 7 B, for valise-straps, driven one in each end of the side bars, and riveted.

SEAT.—1 *leather seat*, stretched and nailed to the pommel, cantle, and side bars; 1 *cotton drilling*, drawn over the leather seat and nailed in the same way; *cotton batting*, stuffed between the cotton drilling and leather seat.

PARTS IN LEATHER, ETC., OF THE BODY OF THE SADDLE.—The same as for the driver's saddle, with the addition of 2 *valise-straps*, each has 1 *buckle* No. 8, 1 *standing* and 1 *sliding loop;* 1 *crupper-strap*, made of two thicknesses, stitched, embracing in the fold at one end the iron loop on the cantle, and at the other end an *iron loop* No. 5, with roller for the back strap of the crupper. The same crupper answers for either saddle.

SKIRTS.—The same, except in dimensions, as those for the driver's saddle.

GIRTHS.—1 *girth*, (leather,) has 1 *buckle* No. 6, and 3 *standing-loops*, fastened to a *layer;* the girth is sewed to the near skirt of the saddle; 1 *billet* sewed to the off-skirt.

Valise.

The valise is cylindrical, 18 inches long, with a flat bottom.

VALISE, (thick bridle-leather.)—1 *body;* 1 *body-lining*, (cotton ticking,) pasted to the body; 2 *ends*, made of 2 thicknesses of leather, sewed together with one seam near the outer edge; 2 *end-linings*, (cotton ticking,) pasted to the ends; 1 *inner flap*, with 6 slits for wire staples sewed to the body, covering the mouth of valise; 1 *strap*, 1 *chape and buckle* No. 9, sewed to the opposite ends of body; the strap passes through the iron staples and holds down the inner flap; 6 *iron-wire staples* No. 3 pass through the body, are bent and held in place by a strip of leather sewed over their ends; 3 *chapes* and *buckles* No. 9, and 3 *standing-loops*, sewed to the body for the billets on the cover; 2 *handles*, (leather, rounded,) sewed into the ends between the two thicknesses; 2 *loops*, 1 inch wide, sewed to the bottom of the body, for the valise-straps to pass through; 1 *cover;* 1 *cover-lining*, larger than the cover, sewed to it around its outer edge, forming a pocket: it has an opening in the middle, which is closed with strings; 1 *binding*, thin leather, sewed around the edge of cover; 3 *billets*, sewed to the cover to fasten it down.

Draught-Harness.

The Collar.—Collars are made of two sizes,—17 inches and 20 inches· the measure taken on the inside of the breast.

1 *rim*, (bridle-leather,) sewed to the belly, stuffed with uncut straw. 1 *belly*, (upper-leather,) made in two pieces, which lap and are sewed together at bottom, stuffed with straw cut into pieces not more than ¼ of an inch long; 2 *chapes and buckles* No. 8, 2 *billets*, sewed to the open ends of the collar and used only to vary the size of the collar; 1 *pad*, (black sheep-skin,) stuffed with deer's hair, to protect the horse's neck from being chafed by the collar-straps; 3 *loops*, sewed to the pad; two pass over the ends of the collar, and the collar-strap passes through the other.

The Hames, iron, (painted black.)—*Two branches*, curved; 2 *double-joint loops* for trace-tugs, attached to the branches by means of a bolt passing through a stud forged on the branch: they turn freely on the bolt, and also admit free motion in the opposite direction; 2 *links*, for holding up the breast-strap, welded into the eyes of the joint-loop bolts; 2 *rings* No. 3, for trussing-straps, welded into the rectangular eyes at the upper ends of the branches; 1 *clasp*, made fast to the off branch, connects the branches at their lower ends; 1 *chain and toggle*, (3 links No. 4,) welded into the eye of the clasp, connects the pole-yoke to the hames; 2 *loop-rings*, 1.75 in. diameter, sewed in the trace-tugs, for the trace-chains to pass through.

Leather.—*Two safes*, sewed round the branches under the joint-loops, to protect the collar from being chafed by the trace-tugs; 2 *trace-tugs*, 0.63 inch thick, made of four thicknesses of leather stitched together with three seams, embracing in the fold the joint-loop at one end and the loop-ring at the other.

Two trussing-straps, each with 1 *buckle* No. 8, 1 *standing* and 1 *sliding loop*. They pass through the rings in the rectangular eyes of the branches to truss up the harness.

1 *hames-strap*, with 1 *buckle* No. 6 and 2 *standing-loops*, connects the two branches at the top; 1 *collar-strap*, having 1 *buckle* No. 6 and 1 *standing-loop*, passes round the hames-strap and is buckled to the billet on the pommel of the saddle, to keep the collar in place.

Traces.

Traces are composed of a leather trace with a chain and toggle attached to each end. They differ only in the length of the leather trace.

Leather trace, 0.63 inch thick, made of three thicknesses of leather sewed together their whole length, with two seams; 2 *iron loops* riveted to the ends of the leather trace with 3 *rivets*, each 0.25 inch diam. *Front trace-chain* made of iron .3 inch diameter, 5 *links* and 1 *toggle*, attached to the leather trace by the iron loop.

Rear trace-chain.—Thirteen links, four rings, (oval,) and *one toggle,* of the same-sized iron and attached in the same manner as the front trace-chain.

BELLY-BAND.—*Two trace-loops,* made by doubling the leather and sewing the branches together near one end; 1 *buckle* No. 6 *and* 1 *standing-loop* embraced in the stitched end of the trace-loop; 1 *iron loop* No. 5, embraced and playing loose on the bottom of the trace-loop; 1 *belly-strap* with 1 *buckle* No. 6 and 1 *standing-loop,* sewed to the iron loop of trace-loop on the off side; 1 *belly-strap billet* sewed to the iron loop of trace-loop on the near side and buckling to the belly-strap; 1 *loin-strap,* each end passes into the buckle of the trace-loop to hold up the traces. The loin-strap for the wheel-horse has 1 *layer* sewed under its middle, forming a loop through which passes the back-strap of the crupper: it is shorter than the loin-strap for the lead-horse; 2 *trace-loops* with 1 *buckle* No. 6 and 1 *standing-loop,* formed as above described.

CRUPPER.—1 *dock,* formed of a single piece 3.5 inches wide and 14 inches long, doubled lengthwise and made round, not stuffed: it has 1 *buckle* No. 9 *and* 1 *standing-loop* sewed to each end; 1 *body,* the rear end is split into 2 *billets* for the buckles of the dock, the other end is sewed to the end of the back-strap; 1 *layer* 10 *inches long,* 1 *buckle* No. 6, and 4 *standing-loops* sewed on the front end of the body, leaving an opening in rear of the back-strap for the hip-strap to pass through; 1 *short layer,* inserted under the long layer and in rear of the opening for the hip-strap; 1 *back-strap,* sewed in between the body and the long layer, passes through the loop of loin-strap of wheel-harness, through the iron loop on the saddle, and returns to the buckle on the body of the crupper; 1 *sliding-loop* holds the two parts of the back-strap together near the saddle.

Breeching.

1 *breech-strap,* (thick harness-leather;) 1 *layer,* thick leather, sewed to the breech-strap its whole length with 2 seams; 1 *buckle* No. 3 and 3 *standing-loops* at each end sewed in the fold of the breech-strap and layer; 2 *iron loops* No. 5 and *chapes* sewed to upper side of breech-strap; 4 *tugs* for hip-straps, made of two thicknesses of leather, sewed together with 2 seams: each has 1 *buckle* No. 6 and 3 *standing-loops,* and embraces in the fold at the other end the buckle or loops of the breech-strap; 4 *safes* sewed on the inside of the tugs; 1 *hip-strap,* split at each end into two billets, which buckle into the tugs of the breech-strap; 1 *breast-strap,* 0.63 inch thick in the middle, .5 inch at the ends, made of three thicknesses, sewed together with 3 seams: it passes through the iron links on the hames and the trace-loops attached to the saddle, and buckles to the breech-strap; 1 *pole-strap,* 0.5 inch thick, made of three thicknesses of leather sewed together with two seams; 1 *buckle* No. 3, and 3 *standing-loops,* sewed in the folds at one end.

Pole-Pad.

It is placed on the end of the pole to prevent the lead-horses from being injured by the pole.

Iron.—1 *ring*, 2.3 inches diameter, 1 inch wide, 0.2 inch thick, with 2 holes for bolt; 1 *bolt* with small hole for key.

Leather.—1 *cylindrical body*, 1 *end*, circular, with hole for pole sewed to the body; 1 *end*, pressed convex, sewed to the other end of body after it is stuffed; 1 *inner cylinder*, the open end sewed in the hole of the circular end; 1 *inner cylinder end*, 1 *reinforce-cylinder* and *end* sewed together and slipped over the closed end of inner cylinder; 2 *stay-straps*, sewed to the body, near the bolt-hole, and nailed over the end of inner cylinder; *hair* stuffed in between the inner cylinder and body. The body is pressed in against the iron ring where the bolt passes through it.

The pole-pad should be taken off from the pole and placed under cover. when the carriage is not in use.

Whip.

1 *stock*, (raw hide,) about 30 inches long. The raw hide is first covered with India-rubber cloth; 1 *leather cover*, sewed over the India-rubber covering, with a loop in the end well secured; 1 *lash*, (thread,) *tied* to the leather cover; 1 *loop* for the hand, nailed to the butt of whip with 2 tacks.

Leg-Guard.

1 *body* (strong kip leather;) 2 *layers*, sewed to the upper and lower part of the body with four seams; 4 *leg-straps*, 4 *buckles* No. 10 *and* 4 *standing-loops*, sewed to the body: the billet-ends pass through slits in the body; 1 *foot-strap*, sewed to the bottom of the body, at both ends; 1 *plate*, (iron,) 0.1 inch thick, riveted to the body with *five rivets*.

Nose-Bag.

1 *body*, (strong linen or cotton duck;) 1 *bottom*, (harness-leather,) 6 inches diameter, 4 inches deep, pressed in a mould, sewed to the body; 1 *head-strap with* 1 *buckle*, No. 8 *and* 1 *standing-loop*, sewed to top of the bottom, and fastened by 2 *copper rivets* No. 1; sewed to the top of the body and to an inside leather washer by the same seam, and fastened by 1 *copper rivet* No. 1; 1 *head-strap billet*, sewed to the top of the bottom, and fastened by 2 *copper rivets* No. 1; sewed to the top of the body and to an inside leather washer by the same seam, and fastened by 1 *copper rivet* No. 1. Width of bag at top, 15 inches; whole height, 15 inches.

PACK-SADDLE AND HARNESS FOR MOUNTAIN ARTILLERY.

The mountain howitzer and its carriage are either carried on pack-mules, or the gun is mounted on the carriage and drawn by mules harnessed to it.

The ammunition, forge, and tool chests are carried on pack-mules; or, when the roads are good, may be carried in common carts.

The equipment is the same whether the gun and carriage are packed or drawn, except that the lashing-girth and lashing-rope are not required for draught.

COMPOSITION.—The harness complete is composed of the *head-gear*, the *pack-saddle*,—which is common for packing the gun-carriage or chests,—the *crupper*, the *breeching*, the *breast-strap*, and the *lashing girth* and *rope*.

Head-Gear.

The head-gear is made of black bridle-leather. The buckles and loops are iron, japanned, (black.)

BRIDLE.—1 *crown-piece:* one end is split into 2 *billets*, and the other into 1 *billet* and 1 *buckle-strap*, for the cheek-pieces and throat-lash; 1 *buckle* No. 10, and 1 *standing-loop*, sewed to the throat-lash; 1 *buckle* No. 10, and 1 *standing-loop*, sewed to the top of the crown-piece for the billets of the winker-straps.

1 *brow-band:* the ends, doubled and sewed, form loops for the crown-piece to pass through.

2 *cheek-straps:* each has 2 *buckles* No. 8, and 5 *standing-loops;* one end buckles to the billet of the crown-piece, and the other to the bit.

2 *winkers*, made of two thicknesses of leather, sewed together by a seam around the edge; 2 *winker-straps*, sewed to the top of the winkers, and fastened to the buckle on top of the crown-piece.

1 *leading-rein:* made of a single strap; one end is sewed to the ring on the right end of the bit, the other end passes through the left ring, and has 1 *wooden toggle*, sewed in a loop at its extremity, and 1 *leather washer* on the inside of the toggle.

THE BIT.—It consists of 1 *bar* and 2 *rings*, 2.25 inches, made of wrought iron, and tinned.

HALTER.—The halter is the same as that used for field artillery, (page 144.)

Pack-Saddle.

It is composed of the *tree, the parts of leather, &c., of the body*, the *pad and girths.*

SADDLE-TREE.—WOOD, (ash, oiled.)—2 *arcs*, each made of three pieces, halved into each other, glued and fastened together with 6 *screws* No. 14, 1 inch, in the front arc, and 8 *screws* No. 14, 1 inch, in the rear arc: a circular notch is cut in the top of the arcs, for the gun; 2 *transoms*, fastened to the arcs by bolts, which pass through their entire length: each transom has a circular notch cut in it for the trunnions of the gun; 1 *cross-bar*, let into the transoms, and fastened to them by 2 *screws* No. 16, 2½ inch, in each end: a circular notch is cut on top of the cross-bar, for the gun; 2 *inner side bars*, let in flush with the inside of the arcs, and fastened by 3 *screws* No. 14, 1¼ inch, in each end; 2 *outer side bars*, mortised into the arcs; 2 *round bars:* a round tenon on each end passes through the lower end of the arcs, and is fastened by 1 *screw* No. 16, 2½ inch, which also strengthens the bearing-notch for the ammunition-chests.

Iron.—1 *front arc-plate*, with hooks on the ends, fastened to the front of the front arc by the assembling-bolts and by 2 *rivets* No. 2 B; 1 *staple*, riveted to the middle of the front arc-plate; 1 *rear arc-plate*, with hooks on the ends, fastened to the rear of the rear arc by the assembling-bolts and by 2 *rivets* No. 2 B; 1 *staple*, riveted to the middle of the rear arc-plate; 2 *assembling-bolts* No. 1, octagonal heads and nuts, connect the front and rear arcs; 4 *staples for lashing-straps*, fastened to the arcs by 2 *rivets*, each No. 2 *wire*.

Parts of Leather, etc., of the Body.—2 pieces of hemp webbing, 2.5 inches wide, stretched from the front to the rear arcs at the top of the hollow, and nailed to the inside of the arcs with tacks; 1 *cover*, (black bridle-leather,) stretched over the hemp webbing, the inner side bars and round bars, and nailed to the inner side of the arcs: a strip of thin leather is put under the heads of the tacks; 2 *flaps*, (harness-leather,) folded round the round bars, and sewed to the lower ends of the cover and arc-lining; 2 *arc-linings*, (harness-leather,) nailed to the side of the front and rear arcs, the lower ends sewed to the flaps; 4 *lining-straps*, nailed to the inner side bars and round bars; 2 *thill-straps*, with 1 *buckle* No. 6 and 1 *standing-loop*, pass over the round bars and form loops for the shafts of the gun-carriage.

6 *girth-billets*, sewed to the inside of the flaps, three on each flap: they pass through slits in the flap to the outside; 4 *iron loops* No. 4, for breeching and breast-straps, embraced in the leather loops, sewed to the inside of the flaps and passing to the outside through slits; 4 *lashing-straps*, with 1 *buckle* No. 8, and 1 *standing-loop*, fastened to the inside of the lower end of the arc by 1 *screw* No. 14, 1 inch; 4 *billets* for lashing-straps, fastened to the outside of the arcs, near the top, by 1 *screw* No. 14, 1 inch, and 1 *staple*, each; 2 *shoulder-strap tugs*, with 1 *buckle* No. 6 and 1 *sliding-loop* each, fastened to the front of the front arc by 1 *screw* No. 14, 1 inch, and 2 *nails*, 10-oz.; 1 *loop* and *toggle*, fastened with 1 *leather thong* to the iron loop on the front arc-plate; 2 *safes*, nailed to the outside of the outer side bars.

Pad.—1 *top*, (sheep-skin;) 1 *side* and *end*, (sheep-skin,) sewed to the top and lining; 1 *lining*, (strong canvas,) stuffed with straw and hair, and quilted. It is fastened to the arc-lining and flaps with 10 *leather thongs*.

GIRTH, (hemp webbing,) 7½ inches wide.—6 *buckles* No. 8, and 6 *standing-loops*, embraced in the ends of leather loops, sewed to the girths.

Crupper.

1 *dock* with 1 *buckle* No. 10, and 1 *standing-loop*, sewed to each end: it is made of a single piece of leather, rounded; 1 *body*, split at one end into 2 *billets* for the dock; 1 *back-strap*, sewed to the body at one end, with 2 seams, leaving an open space for the passage of the loin-strap: the other end passes through the staple on the rear arc-plate, to 1 *buckle* No. 6, and 3 *standing-loops*, sewed in between the body and back-strap; 1 *sliding-loop* on the back-strap, near the saddle.

1 *loin-strap* passes between the body of the crupper and the back-strap, to the buckle of the tugs on the breech-strap.

Breeching.

1 *breech-strap*; 2 *side-straps*, sewed at one end to the breech-strap, the other end passes through iron loops on the pack-saddle, or through the staples on the shafts when the harness is used for draught, into 1 *buckle* No. 4, and 4 *stand-loops*, sewed between the breech-strap and side-strap; 2 *tugs*, for loin-straps: each tug has 1 *buckle* No. 6, and 3 *standing-loops*, sewed to one end—the other end embraces 1 *iron loop* No. 5, which is fastened to the breech-strap by 1 *chape*; 2 *safes*, sewed to the under side of the tugs, with 2 seams, the length of the tug.

Breast-Strap.

1 *front strap*; 2 *side straps*, one end sewed to the front strap: the other end passes through the iron loop on the flap of the pack-saddle, or through the staples on the shafts, when the harness is used for draught, back to 1 *buckle* No. 4, and 3 *standing-loops*, sewed between the front strap and side strap; 2 *shoulder-straps*, sewed at one end to the front strap, the other end passes to the tugs on the front arc.

Lashing Girth and Rope.

1 *girth*, (thick leather,) the ends folded and sewed with 3 seams; 2 *iron hooks*, the bar embraced in the loop formed at the end of the girth.

1 *lashing-rope*, (2½-inch rope,) 10 feet long: it is used in connection with the girth, to secure the pack to the saddle: weight, 1.06 lb.

Packing the Mountain Howitzer.

The howitzer is placed on the pack-saddle, the muzzle to the front, in the recesses cut in the bows and transoms: it is lashed with the lashing-rope.

The shafts are placed upside-down on the same pack-saddle, the cross-bar on the neck of the cascable: the shafts are lashed with the bow-straps.

The carriage is placed on the pack-saddle, the axle-tree against the front face of the front bow: it is fastened by the lashing-rope. The wheels are placed on the same pack with the carriage, one on each side, the small end of the nave against the pack between the bows, one of the spokes resting on the arm of the axle-tree: they are lashed with the bow-straps.

The ammunition-chests are suspended with chains, on hooks, on each side of the pack, and lashed with lashing-ropes.

TO PLACE THE HOWITZER ON THE SADDLE.

Three men load the howitzer on the mule. Introduce the rammer-head into the bore; place the loop of the handspike over the cascable; carry the piece to the saddle, approaching by the croup; raise it and place it in its bed. Three men load the carriage, taking hold of it by the arms of the axle-tree and by the end of the trail.

Four men load 2 ammunition-chests, and hook the 4 chains at the same time.

The load ought to be fastened securely, so as to form, as it were, a part of the animal, and should be raised as little as possible above the mule's back.

HORSE EQUIPMENTS FOR THE CAVALRY SERVICE.

A complete set of horse equipments for cavalry troops consists of 1 *bridle*, 1 *watering-bridle*, 1 *halter*, 1 *saddle*, 1 *pair of saddle-bags*, 1 *saddle-blanket*, 1 *surcingle*, 1 *pair of spurs*, 1 *curry-comb*, 1 *horse-brush*, 1 *picket-pin*, and 1 *lariat;* (1 *link* and 1 *nose-bag*, when specially required.)

Head-Gear.

All the leather is black bridle-leather, not less than 0.1 inch thick, and the buckles are malleable iron flat bar-buckles, blued.

BRIDLE.

It is composed of 1 *headstall*, 1 *bit*, 1 *pair of reins.*

HEADSTALL.—1 *crown-piece*, the ends split, forming 1 *cheek-strap* and 1 *throat-lash billet* on one side, and on the other 1 *cheek-strap* and 1 *throat-lash*, with 1 *buckle* No. 11 A; 2 *chapes*, and 2 *buckles* No. 10 A, sewed to the ends of cheek-pieces to attach the bit; 1 *brow-band:* the ends, doubled and sewed, form 2 loops on each end, through which the cheek-straps, throat-lash, and throat-lash billet pass.

BIT, (shear steel, blued.)—2 *branches*, S-shaped, pierced at top with an *eye* for the cheek-strap billet, and with a small hole near the eye for the curb-chain, terminated at the bottom by 2 *buttons*, into which are welded 2 *rings* No. 5 for the reins. The lower curve of the branch is tangent to the line through the axis of the mouth-piece and the centre of the eye. 1 *mouth-piece*, curved in the middle: its ends pass through the branches, and are riveted to them; 1 *cross-bar*, riveted to the branches near the lower ends; 2 *bosses*, (cast brass,) bearing the number and letter of the regiment and the letter of the company, riveted to the branches with 4 *rivets;* 1 *curb-chain hook*, steel wire No. 10, fastened to the *near* branch; 1 *curb-chain*, steel wire No. 11, curb-chain links 0.7 inch wide, with 1 *loose ring* in the middle, fastened to the *off* branch by an S-hook, cold-shut; 1 *curb-strap*, (leather,) fastened to the curb-chain by 2 *standing-loops.*

1 *curb-ring* for bit No. 1 replaces the curb-chain and curb-strap. They are of 2 sizes: No. 1, interior diameter 4 inches; No. 2, 3.75 inches,—the number marked on the outside of the swell. Three-fourths of the bits of this kind to have the large ring, one-fourth the small ring.

There are *four* varieties of bits; they are all alike below the mouth-piece.

	No. 1.	No. 2.	No 3.	No. 4.
Height of arch	2.25	2.	1.5	0.5
Opening of arch	0.8	1.1		
Distance of eye from axis of mouth-piece	1.5	2.25	2.25	2.25
Diameter of mouth-piece at shoulder	0.5	0.5	0 5	0.65

Distance from axis of mouth-piece to axis of cross-bar, 5 inches.

Distance from centre of button to the axis of cross-bar, 0.5 inch.

Length of mouth-piece in all bits, 4.5 inches; square tenon of mouth-piece, .35 inch.

At centre of arch, .325 inch vertical thickness, 0.45 inch horizontal. Thickness of branch at mouth-piece, 0.225 inch.

REINS.—2 *reins*, sewed together at one end,—the other ends sewed to the rings of the bit.

WATERING-BRIDLE.

The watering-bridle is composed of 1 *bit* and 1 *pair of reins*.

BIT, (wrought iron, blued.)—2 *mouth-piece sides*, united in the middle by a loop-hinge: their ends are pierced with 2 holes to receive 2 *rings* No. 1 for the reins; 2 *chains* and *toggles*, 3 links, each 1 inch $\times$ .55 inch, welded into the rein-rings.

REINS.—2 *reins*, sewed together at one end,—the other sewed to the rings of the bit.

HALTER.

2 *cheek-pieces*, sewed, one end to 2 *square loops* No. 2 A, and the other to 2 *cheek-rings* No. 1 A; 2 *standing-loops* for the toggles of the watering-bridle, sewed to the cheek-pieces near to the square loops; 1 *crown-piece*, sewed to the *off* cheek-ring; 1 *buckle* No. 7 A and *chape*, sewed to the *near* cheek-ring; 1 *nose-band*, the ends sewed to the square loops; 1 *chin-strap*, the ends sewed to the square loops, and passing loose through the hitching-strap ring; 1 *throat-strap*, folded on itself, making two thicknesses, and forming at top a loop for the throat-band to pass through, and embracing in the fold at the other end 1 *bolt*, which holds 1 *hitching-strap ring; 1 throat-band* passes loose through the loop in the throat-strap, and sewed to the cheek-rings; 1 *hitching-strap*, 6½ feet long; 1 *buckle* No. 6 A, and 1 *standing-loop;* 1 *billet*, sewed to the buckle end by the same seam which holds the buckle.

Saddle.

All the leather is black bridle or harness leather, and the buckles are malleable iron blued.

The SADDLE is composed of 1 *tree*, 2 *saddle-skirts*, 2 *stirrups*, 2 *stirrup-leathers*, 1 *girth* and *girth-strap*, 1 *surcingle*, 1 *crupper*.

SADDLE-TREE.—WOOD, (beech.)—1 *pommel*, made of 2 pieces framed together at top and glued; 1 *cantle*, formed of 2 pieces, like the pommel; 2 *side bars*, (poplar,) each made of 3 pieces glued together: they are glued to the pommel and cantle, and fastened by 2 *rivets* No. 1, 2 *burrs*, and 4 *nails*,—the burrs let in on the under side; 1 *strap-mortise* in the pommel; 3 *strap-mortises* in the cantle.

There are three sizes of trees, varying in the length of the seat:

No. 1, 11 inches length of seat, 15 per cent.,					to be marked on the pommel-ornament.
No. 2, $11\frac{1}{2}$	"	"	"	50 "	
No. 3, 12	"	"	"	35 "	

IRON.—1 *pommel-arc*, .1 inch thick, with 3 small holes on top, fastened to the side bars by 4 *rivets* No. 1; 1 *pommel-plate*, .1 inch thick, semi-circular, fastened to the front of the pommel by 4 *rivets* No. 1; 1 *cantle-arc*, .1 inch thick, with 3 small holes on top, fastened to the side bars by 4 *rivets* No. 1; 1 *cantle-plate*, .1 inch thick, fastened to the rear of the cantle by 4 *rivets* No. 1; 2 *stirrup-loops*, hinged in 2 *iron straps*, which are fastened to the side bars by 6 *rivets* No. 1.

The tree is painted with one coat of white lead. It is covered with raw hide, put on wet and sewed with thongs of the same, and held in place by stitches through the wood along the junction of the pommel and cantle with the side bars. The seams are made on the edges of the side bars, where they will not chafe the horse nor rider.

2 *rings*, held by staples driven into the front ends of side bars; 2 *foot-staples* for coat-straps, fastened to the front of the pommel by 4 *brass screws* No. 6, $\frac{3}{4}$ inch; 2 *crupper-rings*, (japanned black,) fastened by staples driven into the rear ends of side bars; 2 *foot-staples*, fastened to the rear of cantle by 4 *brass screws* No. 6, $\frac{3}{4}$ inch; 1 *guard-plate;* 1 *pommel-ornament*, shield-shaped, (sheet brass,) fastened to the pommel, each by 3 *brass screw-pins;* 6 *guard-plates*, fastened to the cantle by 12 *screw-pins;* 2 *foot-staples*, fastened on the back strap by 4 *brass screws* No. 6, $\frac{3}{4}$ inch; 1 *saddle-bag stud*, fastened on the back strap to the cantle-arc by 2 *copper rivets* No. $\frac{1}{2}$ C.

2 SADDLE-SKIRTS, (thick harness-leather,) fastened to the side bars by 38 *brass screws* No. 6, $\frac{3}{4}$ inch; 2 *stay-loops* for the saddle-bag straps, sewed to the rear edge of the skirts.

2 STIRRUPS, (hickory or oak,) made of one piece bent, the ends separated by 1 *transom* and fastened by 2 *iron rivets* No. 2 B, 4 *burrs* each; 2 *leather hoods*, (thick harness-leather,) fastened to the stirrups by 12 *copper rivets* No. $\frac{1}{2}$ and *burrs*,—distance of hood from rear of stirrup, 6 inches; 2 *stirrup-straps*—2 *buckles* No. 5 A; 2 *sliding-loops*—pass through the stirrup-loops and through a hole cut in the skirt; 2 *stirrup-leathers*, (thick harness-leather;) 2 *standing-loops*.

GIRTH.—2 *girth-straps* pass over the pommel and cantle-arcs, to which they are fastened by 4 *copper rivets* No. $\frac{1}{2}$ C and 4 *burrs:* they are fastened to the side bars by 4 *brass screws* No. 6, $\frac{3}{4}$ inch: the ends are sewed into 2 D-*rings* No. 1 A; 2 *girth-billets*, sewed to the straight side of the D-rings; 1 *girth*, 4.5 inches, (blue woollen webbing;) 1 *chape*, 1 *buckle* No. 2 A, 1 *standing-loop*, and 1 *safe* on the off end, and 1 *chape*, 1 *buckle* No. 4 A, 1 D-*ring* No. 1 A, 1 *standing-loop*, and 1 *safe* on the near end; 1 *standing-loop* on the middle.

6 COAT-STRAPS, 6 *buckles* No. 11 A, 6 *stops:* they pass through the mortises in the pommel and cantle and the foot-staples.

CARBINE-THIMBLE.—1 *strap;* 1 *buckle* No. 10 A sewed to the socket: the thimble is buckled to the D-ring on the off side of the saddle.

SURCINGLE, 3.25 inches, (blue woollen webbing.)—1 *chape,* 1 *buckle* No. 4 A, and 1 *standing-loop* on one end, and 1 *billet* on the other; 1 *billet-lining,* sewed over the end of webbing to the billet; 2 *standing-loops* near the buckle end.

CRUPPER.—1 *dock,* made of a single piece and stuffed with hair, the ends sewed to the body of the crupper; 1 *body,* split at one end, has sewed to it 1 *chape* and 1 *ring* No. 3 A; 2 *back-straps:* each has 1 *buckle* No. 10 A and 2 *sliding-loops:* they pass through the rings of the side bars and the ring on the body of the crupper.

Saddle-Bags.

The saddle-bags are composed of 2 *pouches* and 1 *seat,* the ends of the seat sewed to the pouches. Each pouch has 1 *back,* sewed to the gusset and upper part of inner front with a *welt;* 1 *gusset,* sewed to the back and to 1 *outer* and 1 *inner front* with a *welt;* 1 *flap,* sewed to the top of the back and to the seat by 2 *seams;* 1 *flap-billet,* sewed to the point of the flap; 1 *chape* and 1 *buckle* No. 11 A, sewed to the outer front; 1 *billet* and 1 *buckle* No. 11 A, sewed to the chape. The seat is sewed to the pouch by the same seams which join the flap to the back of the pouch. It has 2 *holes* for the foot-staples, and 1 *hole* for the saddle-bag stud; 2 *key-straps,* sewed to the seat near its ends; 4 *lacing-thongs* for the pouches.

Saddle-Blanket.

To be of pure wool, close woven, of stout yarns of an indigo-blue color, with an orange border 3 inches wide, 3 inches from the edge. The letters U. S., 6 inches high, of orange color, in the centre of the blanket. Dimensions, 75 inches long, 67 inches wide. Weight, 3.1875 lbs.; allowance in weight, 0.1875 lb.

SPURS, (brass.)—2 *spurs;* 2 *rowels;* 2 *rivets;* 2 *spur-straps,* 19 inches long; 2 *roller-buckles* No. 11 B; 2 *standing-loops.*

Length of heel—for No. 1, $3\frac{1}{2}$ inches; for No. 2, $3\frac{1}{4}$ inches, } inside mea-
Width of heel " 1, $3\frac{1}{4}$ " " 2, 3 " } sure.

Length of shank to centre of rowel, 1 inch.

Diameter of rowel, 0.85 inch.

Weight of pair of spurs and straps, .57 lb.

HORSE-BRUSH.—1 *body,* (maple;) Russia bristles; 1 *cover,* glued and fastened to the body by 8 *screws* No. 3; 1 *hand-strap,* (fair leather,) fastened to the sides of the body by 6 *screws* No. 5; 2 *leather washers* under the heads of screws.

Dimensions.—Body, 9.25 inches long, 4 inches wide, .5 inch thick; cover, 0.1 in. thick; bristles project .9 in.; hand-strap, 2 in. wide. Weight, .57 lb.

CURRYCOMB, (iron, japanned black.)—1 *body*, (sheet iron, 0.4,) the top and bottom edges turned at right angles, forming 2 rows of teeth; 3 *double rows* of teeth riveted to the body by 6 *rivets;* 1 *cross-bar*, riveted across the top by 2 rivets; 1 *handle-shank*, riveted to the body by 3 rivets; 1 *handle*, (wood,) turned and painted, passes over the shank, and is held by the riveted end of the shank; 1 *ferrule*, sheet iron.

Dimensions.—Length 4 inches, width 4.75 inches, thickness .75 inch; length of handle, 4 inches. Weight .75 lb.

PICKET-PIN, (iron, painted black.)—The parts are, *the body*, *the neck*, *the head*, *the swell*, *the point*, 1 *lariat-ring* around the neck, 8-shaped, the larger opening for the lariat.

Dimensions.—Length, 14 in.; diameter at swell, 4 in. from point, .75 in.; at neck, .5 in.; at head, 1 in. Lariat-ring, .2-in. wire, welded. Int. diameter, 1 inch. Weight of pin, 1.25 lbs.

LARIAT.—Best hemp 1¼-in. rope, 30 ft. long, of 4 strands, an eye spliced in one end, the other end whipped with small twine. Weight, 2.38 lbs.

LINK.—1 *strap*, embracing in the fold at one end 1 *spring-hook*, and at the other 1 *buckle* No. 10 A and 1 *billet*. Weight, .2 lb.

NOSE-BAG, same as that described page 150.

Inspection of Harness and Horse Equipments.

The inspection is made before the parts are assembled. For the convenience of the inspector, the different parts are arranged in separate piles.

MATERIALS.—The quality of the materials is first examined.

The leather should be *firm*, *elastic*, and *pliable*, and should be smooth and shaved to a firm surface on the flesh-side. If it feel hard and horny to the hand, or, being bent, it cracks in the grain, or, when cut, it exhibits a hard and shining texture, it is an indication that the leather has not been tanned sufficiently, and it should be rejected. Leather which has been tanned with hemlock should not be received. The traces, the breast-strap and pole-strap, and straps generally, should be made of the strongest leather, and the saddle-skirts of the thickest leather.

The malleable iron parts should be tested by taking some pieces and bending them back and forth to see that they have the requisite toughness.

WORKMANSHIP.—The saddle-trees should be inspected before they are covered, that it may be seen that the proper kind and quality of wood has been used, that the framing of the parts is well done and secured, that the surface is smooth, the angles rounded, and that the irons are properly fastened.

No old or brash wood should be used.

Examine the edges of the different parts of leather, that they are well blacked and rubbed smooth; that the seams are at the proper distances from the edges, according to the width of the parts; that the splices and laps are of the proper length; that the stitching is neatly done with a uniform length of stitch; that the thread is well waxed, and the ends, whenever they occur, secured with a double knot.

Examine the collars, that they are stuffed compactly. Especial care is to be taken to see that no lumps or irregularities occur on the belly, or part which comes against the shoulders of the horse.

See that the billets pass freely through the loops, that the holes are punched at the proper distance from each other in the central line of the billet, and that they just admit the tongue of the buckle with ease and no more.

Observe the rollers of such buckles as have them, that they work freely, and are sufficiently stiff not to be flattened.

See that the seams of the raw hide covering the tree are well made and will not chafe the horse or rider; that the skirts are thinned down where they are fastened to the trees, the screw-heads are well sunk, and there is as little unevenness at this place as possible; that the stirrups are well riveted at top, and the wood is not split by the rivet.

Examine the bits, that they are made of the proper materials; that the mouth-pieces are forged solid; that they and the cross-bars are firmly fitted to the cheek-pieces; that the curb-rings work freely and are properly shouldered to keep them in place; that the watering-bits are free from cracks or flaws at the joint of the mouth-piece.

See that the blueing is, in all cases, of a uniform dark-blue color, free from any yellow tinge.

The general characteristics of all the work should be *neatness* and *strength.*

All the parts are finally measured and verified, to see that they conform in shape and dimensions to the established patterns.

Preservation of Harness in Store.

The store-houses should be well ventilated, not too dry, but free from dampness. The different articles should be arranged according to kind and class, separated or in bundles according to their nature, so placed as to touch each other and the walls as little as possible, having a free circulation of air about them:—*saddles* on trestles or bars—*collars* hung on pins—*hames* with their straps, and *traces* with chains and hooks, hung up; the traces hanging vertically—*side-pipes* and *belly-bands* piled on the floor or on shelves—*surcingles* and *breast-straps* stretched on racks—*halters, bridles, reins,* &c., hung up in bundles of five or ten—*hames-straps, collar-straps,* &c., hung up in bundles of ten or twenty—*bits, curb-chains, trace-hooks,* in boxes.

All these articles should be examined and cleaned at least four times a year.

The leather articles are brushed and greased with *neat's-foot oil*, as often as their condition requires: if they have a reddish hue, mix a little lamp-black with the oil. First brush the leather carefully, then pass over it a sponge wet with lukewarm water; grease it slightly on the hair-side, applying the oil with a soft brush before the leather is quite dry. In general, new leather is not greased until it has been in store three years, unless it should be found to require it. Iron parts which are not japanned or tinned, or from which the coating is rubbed off, are greased with tallow.

Horseshoes and Nails.

The principal parts of the shoe are the *two faces*, the *two edges*, the inner and outer; the *toe*, the front part; the *quarters* uniting the toe with the heels,—*the fullering*, the crease in which the nail-holes are made: there are generally eight holes; *the calks*, projections at the extremities of the heels on the lower face: they serve principally to prevent the horse from slipping: they should be used with caution; the *clip*, a kind of claw on the outer edge of the shoe, generally on the toe of the hind foot, sometimes on the outer quarter, in which case a small one is made on the inner one: they are used to keep the shoe in place and to guard the hoof; *the bevel*, the concavity of the upper face, that the iron may in no case rest on the arch of the sole of the foot.

The hind shoes are generally a little thicker and broader at the toe than the front shoes. The front shoes are punched nearer the toe, the hind shoes nearer the heels.

The principal parts of the nail are the *head*, the *body*, and the *point*. The head ought to fit into the fullering; the blade near the head should not be too thin: it has a slight curve near the point, that it may turn out instead of going into the foot. Reject those nails that are split or have flaws.

Soft iron is best adapted for horseshoes.

Horseshoes made by machinery are generally furnished to the artillery. There are four sizes,—viz.:—

Dimensions and Weights of Horseshoes.

			In.		In.		Lbs.
Front shoe.........	No. 1.	Length,	5.75	Width,	4.5	Weight,	0.875
	2.	"	6.0	"	4.75	"	1.0
	3.	"	6.25	"	5.75	"	1.1875
	4.	"	6.5	"	5.1	"	1.4375
Hind shoe..........	1.	"	5.25	"	4.0	"	0.875
	2.	"	5.5	"	4.2	"	1.0
	3.	"	5.5	"	4.25	"	1.1875
	4.	"	6.1	"	5.75	"	1.4375
Horseshoe-nails..	2	112 nails	....			"	1.0
	3.	140 "	....			"	1.0

General Directions for Shoeing Horses.

The shoe should be forged to fit the form of the foot: it should project on the outside at the end of the heel about its thickness, beginning at the last hole; should be flush with the hoof at the toe and on the inside; the heels generally short and thin. The holes in the outer quarter should be farther from the edge, and in the inner quarter nearer the edge; in the front shoe nearer the toe, and in the hind shoe nearer the heel. Make the lower face of the shoe perfectly flat, and try it on an iron table. The shoe should bear equally all around on the wall of the foot, and not at all on the sole.

A judicious preparation of the foot for the shoe is of the greatest importance, strict attention being paid to its peculiarities.

Cut away the wall no more than is necessary to make the shoe fit; pare the sole and the frog very sparingly; in using the buttress, place it flat on the foot, and cut off the hoof evenly. The whole thickness of the wall should be left perfectly flat for the bearing of the shoe, which should never rest on the sole. The bars should never be pared except in cases of contracted feet, and then with judgment.

Do not apply the shoe to the foot when too warm; keep it there but for a short time. Drive the nails in the sound hoof and rivet them solidly, all at the same height.

In rasping the rivets, do not touch the wall of the foot: it weakens the foot. When a nail binds, draw it out and take another. If the horse suddenly jerks his foot after a blow of the hammer, withdraw the nail immediately.

Shoes should not be allowed to remain on more than five weeks, when they should be removed, the useless hoof pared off and the shoe replaced if it be still good. This should be regulated by the length of the hoof rather than by the wear of the shoe. In removing shoes, take care to raise the clenches first, that the crust may not be torn or portions of the nail left in the hoof. It is better to remove the shoes one at a time as the new shoe is ready to be put on.

Rough-shoeing differs from ordinary shoeing only in the form of the nails, the heads being longer and more pointed.

The shoe used in *all* other services is to be preferred to that in use in ours. It has no fullering, but each hole is countersunk to receive the head of the nail, which is less apt to be broken off, as it is well supported on all sides: the shoe is not weakened by fullering.

Harness required for each Horse.

	Saddle-horse.	Wheelers. Near Side.	Wheelers. Off Side.	Leaders. Near Side.	Leaders. Off Side.	Weight.
						Lbs.
Halter	1	1	1	1	1	3.0
Bridle	1	1	1	1	1	3.0
Coupling-strap	...	......	1	......	1	0.5
Driver's saddle	1	1	......	1	......	16.25
Valise-saddle	...	......	1	......	1	7.78
Valise	...	......	1	......	1	4.5
Collar and collar-strap	...	1	1	1	1	4.25
Hames and strap and 2 turning-straps	...	1	1	1	1	9.25
Pair of traces. Wheel	...	1	1	......	......	9.75
Pair of traces. Leading	...	......	......	1	1	11.75
Trace-loops and belly-band	...	1	1	1	1	1.
Loin-straps and trace-loops. Wheel	...	1	1	......	......	0.75
Loin-straps and trace-loops. Leading	...	......	......	1	1	0.875
Crupper	...	1	1	1	1	0.75
Breeching and hip-strap	...	1	1	......	......	3.6
Breast-strap	...	1	1	......	......	4.75
Leg-guard	...	1	......	......	......	2.00
Whip	...	1	......	1	......	0.35
Nose-bag	...	1	1	1	1	1.12
Pole-strap (on the carriage-pole)	...	1	1	......	......	2.
Pole-pad " "	...	......	......	......	......	1.5
		Lbs.	Lbs.	Lbs.	Lbs.	
Weight. For each horse	...	59.82	54.0	51.60	47.77	
Weight. Set for 2 horses	...	113.82		99.37		

Buckles, Loops, Rings, and Staples.

Designation.		Interior Dimensions. Width.	Interior Dimensions. Length.	The Frame. Width.	The Frame. Thickness.	Diameter of the Bar.	Remarks.
		Inches.	Inches.	Inches.	Inches.	Inches.	
Buckles.	No. 1 B	2.5	1.3	.4	....	....	For the carbine-sling.
	No. 2 A	2.0	1.1	.25	Round.	.25	With roller.
	No. 3	1.75	2.5	.4	"		
	No. 4	1.5	0.9	.2	"		Those marked A are made of malleable iron; B, made of brass.
	No. 4 A	1.5	1.0	.25	"	.25	
	No. 4 B	1.5	1.6	.3	.18	.24	
	No. 5 A	1.375	2.0	.325	.175	.25	Size of round for strap, .3×.2 inch.
	No. 6	1.25	.8	.2	Round.		
	No. 7 A	1.125	2.0	.3	.175	.25	
	No. 8	1.0	.8	.16	Round.		
	No. 8 B	1.0	1.2	.25	.125	.2	
	No. 9	.88	.7	.16	Round.		
	No. 10	.75	.6	.15	"		
	No. 10 A	.75	1.35	.225	.125	.2	
	No. 10 B	.75	.9	.2	.11	.14	
	No. 11 A	.625	1.15	.2	.125	.175	
	No. 11 B	.625	....	....	....	....	With roller.
Loops.	No. 1 B	1.9 / 1.6	1.4	.185	Round.		
	No. 2 A	1.6	1.2	.3	.25		
	No. 3	1.5	1.25	.25	Round.		
	No. 4	1.4	0.9	.175	"		
	No. 4 B	1.4	1.1	.185	"		
	No. 5	1.25	.8	.2	"		
	No. 6 B	1.125	.5	.185	"		
	No. 7 B	1.0	.45	.2	"	....	Cast with a shank.
D-rings.	No. 1 A	1.85	1.85	.325	.25		
	No. 2 B	1.125	.8	.185	Round.		
Rings.	No. 1	1.7	Round.	.2	"		
	No. 1 A	1.7	"	.25	"		
	No. 2	1.3	"	.15	"	....	Plated with brass.
	No. 3	1.25	"	.13	"		
	No. 3 A	1.25	"	.2	"		
	No. 4	1.1	"	.18			
	No. 5	1.0	"	.21			
Staples.	No. 1	1.25	2.3	.2	Round.		
	No. 2 A	.9	.3	.2		Diameter of Foot. .4	Foot-staples, held by screws.
	No. 3	.88	.6	.1			
Halter-bolt...........		1.2	....	.25	Round.	Diameter of Head. .4	
Saddle-bag stud.....		Foot. 0.4	1.	.225	Round.	Diemeter of Knob. .4	
Link-hook............		Eye. 1.1	.2	.4	1.75	....	Made of iron wire, doubled.

Dimensions of the Principal Leather Parts of Artillery Harness, with the Number and Size of Buckles.

	Parts.	Number.	Width.	Length. Cut.	Length. Finished.	Buckles. No.	Buckles. Width.
			In.	In.	In.		In.
Halter.	Crown-piece	1	1.25	30.	30.		
	Cheek-straps	2	1.25	12.5	8.	2	1.25
	Brow-band	1	1.25	21.	15.		
	Nose-band	1	1.25	18.5	14.		
	Chin-straps	2	1.25	12.	5.25		
	Throat-strap	1	1.25	13.5	6.25		
	Throat-lash	1	1.	44.	42.	1	1.
Bridle.	Crown-piece	1	1.75	26.	26.		
	Throat-lash	1	.75	23.	19.5	2	.75
	Brow-band	1	1.	23.	16.		
	Cheek-straps	2	1.	12.5	8.5	4	1.
	Billets for cheek-straps	2	1.	10.	10.		
	Reins, long	1	1.	66.	64.	1	1.
	Reins, short	1	1.	46.	44.	2	1.
	Billets for reins	2	1.	11.	11.		
	Coupling-straps	1	1.	64.	84.	2	1.
	Billets for do. long	1	1.	26.			
	Billets for do. short	1	1.	10.	10.		
Driver's Saddle.	Skirts	2	14.	24.	24.		
	Billet for collar-strap	1	1.25	14.	12.		
	Stirrup-leathers	2	1.5	65.	56.	2	1.5
	Trace-loop billets	2	1.25	18.	18.		
	Girth-billet	1	1.5	22.	38.		
	Girth, short part	1	2.8	20.			
	Girth, long part	1	2.8	38.	38.	1	1.5
Valise-Saddle.	Skirts	2	10.	21.			
	Girth	1	2.	30.	......	1	1.25
	Girth-billet	1	2.	20.			
	Trace-loop billet	2	1.25	18.	18.		
	Billet for collar-strap	1	1.25	14.	12.		
	Crupper-strap	1	1.25	10.5	4.5		
	Valise-straps	2	1.	48.	46.	2	1.
Valise.	Body	1	18.	25.			
	Ends	2	6.25	7.25			
	Inner flap	1	4.	16.			
	Strap for flap	1	.88	18.	18.	1	.88
	Cover	1	10.	20.3			
	Buckle-straps	3	.88	4.	2.	3	.88
	Billets for buckle-straps	3	.88	7.5	7.5		

Dimensions of Leather Parts of Artillery Harness.—Continued.

Parts.		Number.	Width.	Length. Cut.	Length. Finished.	Buckles. No.	Buckles. Width.
			In.	In.	In.		In
Leg-Guard.	Body	1	17.	20.5			
	Foot-strap	1	.88	14.	14.		
	Leg-straps	4	.75	26.	24.	4	0.75
Collar and Hames.	Collar-billets	2	1.	11.	11.	2	1.
	Trace-lugs	2	1.75	17.	7.		
	Trussing-straps	2	1.	34.	32.	2	1.
	Harness-strap	1	1.25	21.	18.	1	1.25
	Collar-strap	1	1.25	15.	9.	1	1.25
Traces and Straps.	Wheel-traces	2	1.75	50.	50.		
	Leading-traces	2	1.75	96.	96.		
	Trace-loops	2	1.25	21.	9.	2	1.25
	Belly-band	1	1.25	31.	25.	1	1.25
	Belly-band	1	1.25	16.	13.		
	Loin-straps: Wheel	1	1.25	48.	48.		
	Loin-straps: Leading	1	1.25	60.	60.		
	Loin-straps: Layer	1	1.25	6.	6.		
	Loin-straps: Loops	2	1.25	23.	10.	2	1.25
Crupper.	Dock	1	3.5	14.	14.	2	.88
	Body	1	1.75	20.	20.	1	1.25
	Layer for body	1	1.25	10.	10.		
	Back-strap	1	1.25	31.	31.		
Breeching.	Breech-strap	1	2.5	48.	42.	2	1.75
	Layer for breech-strap	1	1.75	50.	42.		
	Tugs	4	1.25	13.	6.	4	1.25
	Safes	4	2.25	6.	6.		
	Hip-strap	1	2.5	48.	48.		
	Breast-strap	1	1.75				

Leather, etc., required for 1 *set of Wheel and* 1 *set of Leading Harness, for* 2 *Horses each.*

Harness-leather	7 sides.
Bridle "	4 "
Collar "	2 "
Goat (morocco) skins	1
Sheep-skins, russet	2
" black	1
Hemp webbing	3 yds.
Cotton ticking	3 "
" drilling	2 "
Tow linen	1 yd.
Cotton batting	2 lbs.
Deers' hair	½ "
Rye straw	24 "
Tacks, assorted	4 M.
Finishing-nails	½ gross.
Shoe-thread	2 lbs.
One side of collar-leather makes	14 whips.

Dimensions of Leather Parts of Cavalry Equipments.

Parts.		Number of parts for one set.	Dimensions. Width.	Length. Cut.	Length. Finished.	Buckles. Number required.	Buckles. Size.	Rings or Loops. Number required.	Rings or Loops. Size.	Weight.
			Inches.	Inches.	Inches.					Lbs.
Bridle	Crown-piece	1	1.425	52.	60.5	2 1	No. 10 A No. 11 A			.93
	Brow-band	1	.75	19.75	16.25					
	Bit-billets	2	.75	10.50	9.60					
	Curb-chain safe	1	.85	5.5	5.5					
	Curb-chain loops	2	.625	3.0	0.75					
	Reins	2	.75	64.	60.					
Watering-Bridle Reins		2	.875	61.	58.					.04
Halter	Cheek-pieces	2	1.25	13.5	8.5			2 loops. 2 rings.	No. 2 A No. 1 A	2.21
	Cheek-piece loops	2	1.	1.25	1.125					
	Crown-piece	1	1.125	27.	24.5					
	Do. chape	1	1.125	8.	2.75	1	No. 7 A			
	Nose-band	1	1.25	18.5	13.5					
	Chin-strap	1	1.25	19.25	14.25					
	Throat-strap	1	1.25	14.625	6.125			1 ring. 1 halter-bolt	No. 1 A	
	Throat-band	1	1.	23.	18.					
	Hitching-strap	1	1.25	84.	81.	1	No. 7 A			
	Hitching-strap billet	1	1.25	12.	9.					
Link	Strap	1	.75	16.0	11.0			1 spring-hook		.21
	Billet	1	.76	10.0	8.0					
Saddle	Skirts	2	15.	16.	16.					Including the tree ironed, 13.98
	Stay-loops for saddle-bags	2	.625	3.	2.875					
	Stirrup-hoods	2	14.	8.5	8.5					
	Stirrup-straps	2	1.375	5.6	53.	2	No. 6 A			
	Stirrup-leathers	2	13.5	9.	9.					
	Do. loops	4	2.	2.87	1.5					
	Stirrup-strap loops	2	1.25	5.25	1.375					
	Girth-straps. Front	1	1.25	44.	39.					
	Girth-straps. Rear	1	1.25	46.5	41.5			2 D-rings.	No. 1 A	
	Girth-billets. Near side	1	1.375	60.	67.					
	Girth-billets. Off side	1	2.	20.	17.5					
	Coat-straps	6	.625	35.	33.	6	No. 11 A			
	Coat-strap stops	1	.625	1.	1.					

Dimensions of Leather Parts of Cavalry Equipments.—Continued.

Parts.		Number of parts for one set.	Dimensions. Width.	Dimensions. Length. Cut.	Dimensions. Length. Finished.	Buckles. Number required.	Buckles. Size.	Rings or Loops. Number required.	Rings or Loops. Size.	Weight.
			Inches.	Inches.	Inches.					Lbs.
Carbine.	Thimble	1	2.5	8.25	Diameter $2\frac{1}{4}$					.2
	Strap	1	.75	12.	11.	1	No. 10 A			
Crupper.	Dock	1	3.	16.	12.					.57
	Body	1	1.75	14.75						
	Chape	1	1.125	5.25	3.25			1 ring.	No. 3 A	
	Back straps	2	.75	30.75	28.75	2	No. 10 A			
	Strap-loops	2	.75	2.5	1.					
Girth.	Webbing	1	4.5	17.	16.25					.71
	Chape. Off side	1	2.	6.75	4.75	1	No. 2 A			
	Chape. Near side	1	2.	7.	5.	1	No. 4 A	1 D-ring	No. 1 A	
	Chape-loops. Off side	1	1.25	3.50	2.5					
	Chape-loops. Near side	1	1.	3.50	1.5					
	Safes. Off side	1	3.	5.50	5.50					
	Safes. Near side	1	3.375	7.	7.					
	Girth billet-loop	1	1.	4.50	4.50					
Surcingle.	Webbing	1	3.5	55.	54.					.69
	Loops	2	.75	3.5	3.5					
	Chape	1	2.	6.5	4.	1	No. 4 A			
	Chape-loops	1	.8	3.	1.75					
	Billet	1	1.9	33.	30.					
	Billet-lining	1	2.	4.	4.					
Saddle-Bags.	Seat	1	6.875	18.75	18.					1.93
	Key-straps	2	.8	5.	5.					
	Pouch. Backs	2	9.25	9.4	9.2					
	Pouch. Gusset	2	3.5	23.50	23.					
	Pouch. Outer front	2	9.25	7.5	7.3					
	Pouch. Inner front	2	9.25	9.4	9.2					
	Pouch. Flap	2	7.7	7.4	7.					
	Pouch. Flap-billets	2	.625	5.5	4.	2	No. 11 A			
	Stay-strap chaps	2	1.375	5.5	3.	2	No. 11 A			
	Stay-strap billet	2	.625	11.	10.					
	Lacing-thongs. Long	2	.25	16.						
	Lacing-thongs. Short	2	.25	12.						

CHAPTER SEVENTH.

PAINTS, LACKERS, ETC.

COMPOSITION AND PREPARATION.

THE proportions are given for 100 parts by weight of prepared colors, &c., when not otherwise designated.

A gallon of linseed-oil weighs	7.5
" spirits of turpentine	7.25
" Japan varnish	7.
" sperm-oil	7.12
" neat's-foot oil	7.63

Boiled Oil.

Raw linseed-oil	103.
Copperas	3.15
Litharge	6.3

Put the copperas and litharge in a cloth bag and suspend it in the middle of the kettle. Boil the oil $4\frac{1}{2}$ hours, with a slow, even fire, so that it may not be burned; then let it stand and deposit the sediment.

Dryings.

Mixture of copperas and litharge taken from the boiled oil	60
Spirits of turpentine	56
Boiled oil	2

The mixture taken from the boiled oil to be ground, and mixed with the turpentine and oil.

Putty.

(*For filling cracks in wood.*)

Spanish whiting, pulverized	81.6
Boiled oil	20.4

Made into a stiff paste. If not intended for immediate use, raw oil should be used, as the putty made with boiled oil hardens quickly.

Another kind of putty for the same purpose is made by mixing fine sifted oak-sawdust with linseed-oil which has been boiled until it assumes a glutinous consistency.

White Paint.

	For inside work.	For outside work.
White lead, ground in oil	80	80
Boiled oil	14.5	9

Raw oil		9
Spirits of turpentine	8	4

Grind the white lead in the oil, and add the spirits of turpentine.

New wood-work requires about 1 lb. to the square yard for three coats.

Lead Color.

White lead, ground in oil	75.
Lampblack	1.
Boiled linseed-oil	23.
Litharge	0.5
Japan varnish	0.5
Spirits of turpentine	2.5

The lampblack and the litharge are ground separately upon the stone, in oil, then stirred into the white lead and the oil; the turpentine ana varnish are added as the paint is required for use, or when it is packed in kegs for transportation.

Black Paint.

Lampblack	28
Litharge	1
Japan varnish	1
Linseed-oil, boiled	73
Spirits of turpentine	1

Grind the lampblack in oil; mix it with the oil, then grind the litharge in oil and add it, stirring it well with the mixture. The varnish and turpentine are added last. The paint is used for the iron-work of carriages.

Olive Paste.

Yellow ochre, pulverized	68.
Lampblack	1.1
Boiled oil	37.
Spirits of turpentine	0.4

Make a thick paste with the ochre and oil, in a paint-pot, and with the lampblack and oil in another; grind them together in small portions, and keep the mixture in a tin vessel.

Liquid Olive Color.

Olive paste	61.5
Boiled oil	29.5
Spirits of turpentine	5.5
Dryings	3.5
Japan varnish	2.

Stirred together in a paint-pot

Liquid Olive Color.

Yellow ochre (French)	46.
Boiled oil (raw, 45)	40.
Litharge	5
Lampblack	2
Spirits of turpentine	5
Japan varnish	2

Brown Paint, for Iron Carriages.

Iron paint.
Spirits of turpentine.

Brainard's Paint.

Dissolve 10 lbs. of shellac in 10 gals. of boiling water, adding 30 oz. of sal-æratus. Mix this solution with an equal quantity of paint prepared in the usual manner. This paint is economical and durable.

Paint for Window-Glass.

Add .25 oz. of best *chrome green* to 1 lb. *sugar of lead*, ground fine, in sufficient linseed-oil to moisten it; mix to the consistency of common paint, and apply it with a soft brush. No drying-material is required. The glass should be well cleaned before the paint is applied.

The above quantity is sufficient for about 200 ft. of glass.

Whiting and Prussian blue may be used for the same purpose.

Gray or Stone Color, for Buildings.

	1st coat.	2d coat.
White lead, in oil	78.	100.
Boiled oil	9.5	20.
Raw oil	9.5	20.
Spirits of turpentine	3.	
Turkey umber	0.5	
Lampblack	0.25	0.25
Yellow ochre		3.

Mixed like the lead color.

A square yard of new brick-work requires, for two coats, 1.1 lb.; for three coats, 1.5 lb.

Cream Color, for Buildings.

	1st coat.	2d coat.
White lead, in oil	66.66	70.
French yellow	3.33	3.33
Japan varnish	1.33	1.33
Raw oil	28.	24.5
Spirits of turpentine	2.25	2.25

A square yard of new brick-work requires, for first coat, 0.75: for second coat, 0.3 lb.

Yellow-Wash for Buildings.

Dissolve 1 lb. of pulverized copperas in 8 gals. of water; let it stand twenty-four hours, stirring it two or three times from the bottom; use this for slaking the lime, and thinning it to the consistency of ordinary whitewash; add hydraulic cement equal in quantity to the lime used, and of clean sand ½-gal. to 15 gals. of wash. Stir it frequently, to prevent the sand from settling.

The walls should be first well cleaned of dust and thoroughly wet from the rose of a watering-pot, and the wash applied immediately after, beginning at the top, laying on the coat horizontally and finishing it vertically.

Before leaving the work, at any time, finish the course to a joint in the wall, to prevent making a mark in the color where the two courses join.

This wash has been known to last for fifteen years without requiring renewal.

For a *gray or stone color*, add lampblack previously deadened with whiskey.

Lacker for Iron Ordnance.

1.—	Black lead, pulverized	12
	Red lead	12
	Litharge	5
	Lampblack	5
	Linseed-oil	66

Boil it gently about twenty minutes, during which time it must be constantly stirred.

2.—	Umber, ground	3.75
	Gum shellac, pulverized	3.75
	Ivory-black	3.75
	Litharge	3.75
	Linseed-oil	78.
	Spirits of turpentine	7.25

The oil must be first boiled half an hour. The mixture is then boiled 24 hours, poured off from the sediment, and put in jugs, corked.

3.—	Coal-tar (of good quality)	2 gals.
	Spirits turpentine	1 pint.

The turpentine to be added in small quantities during the application of the lacker.

In applying lacker, the surface of the iron must be first cleaned with a scraper and a wire brush, if necessary, and the lacker applied hot, in two thin coats, with a paint-brush. It is best done in summer, when the metal is heated by the sun's rays, with gloves made of sheep-skin, the wool turned outwards, cut .4 inch long, the thumb alone being free.

Old lacker should be removed with a scraper, or by scouring, and not by heating the guns or balls, by which the metal is injured.

About 5 gallons of lacker are required for 100 field-guns and 1000 shot; about 1 quart for a sea-coast gun.

Lacker for Iron Ordnance, (used in the British service.)

Anti-corrosion	40 lbs.
Grant's black, ground in oil	4 "
Red lead, as a dryer	3 "
Linseed-oil	4 gals.
Spirits turpentine	1 pint.

This mixture when well stirred and incorporated will be fit for use; but as by long keeping in this state it becomes hard, no more should be mixed than may be required for immediate use.

Anti-corrosion.—	Slag from iron-foundries, pounded	12
	Chalk	12
	Soot, common	1

Lacker for Small Arms, or for Water-Proof Paper.

Beeswax	13 lbs.
Spirits turpentine	13 galls.
Boiled linseed-oil	1 gall.

All the ingredients should be pure and of the best quality. Heat them together in a copper or earthen vessel, over a gentle fire, in a water-bath, until they are well mixed.

Lacker for bright Iron-Work.

Linseed-oil, boiled	80.5
Litharge	5.5
White lead, ground in oil	11.25
Rosin, pulverized	2.75

Add the litharge to the oil; let it simmer over a slow fire 3 hours; strain it, and add the rosin and white lead; keep it gently warmed, and stir it until the rosin is dissolved. Apply it with a paint-brush.

Planton's Composition, for Wood or Iron.

Rosin, pulverized	48
Shellac, "	2
Charcoal or cannel coal, pulverized	16
Spirits turpentine	1

The shellac may be replaced by double the quantity of beeswax. The rosin and shellac are melted in an iron vessel over the fire; the charcoal is then added and stirred briskly until the whole is well intermixed, after which the turpentine is added and stirred until it is well incorporated with the other ingredients.

Black Stain, for Wood.

Copperas	1	lb.
Nutgalls	1	"
Sal ammoniac	.25	"
Vinegar	1	gall.

Stir it occasionally, and it will be ready for use in a few hours.

Clean and make smooth the surface, filling the cracks with black putty, which should be allowed to harden. Apply the stain two or three times, and leave it a day or two to dry; then rub it with boiled oil until it is polished.

The stain will be of a bluish color till the oil is applied.

This forms a cheap and durable preservative for wood.

Varnish for Holsters, Scabbards, &c., (or Patent Leather.)

(*For first and second coats.*)

Prussian blue, in lumps	4.
Sugar of lead	0.7
Aqua fortis	0.7
Linseed-oil, boiled	70.
Spirits turpentine	24.6

The ingredients, except the turpentine, are boiled together in an *iron* kettle eight hours, when the mixture will assume a brilliant black color. When the varnish is nearly cool, stir in the turpentine. The kettle in which the varnish is made should be of a capacity to hold double the quantity of varnish to be boiled.

(*For the third or finishing coat.*—Copal Varnish.)

Gum copal (in clean lumps)	26.5
Boiled linseed-oil	42.5
Spirits turpentine	31.

This varnish is made in a *copper* vessel, smallest at top, in the form of a still.

Put the copal in the vessel, set it on a charcoal fire for one hour, in which time it will melt, and all the watery particles will evaporate. Add the oil while the copal is warm, but not boiling hot. When nearly cool, add the turpentine, which will give it a proper consistency for use.

For 5 lbs. copal and the proper proportions of oil and turpentine, the vessel should hold 6 gallons.

Japan Varnish.

Litharge	4
Boiled oil	87
Spirits turpentine	2
Red lead	6
Umber	1
Gum shellac	8
Sugar of lead	2
White vitriol	1

Japan varnish is generally purchased from the paint-sellers. It is made by boiling over a slow charcoal fire, for five hours, all the ingredients, except the turpentine and a small portion of the oil; the latter is added as required, to check the ebullition and allay the froth which rises to the surface. It must be continually stirred with a wooden spatula, and great care is necessary to prevent it from taking fire.

The turpentine is added after the varnish is nearly cool, and it is stirred well in. The varnish must be put in demijohns, or close cans, and kept tightly corked.

Dye for Blacking Belts.

Extract of logwood	2 lbs.
Broken nutgalls	.5 lbs.
Pyrolignate of iron	.5 pint.
Soft water	1 gall.

The logwood and nutgalls are boiled in the water till the logwood is dissolved. When cold, add the pyrolignate of iron. Stir it well and let it settle. When clear, decant it free from sediment and keep it well corked.

The pyrolignate of iron is made by dissolving iron-filings in pyroligneous acid,—as much as the acid will take up.

The addition of the logwood is not essential.

A solution of copperas may replace the pyrolignate of iron, but it is not so good.

Kit.

Composition.—9 rosin, 6 pitch, 6 beeswax, 1 tallow. To be melted together and poured into water; then worked with the hands until it becomes soft and pliable.

Pitch Cement.

	Lbs.	Oz.
Beeswax	0	3
Pitch	2	
Rosin	1	
Turpentine	1	
Brick-dust	0	9

The materials for the cement are melted successively over a slow fire, and the brick-dust is stirred in last.

Grease for Carriage-Wheels.

Hogs' lard, softened, (if fresh,) by working it.

If this cannot be procured, *tallow* or other grease may be used; if hard, it should be melted with fish-oil.

About 1 lb. of grease is required for four wheels.

Booth's Patent Grease for Railway Axles.

Water	1 gall.
Clean tallow	3 lbs.
Palm-oil	6 "
Common soda	½ lb.
Or, Tallow	8 lbs.
Palm-oil	10 "

To be heated to about 210°, and to be well stirred until it cools down to 70°.

Quantity of Paint required for a Carriage.

Kind of Carriage.	Lead color.	Olive.	Black.
	Lbs.	Lbs.	Lbs.
Field-gun carriage and limber, with implements	6	10	0.75
Caisson, with limber and implements, &c.	8	15	0.8
Forge, with limber	6	10	1.
Battery-wagon, with limber	7	13	0.9
Casemate-carriage and chassis, wooden	7	14	0.75
Barbette-carriage and chassis, wooden	6	11	1.

A priming of lead color and two coats of olive color are applied to new wood-work, and 1 coat of lead color and 1 of black, to the iron-work.

CHAPTER EIGHTH.

SMALL ARMS, SWORDS, SABRES AND ACCOUTREMENTS.

SMALL ARMS.

The small arms adopted for service are:

The rifle musket, model 1855.
The rifle musket, model 1842.
The cadet musket, model 1858.
The rifle, model 1855.
The rifle, model 1842, reamed out to .58 inch.
The pistol carbine, model 1855.

No model has yet been adopted for a carbine for the cavalry service; several different patterns are now in the hands of the troops for trial.

A *repeating pistol* is issued to the cavalry and to the light artillery.

Rifle musket, model 1855. (Plates 24, 25, 26.)

NOMENCLATURE.

Barrel.—Muzzle; *bayonet-stud and front sight,* breech, flats, bevels and oval, cone-seat, vent, vent-screw, cone-screw thread, vent-screw thread, rear-sight mortise, rear-side screw-hole, bore, grooves, lands. The exterior shape of this barrel tapers with a gentle re-entering curve from the breech to the muzzle. That portion of the flat in rear of the cone-seat is parallel to the axis of the bore.

Breech-screw.—Plug with threads, (16 to the inch,) tenon, shoulders, tang, tang-screw hole, bevel.

Rear-sight, (steel.)—*Base*; fence, offsets, ears, screw-hole, joint, groove for barrel, steady-pin; 1st *leaf:* body, ears, screw-holes, sight-notch, graduation-mark; 2d *leaf:* body, tenon, screw-hole, sight-notches, graduation-marks; *joint-screw:* stem, head, slit, and thread.

Base-screw.—Stem, head, holes, thread.

Tang-screw.—Shoulder.

Cone, (steel.)—Screw-thread, shoulder, square, nipple, vent.

Bayonet.—*Blade,* (steel;) point, face-flute, back-flutes, edges of back and blade, bevels, elbow, neck; *Socket,* (iron:) muzzle-end, bridge-end, bridge, mortise, shoulder for clasp, stop-pin; *Clasp,* (iron:) body, studs, bridge, groove, stop, clasp-screw.

Lock.—*Lock-plate*; front and rear ends, sides, cone-seat notch, holster, main-spring notch, chamfer, bevel, magazine, (mouth, throat, and body,) 5 holes for the pivots of the main-spring and bridle, arbor of the tumbler, cover-catch, and cover-hinge stud, 7 screw-holes, 3 mortises for sear-spring stud and cover-hinge, 1 slot for feeding-finger; *hammer:* body, crook, head, comb, checking, countersink, cutter, slit, tumbler-hole; *tumbler,* (steel:) body, friction-shoulder, arbor, square, pivot, swivel-arm, swivel-slot and pin-holes, half-cock notch, cock-notch, screw-hole; *bridle:* body, eye, pivot, 3 holes for tumbler-pivot, sear-screw, and bridle-screw; *bridle-screw; sear,* (steel:) body, eye, nose, tang, screw-hole; *sear-screw; sear-spring,* (steel:) blade, (upper and lower branch and elbow,) eye, stud-screw hole; *sear-spring screw; main-spring,* (steel:) blade, upper and lower branch and elbow, hook, pivot, tang; *swivel,* (steel:) body, axis, 2 holes for tumbler-pin and finger-pivot; *tumbler and swivel-pin; feeding-finger,* (steel:) eye, pivot, crook, curve, point; *finger-spring,* (steel:) eye, long and short branch, elbow.

Magazine-cover.—Body, hinge, jaws, rivet, rivet-holes, chamfer, thumb-nail notch and catch-notch; *stud:* head-rivet hole, stem, and countersink-rivet, (hexagonal in shape;) *cover-catch,* (steel:) head, notch, foot, screw-hole; *cover-catch screw.*

2 *side screws.*

In all the screws the parts are:—the stem, the head, the slit, and the thread.

The bottom of the slit of the larger screws is concave; the base-screw of the rear sight has 2 holes in the head, instead of a slot, in order that it may not be removed by the ordinary screw-driver.

Mountings.—*Upper and lower bands:* body, creases, letter U, to designate the upper from the lower edge; *middle-band:* body, creases, letter U, stud, hole for swivel-rivet; *middle-band swivel:* wire, eyes, rivet; *band-springs,* (steel:) stem, wire, shoulder; *side-screw washers:* countersink, hole for screw; *guard; guard-plate:* body, bolsters, trigger-stud, 2 holes for guard-bow, 2 for wood-screws, and 1 for trigger-screw; *guard-bow:* body, pillars, stems with their screw-threads, swivel-stud, piece and hole, 2 *nuts* for stems, swivel, and rivet; *trigger:* blade, tang or finger piece, hole for screw; *trigger-screw:* 2 *wood-screws* for guard-plate; *butt-plate:* body, toe, heel, hollow, corners, tang and screw holes; 2 *wood-screws* for butt-plate; *box-plate:* the lid and the strap joined by a *hinge* and *rivet; screws:* 3 box-plate and 1 for spring; 3 *springs:* 1 for box-plate; *catch:* 1 for box-plate; *rivets:* 2 for catch.

Ramrod, (steel.)—Stem, swell, head, cup, screw; *stop,* (iron:) for rod.

Stock, (black walnut.)—*Butt:* comb, handle, head, facings, first and second reinforce, chase, shoulders for bands and tip; *grooves* for barrel and ramrod; *beds* for tang and tenon, lock, washers, guard-plate, nuts for guard-bow and trigger-stud, butt-plate, and band-springs and tip; *mortises* for the trigger, and stop; rod-*holes* for the rod, the side screws, tang-screws, guard-screws, butt- late screws, band-springs, and tip-rivet

Tip, (malleable iron.)—Recess for stock, groove for rod, rivet-hole, and shoulder.

The *patch-box* was added July 9, 1859.

The muskets made at this time have not the self-priming lock nor the patch-box.

Rifle Musket, model 1842. (Plate 26.)

(For nomenclature see Ordnance Manual, 1850.)

This arm differs from the original model in the following particulars:— The bore is grooved; it has a *rear sight* similar to that for the new musket.

Cadet Musket, model 1858.

The parts are identical with the rifle musket of 1855, except the barrel, the stock, the bayonet, and the rammer.

Rifle, model 1855. (Plate 26.)

Barrel.—Muzzle: *bayonet-stud, front sight,* (brass,) breech, flats, bevels and oval, cone-seat, vent, vent-screw, cone-screw thread, vent-screw thread, rear-sight mortise, rear-sight screw-hole, bore, grooves, hands. The exterior of the barrel has a uniform taper from the breech to the muzzle. That portion of the flat in rear of the cone-seat is parallel to the axis of the bore.

Breech-screw.—Plug with threads, (16 to the inch,) tenon, shoulders, tang, tang-screw hole, bevel.

Rear-sight.—Similar to that of the rifle musket, 1855.

Tang-screw.—Shoulder.

Cone.—Same as for rifle musket.

Sword Bayonet.—*Blade,* (steel,) shoulder, back, edge, bevel, point, curvature, groove—*tang*, rivet-hole, rivet.

Hilt, (brass.)—*Gripe*—ridges, back, beak, slot for stud, slot for guide, hole for finger-piece, hole for spring-screw, hole for rivet, (tang,) mortise for tang. *Finger-piece*—head, notch. *Finger-piece spring*—blade, screw-hole, boss. *Finger-piece spring-screw. Guard-rivet, guard*—long and short branch, knobs, muzzle-socket.

Lock.—The same as the rifle musket, 1855.

Mountings.—Similar to those of the rifle musket, 1855.

Ramrod.—Similar to that of the rifle musket, 1855.

Stock and tip.—Similar to that of the rifle musket, 1855, except the 2d reinforce of stock.

Rifle Model of 1842.

(For nomenclature see Ordnance Manual, 1850.)

Pistol Carbine, 1855. (Plate 26.)

Barrel.—Muzzle, front sight, breech, breech-pin threads, flats, bevels and oval, cone-seat, vent, vent-screw, bore, grooves, lands. This barrel tapers with a straight line from breech to muzzle. The portion of the flat in rear of the cone-seat is parallel to the axis of the bore.

Breech-screw.—Plug, with threads, (16 to the inch,) tenon, shoulders, tang, tang-screw hole, bevel-sight mortise.

Cone.—Same as for rifle musket.

Rear sight, (steel.)—Base, ears, joint-screw, screw-hole, 1st, 2d, and 3d leaves, 4 sight-notches, eye-joint, screw-holes.

Tang-screw.—Shoulder.

Lock.—Same as for rifle musket, 1855, except in size, which is reduced to conform to a magazine capable of holding one-half a strip of primers.

Mountings, (brass.)—*Band, swivel, and spring,* correspond to the middle band, swivel, and spring of the rifle musket, 1855.

Guard-plate.—Butt-cup: screw-hole, tang. *Butt-strap:* holes for catch-spring and hook, tang, strap, and guard-plate screws, shoulders for breech-screw tang, and butt-cup tang, reinforces for hook, and catch-spring. *Cup-screw:* head, eye. *Swivel-ring.* The remaining mountings are similar to the corresponding parts of the rifle musket, 1855.

Ramrod, (steel.)—Head (iron) riveted on, cup, foot with a female screw.

Ramrod-swivel.—Two side bars, screw, cross-bar, riveted into the side bars.

Stock, (black walnut.)—Butt, handle, curve, facings, reinforce, chase; *shoulders* for band and tip, *grooves* for barrel and ramrod; *beds* for tang and tenon, lock, washers, guard-plate, nuts for guard-bow and trigger-stud, butt-plate, band-spring, tip, butt-cup and strap, butt-piece cap, and catch-spring, hook-nut; *mortises* for trigger, hook and catch-spring; *holes* for rod, tip-rivet, band-spring, side-screws, tang-screw, cup-screw, strap-screw, butt-plate screws, and cap-screws.

Butt-piece.—Plate, 2 wood screws; *cap,* hollow, upper and lower tang, screw-holes, 2 wood-screws, cavity for pistol handle, hook, stem, nut; *spring-catch,* screw, head, blade; *finger-piece,* loop for spring, screw-thread, rivet and nut.

Appendages.

Wiper.—Model, 1855. It answers for all arms. It is composed of the body, prongs, and screw-hole for rod.

Ball-screw.—Body, tang, screw-hole for rod, screw to draw the ball.

Screw-driver.—Cone-wrench, blades, rivet, collets for rivet.

Spring-vice.—Bolster-slide, slide-mortise, slide-screw, thumb-screw.

Band-spring and tumbler-punch.—Punches, collets, rivets.

Tompion, (maple.)—Head, body, slot.

To make the Barrel.

The barrel is made from a short, flat bar of iron, which is first formed into a hollow cylinder and then welded and drawn out to the required size, length, and taper, by passing it through a series of rolls for that purpose.

MATERIALS.—Best refined iron, free from slag and other impurities, of uniform texture, without hard spots: in plates 14 inches long, 5½ inches wide, .5625 inch thick; the edges are so bevelled that they shall form a close joint when the plate is formed into a cylinder. English iron, Marshall brand, is generally used. *Best bituminous coal* for the reverberating furnace, (Cumberland, Broad top.) Best anthracite coal for the forge, (Hazleton, lump.) *Pure sand* for the bottom of the furnace, (New Jersey.)

UTENSILS.—1 *pair of rolls* for bending the plates into cylinders. They have 5 grooves, of different sizes; 3 of them have tongues, 2 are open.

1 *pair of rolls* for welding and shaping the barrel. They have 9 grooves, of different sizes, 2 of them parallel and 7 taper: it has an iron frame to hold the end of the mandrel. The rolls make 36 revolutions per minute.

2 *sets of steel mandrels*, of 8 each set, with an egg-shaped bulb on each end, varying in size from .71 inch to .46 inch in diameter.

1 *small mandrel*, 3 feet long, 1 *mandrel* 6 inches long.

1 *straightening-table*, iron. 1 *straightening-machine*, with 2 dies the length and the shape of the barrel worked by an excentric which opens the dies ½ inch and makes 60 revolutions per minute.

2 *trip-hammers*, with dies.

To form the cylinder.—The plates are put into the furnace and raised to a white heat, and then passed through the rolls, each groove in succession. The first groove forms the plate into a trough-shape; the second and third grooves contract it gradually; the fourth turns the two edges inward, and the fifth completes the cylinder. The operation is performed at one heat.

A day's work.—3 men can form 450 cylinders in 10 hours.

To weld and shape the barrel.—The fireman places two cylinders in the furnace, and brings them to a welding-heat; the foreman thrusts the largest mandrel through one of them *while yet in the furnace*, and, taking it to the rolls, puts the mandrel through the frame, introduces the end into the first groove, and the cylinder is drawn over the bulb of the mandrel, which is held by the collar.

The first assistant, standing on the opposite side of the rolls, catches the barrel as it passes through, with a pair of tongs, and hands it to the second assistant, who stands on the same side as the foreman, and receives it with a small, short mandrel, which he thrusts into the barrel, and straightens it by striking it two or three times on the flat table. He then replaces it in the furnace, and it is raised to a welding heat a second time. The foreman takes out the other cylinder and proceeds with it in the manner just described. When the barrel is brought to a welding-heat the second time, the foreman takes it with the next smaller mandrel and passes it through the second groove, by which the barrel is reduced in diameter and lengthened: it is straightened as before, and returned to the furnace.

The third and remaining grooves taper so as to give the barrel the shape of a frustum of a cone, each succeeding groove reducing the size of the barrel and making it longer. The rolls are of such size that a single revolution takes the barrel through; as they continue to revolve without stopping, it requires care and dexterity on the part of the foreman to insert the barrel in the grove at the proper time, bringing the end against the shoulder in the large part of the groove.

The barrel is so much chilled by passing over the mandrel, that it is necessary it should be straightened and reheated before passing it through the next groove: a high red heat is required.

After the barrel has been passed through the first eight grooves with their corresponding mandrels, it is taken with tongs and passed *twice* through the last groove, for the purpose of making it round and smooth.

To straighten the barrel.—The foreman inserts the muzzle end of the barrel in the dies and turns it around gradually, when the dies are open, pushing it farther into the dies until its whole length is embraced by them. The barrel then receives the pressure of the dies from ten to fifteen times, when it will be found to be straight.

To attach the cone-seat.—The cone-seat is swaged to the proper shape under the trip-hammer, and then welded to the barrel, the dies of the trip-hammer and the short mandrel in the end of the barrel preserving the form of the barrel and the cone-seat.

A day's work.—4 men can form and weld from 75 to 80 barrels in 10 hours.

The barrel is next bored, turned, straightened, and proved.

The stock is turned, the lock and guard-bow are let in, and the grooves for the rammer and barrel are cut by machinery, and made ready for the other mountings.

Principal Dimensions, Weights, etc. of Small Arms.

DIMENSIONS.	Rifle Muskets.			Rifles.		Pistol Carbine.
	1855.	1842.	Cadet, 1855.	1855.	1842.	1855.
	In.	In.	In.	In.	In.	In.
BARREL..... Diameter of bore............	0.58	0.69	.58	0.58	0.58	0.58
BARREL..... Variation allowed, more..	0.0025	0.015	.0025	0.0025	0.0025	0.0025
BARREL..... Diameter at muzzle........	0.78	0.85	.78	0.90	0.90	0.82
BARREL..... Diameter at breech between flats.................	1.14	1.25	1.14	1.14	1.15	1.
BARREL..... Length without breech-screw........................	40.	42.	38.	33.	33.	12.
BAYONET.—Length of blade...............	18.	18.	16.	21.7	21.7	....
RAMROD.—Length............................	39.60	41.70	37.60	33.00	33.00	12.
STOCK, with butt-plate and tip...length	52.85	....	50.	....	....	....
ARM, COMPLETE. Length without bayonet..	55.85	57.80	53.	49.3	48.8	17.6
ARM, COMPLETE. With bayonet fixed........	73.85	75.80	71.	71.8	71.3	....
ARM, COMPLETE. With butt-piece.............	....	....	....	....	....	28.2
GROOVES ... Number	3.	3.	3.	3.	3.	3.
GROOVES ... Twist, uniform, 1 turn in	6 ft.	6 ft.	6 ft.	6 ft.	6 ft.	4 ft.
GROOVES ... Width...........................	0.30	0.36	0.30	0.30	0.30	0.30
GROOVES ... Depth at muzzle............	.005	.005	0.005	.005	.005	.005
GROOVES ... Depth at breech............	.015	.015	.015	.013	.013	.008
WEIGHTS.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
BARREL, without breech-screw...........	4.28	4.19	4.125	4.8	4.8	1.4
LOCK, with side screws.....................	.81	.95	.81	.81	.55	.6
BAYONET...	.72	0.64	.62	2.15	2.15	....
BUTT-PLATE	.375	....	0.34	....	....	.25
ARM, COMPLETE. Without bayonet..........	9.18	9.51	8.50	9.93	9.68	3.56
ARM, COMPLETE. With bayonet................	9.90	10.15	9.12	12.08	11.83	....
ARM, COMPLETE. With butt-piece.............	....	....	....	....	....	5.09

INSPECTION OF SMALL ARMS.

All the materials used in the manufacture of arms must be of the best quality, and they should be tested by the inspectors, according to the methods indicated in Chapter XIV.

The wood for gun-stocks should be seasoned at least three years and kept in a dry place two years before being worked; it must be free from knots and sap, and no wood which is *brash*, or light, or worm-eaten, or in any degree decayed, or which is cut across the grain at the handle of the stock, or which is kiln-dried, should be used or received.

The following rules for inspection apply to all small arms, whether made at the national armories, or by contract at private establishments.

The attention of the inspecting officers should be directed as much as possible to the operations of the workmen in the course of the fabrication of arms.

Each component part is first inspected by itself, and afterwards the arm in a finished state.

The materials and the forms and dimensions of all the parts must conform strictly to those of the established patterns; the workmanship and finish must be equal to those of the model arms, and the several parts must be browned, blued, case-hardened, or polished as in the standard model.

The forms and dimensions of the parts are verified by means of the standard gauges. (See p. 315.)

Inspection of Barrels.

The *first* inspection of the barrel is made in the forged or cone-seated stage; the *second* in the 3d *bored* stage; the *third* in the *ground* stage; the *fourth* in the *proved* stage; the *fifth* in the *filed* stage; the *sixth* in the 6th *bored* stage; the *seventh* in the *rifled* stage; and the *eighth* in the *breeched* stage.

In these inspections, the inspector will verify the barrel with proper gauges for each stage; he will see that the thread for the breech-screw in the barrel is well cut, and the bayonet-stud firmly brazed on; that the exterior and interior dimensions of the barrel are correct; that there are no interior hammer-marks, ring-bores, cinder-holes, flaws, cracks, or other defects which will not disappear in the finishing; and that the thread of the breech-screw is accurately cut.

The barrels rejected for defects that cannot be remedied will be stamped on the upper side, in a line with the vent, with the mark of condemnation, which will be in all cases the letter *C*. If the defect is of such a nature as not to prevent the use of the barrel for a shorter arm when cut off, the mark will be made on the defective part.

Proof.—The barrels which pass this inspection will then be proved by being fired twice, with the following charges:

KIND OF BARREL.	1ST CHARGE.			2D CHARGE.			SIZE OF BALL.		SIZE OF WAD.	Thickness of paper.
	Powder.	Balls.	Wads.	Powder.	Balls.	Wads.	Weight.	Diameter.	Square.	
	Grs.	No.	No.	Grs.	No.	No.	Grs.	In.	In.	In.
Rifle musket, model 1855	280	1	2	250	1	2	500	0.57	32.	.01
Cadet rifle musket, 1858..	280	1	2	250	1	2	500	0.57	32.	.01
Rifle, model 1855............	280	1	2	250	1	2	{557½ 278¾}	0.57	32.	.01
Pistol carbine................	255	1	2	200	1	2	450	0.57	32.	.01

One wad is placed on the powder and the other on the ball, and the charge is well rammed with a copper rod. The wad occupies, when rammed, about ¾ inch in the length of the barrel.

The barrels are closed for proof with *proving-plugs* having vents in them.

Musket-powder will be used for proving the barrels of muskets; the powder must be of the best quality, giving not less than the standard initial velocity; it must be proved immediately before being used, unless it shall have been proved within one year and the inspector has no reason to suppose that it has become deteriorated.

The measures for the proof-charges should be of a conical form, with the mouth as small as may be convenient, in order that there may be less variation in the quantity of powder.

Before commencing the proof of barrels, the inspector will satisfy himself as to the quality and proof of the powder, the size of the balls and of the wads.

The inspector will observe the greatest caution in having the barrels properly loaded; for which purpose, after they are placed on the proving-bed, he will pass a ramrod into each barrel, to verify the accuracy of the charge.

After the discharge he will again pass the ramrod into each barrel, and those which have missed fire will be pricked and primed and discharged, before proceeding to the second proof-charge.

After the second proof-charge, the inspector will examine the barrels which have burst, and note the cause of defect, whether in the materials or workmanship.

He will then examine those which have not burst, and he will mark, as condemned, any which are evidently defective; the others will receive the proof-stamp, viz.: V for viewed, P for proved, with the eagle's head under them, placed on the left square of the barrel, opposite the cone-seat. The barrels will be immediately washed clean, in hot water, and dried, after which they will be again carefully examined.

They will now be inspected in the interior and on the exterior; the inspector will reject such as are too large in the bore, and such as have holes, cross-cracks, scales, seams, or ring-bores; he will examine the brazing of the bayonet-stud, and see that the barrel is not notched too deep, or indented inside.

The barrels, having been reduced to their ultimate dimensions, straightened, and completely finished, are again strictly inspected, to verify the straightness of the bore, the exterior and interior diameters, their weight, (which should not vary more than 1 ounce from the standard weight,) the taps for the breech-screw and cone, the size, position, and direction of the vent.

The straightness of the barrel may be ascertained by holding it up to the light and reflecting a straight edge on the different parts of the bore, by which means an experienced eye readily detects any inaccuracy in the bore. The small or *standard* plug should pass freely through the whole length of the barrel, including the threads for the breech-screw, and the bore should not admit the large or *limit* plug.

The *grooves* should be carefully examined to see that they are formed according to the pattern, and that they are even and uniform throughout.

The *breech-screws* will be examined to see that they are of the proper dimensions, are sound in every part, and have good threads; they are case-hardened. The screw must be tried in the barrel, to see that it occupies all the threads in the tap of the barrel, and that it is not loose after entering three threads.

The *vent* should enter the bore of the barrel clear of the end of the breech-screw.

Marks.—Barrels condemned for defects detected after proof or at any time in the course of inspection, are marked with the letter *C*, struck in deeply; those finally received are stamped, in addition to the proof-mark, with the *year* of fabrication on the top of the barrel, in the direction of the axis of the barrel, ending at .25 inch from the breech.

Cones.

Verify the dimensions, exterior and interior, and the thread of the screw. See that the upper part of the cone is properly hardened and free from cracks or flaws.

Locks.

Examine all the limbs, to see that they are sound, well filed, and of the proper form.

Hammers.—Verify the dimensions and form carefully with the proper gauges; see that they are properly case-hardened, especially in the head, knife-edge, and cup for the cone.

Tumblers must be verified separately, with great care, and their hardness tested.

Feed-Finger and *Spring* must be examined that they are of right length and curve.

Springs.—The strength of the lock-springs, as indicated by the weights they require to bend them up to the cock-notch without causing them to belly or bend beyond a straight line, is as follows:

Main-spring of rifle musket, 1855,	70 to 75 pounds.
" cadet "	70 to 75 "
" pistol carbine,	70 to 75 "
Sear-spring of each, about	20 "

Spring-proof, No. 1.—Shows when the main-springs are evenly tempered, and will weigh from 70 to 75 pounds without bending beyond a straight line, setting, or breaking, by bringing them to the standard mark.

Spring-proof, No. 2.—The main-springs are all required to stand in the position of full cock, in a spring-proof which holds 35 at one time, in the same position as they are held in the lock, for twelve hours, to test their strength and soundness.

Screws.—Examine the forms of the stems and heads of all screws and the cutting of the threads, and gauge them; see that they are properly hardened.

Lock-plates.—Verify with the proper gauges the form and dimensions, the accuracy of the position of the holes and the threads of those which are tapped; see that the plate is sound and free from cracks and flaws, especially about the tumbler-hole, and that it is well hardened.

Finished locks.—The locks having been put together, see—

1. That they are clean in the inside.

2. That the sear works freely when the sear-screw is driven as far as it will go, and that the nose is sufficiently strong and falls properly into the notches of the tumbler.

3. That the bridle has no cracks or flaws about the holes for the tumbler-pivot and screws.

4. That the springs are well bent and of good proportions, that the fixed branches fit close to the lock-plate, and that the movable branches swing clear of it, without having too much play.

5. That the slits of the screw-heads are not defective.

6. That the arbor and pivot of the tumbler fit accurately in their holes.

7. That the hook of the tumbler does not fall below the edge of the lock-plate when the cock is down.

8. That the notches of the tumbler are sound and smooth, and that the tumbler fits and turns well.

9. That the main-spring swivel is sound, by snapping the hammer several times on the bare cone.

10. That the feed-finger and spring are the proper length and the slot of the proper form, by running out a part of a coil of primers and observing that they are cut off in the middle between two primers; and that the feed-finger rises at half-cock sufficiently for the easy insertion of the primer.

11. That the hammer fits well on the square of the tumbler, and that it does not rest on the lock-plate when screwed up tight, and that it has the proper set in relation to the cone.

12. That all the parts work well together.

Marks.—The place and year of fabrication are stamped on the face of the lock-plate,—the year in rear of the hammer, and the name of the place in front of the magazine, with the letters U. S. over it: an *eagle* is stamped on the magazine-cover.

Finished arm.—The initials of the finish inspector and of the master armorer are stamped on the rear end of the face of the stock, opposite the lock, with *italic* letters.

Mountings.

The forms and dimensions are verified with the appropriate gauges and patterns. The trigger should be well fitted to the guard-plate, with as little lateral play as is consistent with its free movement. The form, size, and threads of the screws should be carefully examined. The letters U. S. are marked on the tang of the butt-plate.

Ramrods.

The temper of the rod is tested by springing it in four directions, with the point resting on the floor. The musket ramrod should bend 6 inches from a right line joining the ends; the rod should spring back perfectly straight, without setting. Its soundness and freedom from flaws and cross cracks are ascertained by the sound it gives when suspended by one end and gently struck with a piece of metal, and by passing it over the edge of a block of wood or the closed jaws of a vise, pressing down the ends at the same time and turning the rod, so as to present every side successively to inspection. Rifle and pistol rods are subjected to the last tests only. The diameter of the rod and the tap of the screw for the wiper are verified with the proper gauges. The length is also verified.

Bayonets.

The form and dimensions of the bayonet are verified with the proper gauges; the temper is tried by springing the bayonet attached to the barrel, the point resting on the floor. In case of doubt, the temper of the bayonet is definitely proved in the following manner:

Two iron staples are fixed in a piece of oak plank on a workbench, 16$\frac{5}{8}$ inches apart; one of them serves as a bridge, and has notches to receive the blade,—the other serves as a staple for holding the point of the bayonet close to the plank: the bayonet is fixed on a barrel, to the butt of which is fastened a brass ball weighing 6 pounds; so that, by inserting the point of the blade in the staples, the face and back resting alternately on the bridge, the blade sustains a weight of 9 pounds, which springs it about $\frac{5}{8}$ of an inch. In this situation the blade is also examined to detect flaws and cross-cracks. It should not remain bent after this trial.

The inspector then seizes the blade near the point and strikes the elbow smartly on the workbench, to ascertain that the welding is sound.

If the proof shows no defects, he verifies the dimensions and bore of the socket and the accuracy of the channels. He examines the dimensions of the clasp, to see that it fits well to the shoulder; that it turns evenly, without binding in any part; that the stop is well placed and firmly set; that the clasp-screw and its thread in the stud of the clasp are well cut; that the elbow has the proper form and dimensions.

Marks.—Bayonets are marked on the face of the blade, near the neck, with the letters U. S.; those rejected for defects that cannot be remedied are marked with the stamp of condemnation.

Stocks.

The examination of the stock will be directed—

1. To the quality of the wood: that it has good straight grain, is well seasoned, and free from sap and worm-holes.

The degree of seasoning is indicated by the smell of the wood at a fresh-cut place; by the appearance of the lock and barrel, &c. when removed from the stock: they will be rusted by unseasoned wood; by rolling a thin shaving between the fingers: it will crumble if the wood be well seasoned, otherwise it will be tough and will bend.

The medium weight of a well-seasoned musket-stock is 2 pounds; a stock made of good walnut will not weigh *less* than 1 pound 13 ounces.

2. To the workmanship: that it is free from splits, especially about the barrel-groove and heading; that it has not been split and glued up; that the grooves and beds are of the proper forms and dimensions; that the roundings for the bands are smooth and accurate; that the handle and comb are of the proper size and form; that the stock has the proper *fall* or crook, and is of the right length; that the holes are well drilled, and that those for the wood-screws have good threads.

In examining the bed of the lock, see—

1. That all the edges are sharp and smooth.

2. That the beds of the sear-screw and sear-spring screw are not bored down to the trigger or to the breech-screw.

3. That the beds of the main-spring and main-spring screw do not penetrate to the barrel.

4. That the hole for the tang of the sear is as small as possible, so that the sear shall not be wood-bound.

5. That the wires fit well in their holes.

Marks.—The stocks inspected are marked on the left side with the stamp of approval (the initials of the inspector's name) or of condemnation, as the case may be.

Appendages.

Ball-screws and wipers are examined by screwing them on a piece of ram-rod furnished with a handle, to verify the accuracy of the screw-thread; the temper of the branches is tested by pressing the points on a piece of hard wood, in which proof they should spring back to their proper form.

Screw-drivers, by inserting the blades in a vise, or in a slit made for the purpose, and twisting them with the hand. Test the strength and size of the cone-wrench by putting it on a square socket and wrenching it by hand.

Other implements are examined by applying the appropriate patterns, &c., and their soundness may be further tested by striking them a smart blow with a hammer.

Finished Arms.

Finished arms offered for inspection must be taken entirely to pieces, and each part must be examined as above directed; if the parts have been previously inspected, see that they have suffered no subsequent injury. This being done, the arms will be put together and examined in their complete state. Some of the arms in every lot should be put together by the inspector himself.

The inspector will examine the finished arms on every side, to see that the parts are well fitted together: he will verify the principal dimensions and forms by means of the appropriate gauges and patterns.

Barrel.—The diameter of the bore must be verified with the standard and limit gauges. The barrel should enter the groove of the stock to the depth of half its diameter, and should bear well in the whole length of the groove, particularly at the breech. The vent should be accurate in its dimensions, position, and direction, and a wire should be passed into the vent through the cone and cone-seat, to see that they are free. The cone should be examined, to see that it is sound. The shoulders of the breech-screw should fit close to the end of the barrel, and it must be free from cracks or flaws about the tang-screw hole; the tang-screw should be perpendicular to the tang. The bore of the barrel should be clean and bright.

Ramrod.—The fitting of the groove is ascertained by drawing and returning the rod smartly several times, to see that it holds well and does not stick too tight; the pistol-carbine ramrod should hold more firmly than that of the musket; the ramrod must bear on the rod-stop, and in that position its head should not project beyond the end of the barrel; it should fill the groove well; the open part of the groove should be in the centre of the stock, the covered part in the middle of the thickness of the stock, between the outside and the bottom of the barrel-groove, and the rod should not interfere with the front side-screw.

Bayonet.—The socket of the bayonet should be a little below the muzzle of the barrel at the upper end. Work the clasp, to see that the ramrod does not interfere with it, that it bears well on the shoulders, that the clasp-screw holds well, that the stock is firmly fixed, and that the clasp moves evenly, without binding; the blade of the bayonet should set outwards a little toward the point. To try the strength and temper of the bayonet when fixed, spring it smartly in four directions, toward the back and face and each edge, resting the point on the floor, and grasping the butt of the stock with the right hand and the middle of the barrel with the left.

Examine the fitting of the bayonet to the barrel, and see that the inside of the socket is clean and free from rust, and that the bayonet-stud is well brazed and of the right dimensions.

Lock.—Examine carefully the action of the lock; snap the hammer on the cone, to see that it fits well. Let the hammer down several times, to judge of the working of the lock. See, also:

1. That the interior parts are not wood-bound.

2. That the hammer stands off (0.02 inch) from the lock.

3. That it does not go off at half-cock when the trigger is pulled hard.

4. That it goes neither too hard nor too easily when cocked.

5. That it does not stop at half-cock.

6. That the trigger is steady at cock and half-cock, and free when the hammer is down.

7. That the fall of the hammer is not stopped by the heel of the tumbler before it touches the cone.

8. That the hammer has sufficient sweep; that it falls evenly, without a jerk, and that the knife-edge passes freely over the plate.

Examine the soundness of the hammer at the tumbler-hole.

In examining a finished lock by itself, observe the rules laid down above; see that the lock-plate fits accurately in its bed, and that the wood around it is full and sound.

Mountings.—The front part of the trigger at half-cock should be nearly perpendicular to the surface of the guard-plate; the slit for the trigger should be of the exact width, so that the trigger shall have no lateral motion.

It is important that the guard-plate should bear firmly on the wood in every part; as, otherwise, by driving the tang-screw too hard, the trigger might be brought too close to the sear and the action of the lock be thus interfered with.

The butt-plate should be well fitted in the centre of the stock.

The bands should fit smoothly at the shoulders and closely to the stock and barrel, but not so tight as to require a great effort to remove them. The band-springs should not be too deeply set; they should spring back freely when pressed down; the holes for the wires should not interfere with the barrel or ramrod grooves.

All the mountings should fit smoothly to the stock. The stock should have the proper fall or crook, which is ascertained by applying the pattern and by trying the piece in the position of aiming.

By sighting along the barrel, it will be seen whether it is well stocked, whether the bands, the front and rear sights, and the bayonet, are well set.

See, also, *Inspection of arms in service.*

General Directions.

The inspector is not restricted to the particular examinations above mentioned; he will make any other examinations which he may deem necessary to ascertain the quality of any part of the arms and their conformity to the standard models; if he discover or suspect any attempts on the part of the workmen to cover or conceal serious defects, he will subject the arms to the most severe scrutiny, in order to detect such defects.

In the inspection of contract arms, the inspector will judge of the quality of materials and workmanship by the rules which govern in like cases at the national armories; that is, he will reject such arms or parts of arms as would be condemned at the national armories, and he will receive such as would be approved at the national armories,—without exacting, in any case, more rigid conditions than are enforced at those establishments.

The ordnance officer charged with the inspection of arms, or the master armorer at a national armory, will cause at least *one in twenty* of each lot of arms passed by a sub-inspector to be taken to pieces in his presence, and he will examine them strictly, agreeably to the foregoing directions, before affixing his stamp of approval on the finished arms, all of which must be examined by him.

Marks.—As a general rule, every part condemned on inspection will be indelibly marked with the letter *C*, and every principal part approved will be marked with the initials of the inspector's name. Care must be taken that the marks of approval are not stamped so deep as to be injurious.

Finished arms approved in inspection will be marked on the left face of the stock with the initials of the name of the principal inspector, and the year of inspection.

Report of Inspection of Barrels.

After the inspection of each lot of barrels the inspector will make a statement, showing:

1. The number of barrels offered for proof.
2. The number rejected before proof.
3. The number burst in proof.
4. The number rejected after proof, for flaws, cross-cracks, or other defects.
5. The number received after the proof and inspections.
6. The number rejected on inspection of the finished arm.

These statements furnish the materials for the reports of inspection required by the Ordnance Regulations.

Browned Arms.

The barrels of rifles are browned at the armories before being received for the service; the *locks*, *ramrods*, *band-springs*, *triggers*, and *screws* are not browned. The parts of these arms should be thoroughly inspected before browning, and the finished arm after being browned.

INSTRUCTIONS FOR BROWNING ARMS.

Materials for Browning-Mixture.

1½ oz. spirits of wine.
1½ oz. tincture of steel.
½ oz. corrosive sublimate.
1½ oz. sweet spirits of nitre.
1 oz. blue vitriol.
¾ oz. nitric acid.

To be mixed and dissolved in 1 quart of soft water; the mixture to be kept in *glass bottles*, and not in earthen jugs.

Previous to commencing the operation of browning, it is necessary that the barrel or other part should be made quite bright with emery or a fine smooth file, (but not burnished,) after which it must be carefully cleaned from all greasiness; a small quantity of pounded lime rubbed well over every part of the barrel is the best for this purpose. Plugs of wood are then to be put into the muzzle of the barrel and into the vent, and the mixture applied to every part with a clean sponge or rag. The barrel is then to be exposed to the air for twenty-four hours; after which time it is to be well rubbed over with a *steel scratch-card* or *scratch-brush*, until the rust is entirely removed; the mixture may then be applied again, as before, and in a few hours the barrel will be sufficiently corroded for the operation of scratch-brushing to be repeated. The same process of scratching off the rust and applying the mixture is to be repeated twice or three times a day for four or five days, by which time the barrel will be of a very dark brown color.

When the barrel is sufficiently brown and the rust has been carefully removed from every part, about a quart of boiling water should be poured over every part of the barrel, in order that the action of the acid mixture upon the barrel may be destroyed and the rust thereby prevented from rising again.

The barrel, when cold, should afterwards be rubbed over with linseed-oil or sperm-oil. It is particularly directed that the steel scratch-card or scratch-brush be used in the place of a hard hair-brush, otherwise the browning will not be durable nor have a good appearance.

The browning-mixture is applied to other parts of arms in the same manner as to the barrels.

About 6 quarts of browning-mixture are required for 1,000 barrels.

Varnish for browned iron.

Shellac	1 oz.
Dragons' blood	.1875 oz.
Alcohol	1 quart.

To remove old browning: Plug the vent and the muzzle of the barrels; immerse the browned parts for one hour in boiling lime-water or lye, to remove the varnish or grease; wipe them, and put them in vinegar, in a wooden trough, for half an hour or an hour, when the browning may be rubbed off with a rag.

PACKING SMALL ARMS.

Box for 20 *Rifle Muskets.* (Plate 27.)

The box is made of well-seasoned white pine boards 1 inch thick; the sides and bottoms lap over the ends. 4 *corner-pieces,* (yellow pine,) 2.25 inches wide, 1.25 inch thick; the width of the corner-piece is placed against the end of the box; a rabbet is cut in each piece to receive the ends of a board 4.5 inches wide and .125 inch thick, which forms the inner lining of the implement-pocket. 2 *end-linings,* between the corner-pieces, 8.75 inches deep, leaving vacant spaces above them, between the corner-pieces, 4.5 inches deep, for the implements. They are fastened to the ends, each with two nails.

Interior dimensions of the box.—Length between the end-linings, 59.25 inches; width, 16 inches; depth, 13.25 inches.

The *ends* are fastened with nine 8-penny nails in two rows, in each corner-piece. Each *side* is fastened with five 12-penny nails in each end, three 10-penny nails, and one 2-inch screw No. 14, (above the nails,) in each corner-piece. The *bottom* is fastened to each end and lining with twelve 10-penny nails, and to each side with ten 10-penny nails and two 2-inch screws. The top is fastened with two 2-inch screws to each end and four to each side. Two holes are bored in each end, 6 inches apart and 8 inches from the bottom, to receive *rope beckets,* .5 inch thick and 18 inches long, which are inserted and fastened by a knot countersunk in the end, before the linings are nailed on.

4 *bayonet-clamps,* each 1 inch thick; two of them are 1 inch deep; the others, 1.5 inch. They have each ten notches on the under side to receive the blades of the bayonets, and they are fastened to the bottom of the box each with 2 screws, except when the box is lined with tin. The small clamps are placed 6 inches apart, in the clear; the large ones, 12.5 inches apart for the model of 1855, and 5 inches apart for the model of 1842.

4 *muzzle-clamps,* 1 inch thick and 2.25 inches wide, 16 inches long; each clamp has 5 holes for the muzzles of the barrels and 5 for the heads of the ramrods.

4 *butt-clamps*, each 1.85 inch thick and 2.20 inches wide: each clamp has 5 sloping notches, 1 inch deep, 1.55 inch wide at the top, and 1.8 inch at the bottom for the model of 1842, and 1.45 inch wide and 1.7 inch at the bottom for the model of 1855, to receive the butts of the muskets.

On the back of the upper corner a rabbet, .25 inch deep and .45 inch wide, is cut to receive a corresponding projection or tongue on the middle-clamp: this serves to hold the pieces together, and thereby save the necessity of grooves on the sides of the box.

2 *middle-clamps*, each 1.85 inch thick, 1.10 inch wide in front; a projecting square lip, .25 inch deep by .45 inch wide, on the lower rear corner, to fit into the rabbet of the butt-clamp.

2 *top-clamps*, each 1.85 inch thick and 3 inches wide: the cover of the box presses on them and keeps the muskets tight in place. A lip is made on these clamps to fit into the butt-clamps, as described in the butt-clamps.

NOTE.—The rifle-musket (model 1855) is 1.85 inch shorter than that of 1842. For this reason an *extra* end-piece, 1 inch thick, with cleats nailed upon each end, 2 inches wide, .85 inch thick, is placed in one end of the box previous to putting in the muskets. This forms a pocket for the tompions.

To pack a box of Muskets.

Unfix the bayonets and let down the hammers.

The small bayonet-clamps being fastened down, place the points of the bayonets in their notches, the bayonets lying on the edge of the blade; then put in the large clamps and screw them down.

Place the lower tier of ten muskets; the muzzles and ramrods in the holes in the lower end-clamps, the butts resting on the opposite clamp; put two lower butt-clamps in over the butts of the lower tier of muskets, and over them the two middle-clamps. Place the upper muzzle-clamps in; insert the upper tier of muskets like the lower; put in the upper butt-clamps and the top-clamps.

Put the implements in the pockets provided for them, and screw on the cover.

Packing-Box for twenty Rifles. (Plate 27.)

Rifles are packed in the same manner as muskets, the box being made like the musket-box, except in its dimensions, and changing the *bayonet-clamps*, and adding 2 *end cleats* and 2 *steel springs*; 1 *rabbet* in each side.

Interior dimensions of rifle-box.—Length between the end-linings, 50.2 inches; width, 16.5 inches; depth, 13.5 inches.

When small arms are to be sent on a long sea-voyage, the packing-boxes are provided with tin linings securely soldered, so as to exclude all dampness.

The *clamps* for the bayonets are held down by *tin loops* soldered to the sides of the tin lining, and bent over the clamps and screwed to them after the bayonets are in place.

Two strips of wood, 1.8 inch wide and 1 inch thick, are placed on each side of the box, their ends resting in notches cut in the ends of the top-clamps.

A tin cover is then placed upon these pieces, and the edges of the lining are bent over it and soldered.

To open the box, a soldering-iron and thin knife are required to open the soldered joint, and the cover is removed.

Weights of boxes of Arms packed.

20 muskets	and appendages,	model	1855, 286 lbs.		
20 "	"	"	"	for sea-voyage, 301 lbs.	
20 "	"	"	1842, 285 lbs.		
20 "	"	"	"	for sea-voyage, 300 lbs.	
20 rifles	"	"	1855, 321 lbs.		

Packing Arms with Straw.

In the field, or under other circumstances, when the proper arm-chests are not on hand, it may sometimes be necessary to pack arms in this manner.

The interior dimensions of a box for 20 muskets may be the same as for the regular packing-box.

The straw should be long, perfectly dry, and free from dust; *rye straw* is the best; *hay* should not be used: about 25 pounds of straw are required to a box.

To prepare the musket for packing.—Oil it; let down the hammer, pass the bayonet up to the socket into the guard-bow, on the right side, in front of the trigger. Make a rope of about 40 straws, slightly twisted, and 40 inches long: wrap it about the musket, commencing on top of the hammer, going round the bayonet below, again over the hammer and round the piece in front of the guard, then over the socket of the bayonet near the neck, and wrapping the rest around the handle of the stock.

Lay a bed of straw 2 inches thick in the bottom of the box; in the middle and at 6 inches from the ends, place three cushions of straw 6 inches thick and 12 inches wide. Put in a tier of 10 muskets crossing each other, the butts resting alternately against the ends of the box, the guards uppermost, and the hammers bearing on the cushions. Put small trusses of straw under the upper and middle bands, by raising the muskets at one end and then pressing them down between the others. Pack, between the butts, wads of straw 8 inches long, made of a handful of straws folded in three; cover the guards and guard-bows with the ends of the straw that form these wads, which will be still about 12 inches long. Put in another tier of 10 muskets in the same manner, making the cushions 4 inches thick. Pack the implements in straw in the vacant spaces. Fill the box with straw, so that the cover shall require strong pressure to keep it down. Put two hoops round the box, at 18 inches from the ends.

Other arms, swords, etc., are packed in a similar manner.

Arms should not be wrapped in paper, unless it be oiled, as it attracts moisture more readily than straw does.

PRESERVATION OF ARMS IN STORE.

Arrangement and Manner of Storing Arms.

Arms are kept at the arsenals either in the boxes in which they are received from the armories, or in racks.

Those of each kind are kept separate, and they are arranged according to the model, the place and year of fabrication, and the time when they were last cleaned.

New arms are kept distinct from those which have been repaired.

Each parcel should have a label, indicating the kind, number, model, date of their receipt in store and of their being last cleaned.

The manner of keeping arms at the arsenals is determined by the chief of the Ordnance Department, according to the peculiar circumstances of each case, and racks are constructed for them only in pursuance of special authority from the Ordnance Office; without such authority they are kept in boxes. The form and arrangement of the racks vary with those of the room in which they are placed, so as to use the space to the best advantage and give light and air to every part of the room. The usual arrangement of racks for muskets is to establish two rows of double racks, two tiers high, perpendicular to the length of the room, leaving alleys around the room next to the walls, and in the centre, if necessary. The bayonets are passed through the middle-band swivel, the socket covering the top of the ramrod. Other racks of a similar kind may be made for *rifles*, *carbines*, &c. *Pistols* are suspended by the guard-bows, on hooks driven into the faces of the musket-racks, or into the joists, or into strips attached to the walls of the building.

When there are neither racks nor boxes prepared, the arms are stored in dry rooms, arranged in rows apart from the walls, standing on their muzzles and supported by frames to prevent them from pressing too much on each other. The bayonet should be unfixed and passed through the swivel. They should be covered with tarpaulins or cloths, if necessary, to protect them from dust.

Arms of peculiar kinds, and arms to be repaired, are kept separate from others; as also arms unserviceable or condemned to be broken up.

Limbs and spare parts intended for repairs of arms should be kept in store by themselves, in a dry place, classed according to the kind of arms and to the model and year of fabrication, and labelled accordingly.

Musket and *rifle barrels* and other long barrels, standing on their muzzles; the piles covered from the dust with tarpaulins supported so as not to touch the barrels. *Pistol-barrels, bayonets,* and other small parts, in drawers or boxes, properly labelled. *Stocks,* in square piles, in the attic or upper story of the building.

Care of Arms in Store.

Arms when received at an arsenal should be unpacked and carefully examined, to detect any damage suffered in transportation; they should be cleaned and oiled, if they require it. Those arms which are not to be placed in racks should be returned to the boxes, laid in loosely but safely, and the cover slightly fastened down, so that they can be readily examined.

All arms in store should be frequently examined, to see that they do not become rusty. Those which are found to be rusted should be immediately cleaned and again oiled. Browned arms, if affected with specks of rust, should be rubbed hard with linseed-oil; and if the appearance of the browning indicate that the acid is not neutralized, care should be taken to examine the arms again within a short time, as it may be found necessary to remove and renew the browning; but this operation should not be performed without special authority from the chief of the Ordnance Department, on the report of a duly-authorized inspector.

Arms which are to be repaired should be oiled and taken care of in the same manner as serviceable arms. Irreparable arms, the parts of which can be used for repairs, should be oiled. Similar remarks apply to spare parts for repair of arms.

Sperm-oil should be used for greasing arms.

Empty boxes, from which the arms in racks are taken, should be kept, with all the parts belonging to them, in the attics or other dry situations.

The store-houses for arms should be aired in clear, dry weather.

Issuing Arms.

The Ordnance Regulations prescribe the manner of issuing arms to the troops, under the various circumstances of service, and to the States, for arming the militia.

All arms issued from an arsenal should be carefully examined before delivery, cleaned, and put in good order; if intended for transportation, they should be oiled, if necessary, after cleaning, and carefully packed.

PRESERVATION OF ARMS IN SERVICE.

The officers, non-commissioned officers, and soldiers should be instructed and practised in the nomenclature of the arms, the manner of dismounting and mounting them, and the precautions and care required for their preservation.

Each soldier should have a screw-driver and a wiper, and each squad of ten a band-spring and tumbler punch, and a spring-vise. No other implements should be used in taking arms apart or in setting them up.

In the inspection of arms, officers should attend to the qualities essential to service, rather than to a bright polish on the exterior of the arms. The arms should be inspected in the quarters at least once a month, with the barrel and lock separated from the stock.

Taking Arms to Pieces.

To take apart the rifle musket, model 1855:—

1. Unfix the bayonet.
2. Put the tompion in the muzzle of the barrel.
3. Draw the ramrod.
4. Turn the tang-screw.
5. Take off the lock: to do this, first put the hammer at half-cock, then unscrew partially the side screws, and, with a slight tap on the head of each screw with a wooden instrument, loosen the lock from its bed in the stock; then turn out the side screws, and remove the lock with the left hand.
6. Remove the side screws, taking care not to disturb the washers.
7. Take off the upper band.
8. Take off the middle band.
9. Take off the lower band.
10. Take out the barrel.

In doing this, turn the musket horizontally, with the barrel downward, holding the barrel loosely with the left hand below the rear sight, the right hand grasping the stock by the handle; and if it does not leave the stock, tap the tompion in the muzzle gently against the ground or floor, which will loosen the breech-end from the stock. This is preferable to lifting the barrel out by the muzzle, because if the tang of the breech-screw should bind in the wood, the head of the stock would be liable to be split by raising the muzzle first.

The foregoing parts of the rifle musket are all that should usually be taken off or dismounted.

The soldier should never dismount the *band-springs, guard, side screw, washers, butt-plate, rear sight, cone, and cone-seat screw,* except when an officer considers it necessary. The breech-screw should be taken out only by an armorer, and *never* in ordinary cleaning. The lock should not be taken apart, nor the bayonet-clasp taken off, except when absolutely necessary in the opinion of an officer. *If proper and regular care be taken of the arm, this will be very seldom necessary.*

The parts which are specially assigned to be dismounted by an experienced armorer will be stated in their regular order following No. 10, viz.:

11. Unscrew the cone, keeping the wrench well down on the square of the cone, to prevent the corners from being injured.

12. Take out the cone-seat screw.

13. Take out the upper, middle, and lower band-springs, using a wire punch of proper size.

14. Take out the side screws.*

15. Take out the guard, using care to prevent injuring the wood at each end of the guard-plate.

16. Take out the side-screw washers with a drift punch.

17. Take out the butt-plate screws with the largest blade of the screw-driver, and remove the butt-plate.

18. Remove the rear sight by turning out the leaf-spring screw, which will release the sight from the barrel.

19. Turn out the breech-screw by means of a "breech-screw wrench" suited to the tenon of the breech-screw. No other wrench should ever be used for this purpose, and the barrel should be held in clamps fitting neatly the breech.

ORDER IN WHICH THE LOCK IS TAKEN APART.

1. Cock the piece, and put the spring-vise on the main-spring; give the thumb-screw a turn sufficient to liberate the spring from the swivel and main-spring notch. Remove the spring.

2. The sear-spring screw. Before turning this screw entirely out, strike the elbow of the spring with the screw-driver, so as to disengage the pivot from its mortise; then remove the screw and spring.

3. The sear-screw and sear.

4. The bridle-screw and bridle.

5. The tumbler-screw.

6. The tumbler. This is driven out with a punch inserted in the screw-hole, which at the same time liberates the hammer.

7. Detach the main-spring swivel from the tumbler with a drift-punch.

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* The guard, butt-plate, and side-screw heads have concave slits, for which the screw-driver is adapted: this lessens the danger of the stock being marred by accident or carelessness in letting the screw-driver slip out while in the act of turning the screw. Great care should be observed to prevent injury in this particular.

8. Take out the feed-finger and spring. The magazine-cover should never be taken off except when absolutely necessary.

9. The catch-spring and screw.

Assembling Arms.

The lock and the musket are put together in the inverse order of taking them apart.

THE LOCK.

1. The catch-spring. 2. The feed-finger and spring. 3. The main spring swivel. 4. The tumbler and hammer. 5. The tumbler-screw. 6. Bridle and screw. 7. Sear and screw. 8. Sear-spring and screw. 9. Main-spring.

Before replacing the screws, oil them slightly with good sperm-oil, putting a drop on the point of the screw; also on the arbor and pivot of the tumbler; between the movable branches of the springs and the lock-plate; on the hook and notches of the tumbler. After the lock is put together, avoid turning the screws in so hard as to make the limbs bind: to insure this, try the motion of each limb before and after its spring is mounted, and see that it moves without friction.

THE MUSKET.

1. The barrel. Drop the barrel into its place in the stock, and squeeze it down with the hand; give the butt of the stock a gentle tap against the floor, to settle the breech-end of the barrel against the head of the stock.

2. Put on the lower band with the letter U upward, being careful not to mar the stock or barrel in sliding it into its place; apply the thumb to the band-spring, to see that it plays freely.

3. Put on the middle band; and,

4. The upper band, in the same manner.

5. The lock. Half-cock the hammer; take the lock in the right hand, with the main-spring and sear toward you, holding the stock with the left hand by the swell, with the butt between the knees. Enter the lock fairly into the lock-bed, taking care to keep the arm of the sear clear of the trigger; press the plate well down into the wood, and then turn the musket over, holding the lock and stock together with the left hand.

6. With the right hand, turn in the side screws, after having touched their screw-threads with oil. Observe that the point of the rear-screw is *flat*, and should not project beyond the plate, to interfere with the hammer. The front screw has a round point.

7. Turn in the tang-screw, after having oiled the screw-thread. Be careful to see that each of these screws are turned firmly home, *but not forced.* Observe that the lock plays freely, without friction, and that no limb is bound by the wood.

8. Return the ramrod.

9. Refix the bayonet, after having oiled the clasp and socket to prevent chafing.

10. Replace the tompion. *Oil the stock* well with sperm or linseed oil; let it stand a few hours, and then rub it with a woollen rag until the wood is perfectly dry. Repeat this from time to time, and it will produce a polish which moisture will not affect.

Linseed-oil is the best for this purpose, and it should be used while the arm is dismounted.

Cleaning and Care of Arms.

TO CLEAN THE BARREL.

1. Stop the hole in the cone with a peg of soft wood; pour a gill of water (warm, if it can be had) into the muzzle; let it stand a short time, to soften the deposit of the powder; put a plug of soft wood into the muzzle, and shake the water up and down the barrel well; pour this out and repeat the washing until the water comes out clear; take out the peg from the cone, and stand the barrel, muzzle downward, to drain for a few moments.

2. Screw the wiper on to the end of the ramrod, and put a piece of *dry cloth* or *tow* round it, sufficient to prevent it from chafing the grooves of the barrel; wipe the barrel quite dry, changing or drying the cloth two or three times.

3. Put no oil into the vent, as it will clog the passage, and cause the first cap to miss fire; but, with a slightly-oiled rag on the wiper, rub the bore of the barrel and the face of the breech-screw and immediately insert the tompion into the muzzle.

4. To clean the exterior of the barrel, lay it flat on a bench or board, to avoid bending it. The practice of supporting the barrel at each end and rubbing it with a strap or buff-stick, or with the ramrod or any other instrument, *to burnish* it, is pernicious, and should be strictly forbidden.

5. After firing, the barrel should always be washed as soon as practicable; when the water comes off clear, wipe the barrel dry, and pass into it a rag moistened with oil.

As rust and dirt are produced by exploding caps or primers, although no charge be fired, the parts of the barrel and cone exposed should be carefully wiped and oiled after such practice.

Fine *flour-of-emery* cloth is the best article to clean the exterior of the barrel.

TO CLEAN THE LOCK.

Wipe every part with a moist rag, and then a dry one; if any part of the interior shows rust, put a drop of oil on the point or end of a piece of soft wood dipped into flour of emery; rub out the rust clean and wipe the surface dry; then rub every part with a slightly-oiled rag.

When a lock has, from any cause, become gummed with oil and dirt, it may be cleaned by being boiled in soap-suds or in pearlash or soda water, to loosen the thick oil; but heat should never be applied to any part of it in any other way.

TO CLEAN THE MOUNTINGS.

For the mountings, and all of the iron and steel parts, use fine flour of emery moistened with oil, or flour-of-emery cloth.

For brass, use rotten-stone moistened with vinegar or water, and keep free from oil or grease. Use a hard brush, or a piece of soft pine, cedar, or crocus-cloth.

Remove dirt from the screw-holes by screwing a piece of soft wood into them.

Wipe clean with a linen rag, and leave the parts slightly oiled.

In cleaning the arms, great care should be observed to *preserve the qualities essential to service*, rather than to obtain a bright polish.

Burnishing the barrel (or other parts) should be strictly avoided, as it tends to crook the barrel, and also to destroy the uniformity of the exterior finish of the arm.

It is not essential for the musket to be dismounted every time that it is cleaned; for, after firing it in fine weather, or when there has been no chance for the wet to get between the barrel and the stock, it can be perfectly cleaned in the following manner:—

Put a piece of rag or soft leather on the top of the cone, and let the hammer down upon it; pour a gill of water into the muzzle, carefully, so that it does not run down the outside; put a plug of wood into the muzzle, and shake the gun up and down, changing the water repeatedly until it comes out clear. When clear, withdraw the leather, and stand the musket on the muzzle a few moments; then wipe out the barrel, (as given in the second rule for cleaning,) and also wipe the exterior of the lock and the outside of the barrel around the cone and cone-seat, first with a damp rag, and then with a dry one, and lastly with a rag that has been slightly oiled. In this way, all the dirt due to the firing may be removed without taking out a screw.

If, however, the hammer be observed to work stiff, or to grate upon the tumbler, the lock must immediately be taken off and the parts cleaned and touched with oil.

To change the cone, when it is broken or worn out.—After removing the old cone, enter the new one carefully with the fingers, before using the wrench, in order to avoid bruising the thread in the barrel.

It is very important to use no other implements than those before mentioned. By using nails to drive out the wires, their holes are enlarged. The main-spring should never be heated for the purpose of either raising or lowering its temper; this destroys the elasticity of the spring, and the lock no longer gives fire.

The notches of the tumbler, the main-spring swivel, and, in general, all the joints of the lock, should be frequently oiled, after first wiping off the hard grease and the dust.

Browned arms are cleaned by rubbing them hard with an oiled rag until the oil is well incorporated with the browning, or by rubbing them with beeswax on a rag or cork.

Rifled arms should not have the *ramrod sprung* in the bore with unnecessary force. It batters the head of the rod, and wears injuriously the grooves. The soldier should let the rod slide down gently, supported by the thumb and finger; and the inspecting officer can satisfy himself of the condition of the bottom of the bore by gently tapping with the rod. The face of the breech can be polished, after washing, by means of a cork fixed on the wiper or ball-screw; the polished surface can be seen if the muzzle is turned to the light.

Besides all the precautions in dismounting, remounting, and cleaning, which have been pointed out in the foregoing pages, habitual care in handling the arms is necessary to keep them in good and serviceable condition.

In *ordering arms* on parade, let the butt be brought gently to the ground, especially when the exercises take place on pavements or hard roads. This will save the mechanism of the lock from shocks, which are very injurious to it, and which tend to loosen and mar the screws and split the wood-work.

In *stacking arms*, care should be taken not to injure the bayonets by forcibly straining the edges against each other. The stack can be as well secured without such force being used.

No cutting, marking, or scraping in any way the wood or iron should be allowed; and no part of the gun should be touched with a file. Take every possible care to prevent water from getting in between the lock, or barrel, and stock. If any should get there, dismount the gun as soon as possible, clean and oil the parts as directed, and see that they are perfectly dry before reassembling them.

TO PLACE A COIL OF PRIMERS IN THE MAGAZINE.

Let down the hammer; open the magazine, by pulling back the head of the cover-catch with the thumb-nail of the left hand, while the thumb-nail of the right hand is pushed under the cover at the bottom. Remove the covering-paper from the coil of primers; separate any parts that may happen to stick together; unwind about one inch; place the coil in the magazine, and the free end of it in the groove, flat side toward the cone, and one primer beyond the end of the feed-finger; close the magazine

Should an exploded primer fail to ignite the charge, there must be moisture, or some obstruction, in the vent; or the gun may be improperly loaded. After a night in a damp place, a drop of moisture sometimes collects in the vent, and, unless removed, prevents the first primer, or cap, from igniting the charge.

If, by accident, a coil of primers become softened by dampness, it can be made good again by a short exposure to a dry, warm atmosphere.

Should the cocking of the hammer fail to feed out properly the primer, open the magazine, and notice, while working the hammer, the cause of the difficulty. It can generally be readily corrected.

INSPECTION OF ARMS IN SERVICE, OR WHICH HAVE BEEN IN SERVICE.

Implements.—Standard and limit gauges for the bore, limit-gauges for the exterior of the barrel, and a screw-plate with taps for the holes of the lock-plate.

The following are the principal points to be attended to in the inspection of arms:—

The arms being taken to pieces and cleaned.

BARREL.—*Defects for which the barrel must be condemned as unfit for service.* The large gauge entering the whole length of the barrel. The small or standard gauge not entering, unless the diminution of the bore be caused by the barrel being indented or bent,—defects which may be remedied. A diminution of the exterior diameter at the breech or at the muzzle, so as to enter the small receiving-gauges: this diminution is 0.1 inch at the breech; 0.03 inch at the muzzle for arms with bayonets, and 0.045 inch for arms without bayonets. A diminution of more than 0.25 in the length of a pistol-barrel, or 0.5 inch in the length of other barrels. Splits, cross-cracks, and other serious defects, caused either by bad workmanship or by use.

Examine the barrel carefully, to see if it have any of the above defects, and, if so, mark them with a file, when not very apparent. See if the bayonet-stud be broken or too much worn, if the cone-seat be perfect, and its thread in good order and the vent unobstructed. If the breech-screw be not tight after entering 5 or 6 threads, or if it can be screwed down by hand without the use of a wrench, if the threads be not sharp and sound, if the plug do not fill up the whole box of the female screw, if the tang be broken or cracked at the screw-hole, or if, when the breech-screw is in, the tang be not even with the upper surface of the barrel, a new breech-screw is required.

CONE.—Examine the chamfered end of the cone, to see that it be not broken or bruised; examine also the thread and the vent.

BAYONET.—A bayonet is considered unserviceable if the blade be 1 inch too short. See if it be sound and perfect in all its parts, and if it fit the barrel; also, if the clasp be in good order and turn freely.

Lock.—See if the fixed branches of the *springs* fit close to the lock-plate, if the movable branches be clear of it, and if any of the parts be wood-bound.

Have the springs and the bridle of the tumbler renewed when their pivots are broken. There should be an equal space between the lock-plate and the sear, the tumbler and the hammer.

If the *sear* rub on the plate, have it adjusted. The friction of the *tumbler* may be caused by the bridle being badly pierced, in which case renew the bridle. If the hammer rub on one side only, have it adjusted; if it rub everywhere, the arbor of the tumbler does not project sufficiently, and the tumbler should be renewed. If the *notches of the tumbler* be broken, or the edges too blunt, have them dressed; if the hook of the tumbler project beyond the edge of the lock-plate when the hammer is let down, the tumbler should be renewed. The arbor and the pivot of the tumbler should fit well in their holes. Examine the *sear* closely, and have it renewed when the nose is too thin or is worn on the side next the lock-plate, although it may be perfect on the exterior. If the hammer be not steady, the tumbler should be renewed. Try the action of the hammer, to see that it explodes the cap with certainty.

Renew the *lock-plate* when the holes are too much worn to be dressed over. Renew every limb that is broken or cracked, the screws which are too much worn, or of which the stems are bent or the slits too much enlarged.

Mountings.—See if the parts be complete and sound.

If the *tang-screw* do not fit tight in the screw-hole of the guard-plate, renew whichever part is defective.

Ramrod.—See if it be sound and have a good thread and be of the proper length; otherwise, replace it.

Stock.—Examine carefully the *bed of the lock*, and the holes for the band-springs. Press the thumb against the *facings*, to see if they be split at the holes for the side screws, and renew the stock if it be split there or at any other part to an injurious extent.

The arms complete

Are inspected according to the rules before laid down for the inspection of finished arms; due allowance being made for the necessary wear in service.

REPAIRS OF ARMS AT ARSENALS.

When arms which have been in the hands of the troops are turned into store at an arsenal, they should be inspected by a master armorer, under the supervision of an officer, and classed as follows:—

1. *Serviceable arms.*
2. *Arms requiring repairs.*
3. *Irreparable arms.*

Arms requiring repairs are classified according to their kinds and models and to the extent of the repairs required. Each arm should be marked with a number, and the requisite repairs should be noted on the register of inspection, to guide the workmen and to govern the issue of spare parts required for repairs.

Repairs prohibited.—The following repairs being always imperfect, the parts requiring them should be replaced:—Cutting off a barrel; brazing a patch on a barrel; brazing a tang on the breech-screw; brazing a bolster on a lock-plate; reaming out the hole for the arbor of the tumbler; brazing a piece for a tumbler-hole or a shoulder on the hammer; hammering in the edge of the hole to make it fit tight on the square of the tumbler; putting a pivot to a tumbler; twisting the square of the tumbler to increase the sweep of the hammer; straightening the arbor; brazing a ramrod; splicing a stock.

The spare parts furnished from the armories are in general *filed, finished, hardened, and tempered,* including the breech-screw.

Fitting new parts.—To adjust a new lock, the flat of the barrel should not be filed, but the bolsters of the lock-plate should be ground.

The *barrel* should not be touched with a file when it has been injured by rust. *In replacing the bayonet-stud,* avoid cutting too deep into the barrel and producing a projection inside; try the small gauge in the barrel after the operation. *In fitting a new bayonet,* dress out the groove of the socket and ream out the socket if necessary.

Braze sights and bayonet-studs only, and no other pieces; the solder is composed of two parts of brass and one of zinc, without any tin.

Irreparable Arms.

Arms are considered *irreparable* when both the barrel and stock are unfit for service; or when the arms require very extensive repairs and the parts can be made useful for repairs of other arms. They can be broken up only by special authority; and they should therefore be oiled and preserved, in order to be submitted to an inspector, as prescribed in the Ordnance Regulations.

When arms are broken up, the parts are classed either as *serviceable, reparable,* or *unserviceable;* those of the last class should be turned into store as *scrap iron or steel, &c.*

STRENGTH AND DURABILITY OF MUSKET-BARRELS.

To test the strength of musket-barrels, model 1855, they have been fired with an increasing number of cartridges, until the force of the explosion of the first two cartridges was unable to drive out the other charges, and the gas escaped through the vent, leaving the barrel uninjured.

The strength of the barrel, therefore, furnishes every requisite security against the accidents of service and the want of care on the part of the soldier.

Experience has shown that a musket-barrel may be fired 25,000 times without becoming unserviceable.

Barrels which are condemned in service are almost always the result of accident, very rarely from enlargement of the bore or from the diminution of the exterior dimensions.

The following trials of the strength and durability of the French musket-barrel are taken from the *Aide-Mémoire.* They refer to the smooth-bore musket: It is to be observed that the charge of the French musket was formerly 162 grains Troy, priming included, (or 146 grains, exclusive of priming,) and is therefore considerably greater than our present service-charge.

In experiments made in 1806, barrels reduced 0.13 inch at the breech bore a double and triple charge with one ball, or 2 cartridges placed one over the other.

Other trials were made in 1829, at the manufactory of Mutzig, on arms sent there for repairs, which had been a greater or less time in the hands of the troops. They furnished the following results:—

1st. When a musket-barrel is charged with a single cartridge, placed in any part of it, or with 2 or even with 3 cartridges, inserted regularly, without any interval between them, there is no danger of bursting; with 4 cartridges inserted regularly over each other, or with 2 or even 3 cartridges placed over each other with slugged balls, (or balls *driven* in, as in a rifle,) there is danger only in case of some defect of fabrication, or some deterioration in the barrel; with more than 4 cartridges inserted regularly one over another, or with 2, 3, and 4 cartridges with intervals between them, it is not safe to fire.

2d. No danger of bursting is occasioned by leaving a ball-screw in the barrel. There may be danger from a plug of wood driven tight into the muzzle, when the barrel has been loaded with 2 cartridges; or from a cork rammed into the barrel to a certain distance from the charge, with another cartridge over it.

Snow, clay, and sand, which may be accidentally introduced into the barrel, are not dangerous, if they lie close to the charge; but they are so when there is a space between them and the charge; in this case sand is the most dangerous, then clay and snow.

Balls or pieces of iron inserted over the charge were not attended with danger when placed close to the charge, even when their weight amounted to 1¼ lb.; but there is danger from a piece of iron, 0.5 inch square, weighing ¼ lb., if placed 20 inches or more from the breech.

3d. A barrel with a defect which might have escaped the inspector at the armory, bore the explosion of 3 cartridges, regularly inserted. After mutilation, which may have caused a reduction of metal in some parts, it may still be used without danger.

Finally, the diminutions of exterior diameter which may be produced in ordinary service are never sufficient to be dangerous. In these trials, barrels originally 0.272 inch thick at the breech did not burst when loaded with 2 cartridges, until the thickness was reduced to 0.169 inch, and with 1 cartridge to 0.091 inch.

Spare Parts required for the repair of 1,000 *Rifle Muskets, and also* 1,000 *Cadet Rifle Muskets, during one year in the field.*

	Nos.		Nos.
Tip for stocks	10	Lower band springs	30
Tip-rivets	20	Middle band swivels	75
Ramrod-stops	10	" " " rivets	100
Stocks	50	Lock-plates	8
Butt-plates	5	Magazine-cover studs	50
Butt-plate screws	25	Magazine-covers	75
Guard-plates	10	" " rivets	100
Guard-bows	10	" " catches	75
Guard-bow swivels	75	" " " screws	100
" " " rivets	100	Feeding-springs	300
" " " nuts	50	" " screws	150
Triggers	25	" fingers	100
Trigger-screws	25	Main-spring swivels	20
Guard-screws	75	" " " rivets	50
Sight-bases	100	Hammers	75
Sight-leaves	100	Tumblers	75
Sight-leaf springs	100	Tumbler-screws	125
" " " screws	150	Bridles	25
Sight-joint pins	150	Bridle-screws	125
Sight-slides	100	Sears	40
Sight-slide springs	150	Sear-screws	125
" " rivets	300	Sear-springs	125
Leaf-sight base	50	" " screws	125
First leaf	50	Main-springs	125
Second leaf	50	Side-screw washers	60
Joint-screw	50	Side-screws	200
Base-screw	100	Ramrods	100
Front sights	25	Bayonets	75
Breech-screws	20	Bayonet-clasps	100
Cones	75	Bayonet-clasp screws	100
Vent-screws	125		
Barrels	2	APPENDAGES.	
Tang-screws	50	Wipers	75
Upper bands	50	Screw-drivers	25
Middle "	30	Ball-screws	25
Lower "	30	Spring-vises	25
Upper band springs	30	Tompions	100
Middle " "	30	Band-sp. and tumbler-punch	25

Spare Parts for 1,000 *Rifles* (*Model* 1855) *one year in the field.*

	Nos.		Nos.
Barrels	2	Lower band springs	20
Vent-screws	30	Side-screw washers	30
Rear-sights	20	Guard-plates	10
Breech-screws	10	" bows	20
Tang "	30	" " nuts	40
Cones	50	" " " swivels and rivets	50
Locks	2	Triggers	10
Lock-plates	5	" screws	10
Hammers	25	Guard-plate screws	50
Tumblers	20	Butt-plates	2
" screws	100	" " screws	20
Bridles	20	Box-plates with catches	5
" screws	50	" " screws	10
Sears	20	" " springs	10
" screws	50	" " " screws	10
Sear-springs	50	Ramrods	50
" " screws	50	" stops	10
Main-springs	50	Stocks	30
" " swivels	40	Screw-drivers	50
" " " rivets	40	Wipers	50
Feed-fingers	40	Ball-screws	10
" " springs	100	Spring-vises	10
" " " screws	100	Tumbler and wire punches	10
Magazine-covers	20	Bullet-moulds	5
" " studs	20	Swages for balls	5
" " " rivets	20	Sword bayonets	30
" " catches	100	Tompions	20
" " " screws	100	Sword bayonet lock-pins	25
Side-screws	100	Sword bayonet lock-pin springs	50
Upper bands with swivels	10	Sword bayonet lock-pin spring screws	50
" band swivels and rivets	50		
" " springs	30		
Lower bands	10		

Number and kind of Armorer's Tools required for any number of workmen, from 1 *to* 12, *at an Armory or Arsenal, for Repairs, &c.*

Number of Workmen.	1	2	3	4	5	6	7	8	9	10	11	12
TOOLS.												
Awls, stocker's	3	3	3	3	3	3	6	6	6	6	6	6
Axes, hand	1	1	1	1	1	1	1	1	1	1	1	1
Augers, armorer's	6	6	6	6	6	6	6	6	6	6	6	6
Anvils	1	1	1	1	1	1	1	1	1	1	1	1
Bending-tools	2	2	2	2	2	2	2	2	2	2	2	2
Balances	1	1	1	1	1	1	1	1	1	1	1	1
Bayonet-proofs	1	1	1	1	1	1	1	1	1	1	1	1
Bevels	1	1	1	1	1	1	2	2	2	2	2	2
Bick-irons	2	1	2	2	2	2	3	3	4	4	5	5
Bits, assorted	20	20	20	24	24	24	28	28	28	30	30	30
" auger	6	6	6	6	6	6	6	6	6	6	12	12
" stocker's	18	18	18	18	18	18	20	20	20	24	24	24
Braces, iron	1	1	1	1	1	1	1	1	1	1	1	1
Braces and bits	1	1	1	1	1	1	1	1	1	1	1	1
Brands, U.S.	1	1	1	1	1	1	1	1	1	1	1	1
Brushes, dust	1	1	2	3	3	4	4	5	5	6	6	6
" tool	1	1	2	2	3	3	3	4	4	5	5	6
Buff, sticks	3	3	3	6	6	12	12	24	24	24	24	24
Burrs	6	6	6	6	6	6	6	6	6	6	6	6
Burnishers	2	2	2	2	2	2	2	2	2	2	2	2
Cutter, boxes	2	2	2	2	2	2	2	2	2	2	2	2
" dies	2	2	2	2	2	2	2	2	2	2	2	2
" jumpers	2	2	2	2	2	2	2	2	2	2	2	2
Cutters, smith's	1	1	1	1	1	1	1	1	1	1	1	1
" graduated machinist's	1	1	1	1	1	1	1	1	1	1	1	1
Callipers	1	1	1	2	2	2	3	3	3	3	3	3
Chargers	1	1	1	1	1	1	1	1	1	1	1	1
Chisels, turning metal	6	6	6	6	6	6	6	6	6	6	6	6
" " wood	4	4	4	4	4	4	4	4	4	4	4	4
" cold	3	6	9	12	15	18	21	24	27	30	33	36
" stocker's	6	6	6	6	6	6	6	6	6	6	6	6
" smith's	2	2	2	2	2	2	2	2	2	2	2	2
Clamps, iron	6	6	6	6	6	6	6	6	6	6	6	6
Combs, screw	6	6	6	6	6	6	6	6	6	6	6	6
Comb, grinder's	6	6	6	6	6	6	6	6	6	6	6	6
Countersinks	4	4	4	4	4	4	8	8	8	14	14	16
Chucks, scroll	1	1	1	1	1	1	1	1	1	1	1	1
Cutting-off tools	1	1	1	1	1	1	1	1	1	1	1	1
Crucibles	1	1	1	1	1	1	2	2	2	2	2	2
Cone-boxes	1	1	1	1	1	1	1	1	1	1	1	1
Cans, tin	1	1	1	1	1	1	1	1	1	1	1	1

Number and kind of Armorer's Tools, &c.—Continued.

Number of Workmen.	1	2	3	4	5	6	7	8	9	10	11	12
TOOLS.												
Dies, screw-cutting	13	13	13	13	13	13	13	13	13	13	13	13
" milling	13	13	13	13	13	13	13	13	13	13	13	13
" trimming	11	11	11	11	11	11	11	11	11	11	11	11
" shaving	3	3	3	3	3	3	3	3	3	3	3	3
" tilt-hammer	12	12	12	12	12	12	12	12	12	12	12	12
Drilling-collars	1	1	1	1	1	1	1	1	1	1	1	1
Drill-presses, portable	1	1	1	1	1	1	1	1	1	1	1	1
Drill-stocks	1	1	1	1	1	1	1	1	1	1	1	1
Drills, pivot	6	6	6	6	6	6	6	6	6	6	6	6
" assorted	46	46	46	46	46	46	46	46	46	46	46	46
Dividers	1	1	1	1	1	1	1	1	1	1	1	1
Dogs, turning	3	3	3	3	3	3	3	3	3	3	3	3
Files, assorted	12	24	36	48	60	72	84	96	108	120	132	144
Formers, forger's	1	1	1	1	1	1	1	1	1	1	1	1
Flatters, forger's	1	1	1	1	1	1	1	1	1	1	1	1
Floats, stocker's	1	1	1	1	1	1	1	1	1	1	1	1
Fullers and sets	3	3	3	3	3	3	3	3	3	3	3	3
Furnaces, portable	1	1	1	1	1	1	1	1	1	1	1	1
Gauges, sc. cutting	6	6	6	6	6	6	6	6	6	6	6	6
" graduating	1	1	1	1	1	1	1	1	1	1	1	1
" sliding	1	1	1	1	1	1	1	1	1	1	1	1
" assorted	200	200	200	200	200	200	200	200	200	200	200	200
" wire	1	1	1	1	1	1	1	1	1	1	1	1
Glue-pots	1	1	1	1	1	1	1	1	1	1	1	1
Gouges, stocker's	12	12	12	12	12	12	24	24	24	24	24	24
Grindstones, small	1	1	1	1	1	1	1	1	1	1	1	1
" large	1	1	1	1	1	1	1	1	1	1	1	1
Gravers	2	2	2	2	2	2	2	2	2	2	2	2
Hammers, set	1	1	1	1	1	1	1	1	1	1	1	1
" copper	1	1	1	1	1	1	1	1	1	1	1	1
" hand	1	1	1	1	1	1	1	1	1	1	1	1
Heading-tools	6	6	6	6	6	6	6	6	6	6	6	6
Hods, iron	1	1	1	1	1	1	1	1	1	1	1	1
Jumper boxes	4	4	4	4	4	4	4	4	4	4	4	4
" dies	16	16	16	16	16	16	16	16	16	16	16	16
Jigs, drilling	31	31	31	31	31	31	31	31	31	31	31	31
" filing	50	50	50	50	50	50	50	50	50	50	50	50
" tapping	6	6	6	6	6	6	6	6	6	6	6	6
" milling	5	5	5	5	5	5	5	5	5	5	5	5
" shaving	4	4	4	4	4	4	4	4	4	4	4	4
Knives, drawing	1	1	1	1	1	1	1	1	1	1	1	1
" stocking	2	2	2	2	2	2	4	4	4	4	4	4
Ladles, iron	1	1	1	1	1	1	1	1	1	1	1	1
Levellers, iron	2	2	2	2	2	2	4	4	4	4	4	4

Number and kind of Armorer's Tools, &c.—Continued.

Number of Workmen.	1	2	3	4	5	6	7	8	9	10	11	12
TOOLS.												
Measures, tape	1	1	1	1	1	1	1	1	1	1	1	1
" tin	1	1	1	1	1	1	1	1	1	1	1	1
Mills	244	244	244	244	244	244	244	244	244	244	244	244
Mandrels, forger's	3	3	3	3	3	3	3	3	3	3	3	3
" assorted	8	8	8	8	8	8	8	8	8	8	8	8
" boring	1	1	1	1	1	1	1	1	1	1	1	1
" band	6	6	6	6	6	6	6	6	6	6	6	6
Moulds, grind-wheel	1	1	1	1	1	1	1	1	1	1	1	1
" bullet	2	2	2	2	2	2	2	2	2	2	2	2
Oil-cans	1	1	1	1	1	1	1	1	1	1	1	1
Oilers	1	1	1	1	2	2	2	3	3	3	3	3
Oil-cups	1	1	1	1	2	2	2	3	3	3	3	3
Oil-stones	1	1	1	1	1	1	2	2	2	2	2	2
Pans, copper vitrioling	1	1	1	1	1	1	1	1	1	1	1	1
" tin	1	1	1	1	1	1	1	1	1	1	1	1
" annealing	1	1	1	1	1	1	1	1	1	1	1	1
" sheet iron	1	1	1	1	1	1	1	1	1	1	1	1
Pincers	1	1	1	1	1	1	2	2	2	2	2	2
Pliers	1	1	1	1	1	1	2	2	2	2	2	2
Planes, stocker's	7	7	7	7	7	7	14	14	14	14	14	14
Powder, canister	1	1	1	1	1	1	1	1	1	1	1	1
Plugs, calibre	5	5	5	5	5	5	5	5	5	5	5	5
" proving	1	1	1	1	1	1	2	2	2	2	2	2
Punches, assorted	4	4	4	4	4	4	4	4	4	4	4	4
" handled	2	2	2	2	2	2	2	2	2	2	2	2
" spring	1	1	1	1	1	1	1	1	1	1	1	1
Pails, wood	1	1	1	1	1	1	2	2	2	2	2	2
" iron washing	1	1	1	1	1	1	1	1	1	1	1	1
Pots, water	1	1	1	1	1	1	1	1	1	1	1	1
Rods, wiping	1	1	1	1	1	1	2	2	2	2	2	2
" rifling	1	1	1	1	1	1	2	2	2	2	2	2
Riflers	2	2	2	2	2	2	4	4	4	4	4	4
Reamers	28	28	28	28	28	28	28	28	28	28	28	28
Rules, carpenter's	1	1	1	1	1	1	1	1	1	1	1	1
Rests, filer's	1	1	1	2	2	2	3	3	3	3	3	3
Racks, movable	1	1	1	1	1	1	1	1	1	1	1	1
Stands, straightening bls.	1	1	1	1	1	1	1	1	1	1	1	1
Scales, graduated	1	1	1	1	1	1	1	1	1	1	1	1
" standard	1	1	1	1	1	1	1	1	1	1	1	1
Scales and weights	1	1	1	1	1	1	1	1	1	1	1	1
Saws, hand	1	1	1	1	1	1	1	1	1	1	1	1
" metal circular	1	1	1	1	1	1	1	1	1	1	1	1
" hack	1	1	2	2	3	3	4	4	6	6	6	6
" stocker's	1	1	1	1	1	1	1	1	1	1	1	1
" whip	1	1	1	1	1	1	1	1	1	1	1	1

Number and kind of Armorer's Tools, &c.—Concluded.

Number of Workmen.	1	2	3	4	5	6	7	8	9	10	11	12
TOOLS.												
Shovels, smith's	1	1	1	1	1	1	1	1	1	1	1	1
" steel	1	1	1	1	1	1	1	1	1	1	1	1
Screw-drivers	6	6	8	8	10	10	12	12	14	14	16	16
Screw-plates	7	7	7	7	7	7	7	7	7	7	7	7
Screw-stocks	1	1	1	1	1	1	2	2	2	2	2	2
Scribers	1	2	3	4	5	6	7	8	9	10	11	12
Sets, assorted	1	2	3	4	5	6	7	8	9	10	11	12
Saw-sets	1	1	1	1	1	1	1	1	1	1	1	1
Shears, hand	1	1	1	1	1	1	1	1	1	1	1	1
" bench	1	1	1	1	1	1	1	1	1	1	1	1
Sledges	2	2	2	2	2	2	4	4	4	4	4	4
Sows, cast iron	1	1	1	1	1	1	1	1	1	1	1	1
Soldering-copper	1	1	1	1	1	1	1	1	1	1	1	1
Spoke-shaves	1	1	1	1	1	1	1	1	1	1	1	1
Spring-proofs	1	1	1	1	1	1	1	1	1	1	1	1
Squares, 2-feet	1	1	1	1	1	1	1	1	1	1	1	1
" assorted	2	2	2	2	2	2	4	4	4	4	4	4
" trying	1	1	1	1	1	1	1	1	1	1	1	1
Stakes, iron	1	2	3	4	5	6	7	8	9	10	11	12
" lead	1	2	3	4	5	6	7	8	9	10	11	12
Stamps, letters	24	24	24	24	24	24	24	24	24	24	24	24
" figures	10	10	10	10	10	10	10	10	10	10	10	10
" eagles	1	1	1	1	1	1	1	1	1	1	1	1
Straight-edges	1	1	1	1	1	1	2	2	2	2	2	2
Swages	56	56	56	56	56	56	56	56	56	56	56	55
Swage-boxes	15	15	15	15	15	15	15	15	15	15	15	15
" dies	59	59	59	59	59	59	59	59	59	59	59	59
" jumpers	59	59	59	59	59	59	59	59	59	59	59	59
" bullet	2	2	2	2	2	2	2	2	2	2	2	2
Trimmers	2	2	2	2	2	2	2	2	2	2	2	2
Taps, metal	37	37	37	37	37	37	37	37	37	37	37	37
Tongs, grinder's	2	2	2	2	2	2	2	2	2	2	2	2
" smith's	30	30	30	30	30	30	30	30	30	30	30	30
Trowels, mason's	1	1	1	1	1	1	1	1	1	1	1	1
Tunnels, tin	1	1	1	1	1	1	1	1	1	1	1	1
Trucks, hand	1	1	1	1	1	1	1	1	1	1	1	1
Tool-cases	1	1	1	1	1	1	1	1	1	1	1	1
Target, iron	1	1	1	1	1	1	1	1	1	1	1	1
Vises, barrel	1	1	1	1	1	1	1	1	1	1	1	1
" bench	1	2	3	4	5	6	7	8	9	10	11	12
" hand	1	1	2	2	3	3	3	4	4	4	6	6
" foot	5	5	5	5	5	5	5	5	5	5	5	5
Wheels, polishing	6	6	6	6	6	6	6	6	6	6	6	6
Wrenches, patent	1	1	1	1	1	1	2	2	2	2	2	2
" assorted	6	6	6	6	6	6	6	6	6	6	6	6

List of Verifying Gauges for the Rifle Musket, Model of 1855.

Each set of gauges is distinguished by the term "RIFLE MUSKET, U. S.," and the number to correspond with those contained in the following list, with descriptions.

No.	FOR BARRELS.
1	*Calibre-Gauge:* Measures the size of the bore, .58 inch diameter.
2	*Groove-Gauge, No.* 1: Measures the depth of the groove at the muzzle, .585 inch.
3	*Groove-Gauge, No.* 2: Measures the depth of the groove at the breech, .595 inch.
4	*Dimension-Gauge, No.* 1: Shows the distance between flats, vertical diameter, position of top, left-hand bevel and oval, size of tenon at shoulder, ends of the two flats, and one bevel.
5	*Dimension-Gauge, No.* 2: Shows the exterior diameter of the barrel at the butt, at 1.5 inch, 2.5 inches, 5.5 inches, 9.875 inches, 21.5 inches, 33.25 inches, from rear end of barrel, and at top and bottom of bayonet-socket, and the length of the bayonet-socket.
5½	*Calliper-Gauge:* Corresponding with No. 5.
5¾	*Barrel-Holder:* Holds barrel and marks the above points for measurement.
6	*Receiving-Gauge:* Shows dimensions of barrel at butt, position and form of cone-seat, direction and position of tap for cone-screw, position of vent-screw, shape of tang, and position of tang-screw hole.
6½	*Rear-Sight Mortise Gauge:* Shows the position, depth, width, and bevel of mortise, and the position, size, and depth of rear-sight screw-hole.
7	*Gauge for Counterbore of Barrel:* Shows length and diameter of the counterbore.
7¾	*Tap-Gauge for Barrel-Thread:* Shows length, depth, and width of thread.
8	*Bayonet-Stud and Barrel-Muzzle:* Shows the height of stud, distance of stud from muzzle, and diameter of barrel at 3.03 inches from the muzzle.
9	*Front-Sight Gauge:* Shows height, length, and form of sight.
10	*Barrel, Sight, and Rod Gauge:* Shows position and mortise, screw-hole for rear sight, length of barrel, position of front sight, length of ramrod.
11	*Die-Gauge for Breech-Screw:* Shows size and commencement of thread, length of body, diameter of the body.

No.	FOR BARRELS.—*Continued.*
11½	*Limit-Gauge for Breech-Screw:* Shows maximum size of thread, limit of entrance of pin, diameter and length of stem.
	FOR LOCKS.
12	*Receiving-Gauge for Lock-Plate:* Shows the form of the lock-plate, and thickness.
13	*Lock-Plate Gauge:* Shows thickness of plate and bevel, thickness of plate, notch for main-spring, thickness of bolster and plate, height of bolster-body, and height at notch.
14	*Tumbler-Gauge:* Has a receiving cavity to show the form of tumbler, diameter of arbor and square, thickness of body, length of arbor and square, taper of square, size of pivot, position of swivel-pin hole and swivel-slot.
14½	*Tumbler-Gauge, No. 2:* Tests the thread in the tumbler.
15	*Bridle-Gauge:* Shows the form of the bridle, position of the pivot and stud, thickness of body, and thickness at eye.
16	*Sear-Gauge:* Receiving cavity shows form of sear, height and form of tang, freeing of sear, thickness of tang, width of nose, and width at eye.
17	*Hammer-Gauge:* Shows form of hammer and position of hole for square of tumbler, with a drift for size of tumbler-hole, and form of knife-edge.
18	*Dimension-Gauge:* Shows thickness of body at tumbler-hole and bevel, thickness of body, profile of comb, width of comb and shape of back, curve of front of comb at start of body, thickness and curve of head, curve of top of comb, depth and size of countersink, crook of body.
19	*Lock Screw-Hole Gauge:* Shows position of all holes on the inside of the lock-plate.
20	*Magazine-Gauge:* Shows position and form of magazine, position and size of finger-spring screw-hole, and position of hinge-stud.
21	*Magazine-Gauge, No. 2:* Shows depth of magazine, depth and width of magazine-throat, position and size of hinge-stud, size and depth of mortise above and below stud.
22	*Main-Spring Gauge:* Shows the curve of long branch, freeing of spring, shape of spring at hook, position of pivot and relative position and thickness of the two branches, length of short branch, shape of tang, width of hook, width of long branch opposite extremity of short branch, width of body, curve of bend, form of slot for swivel.

FOR LOCKS.—*Continued.*

No.	
$22\frac{1}{2}$	*Main-Spring Gauge, No. 2:* Shows the thickness of long branch close to the hook, opposite the end of short branch, close to stud, thickness of short branch close to tang, opposite to stud, and at centre of tang, and height above top of tang-slope.
23	*Sear-Spring Gauge:* Shows spread of spring, length of arm, size of stud and freeing of small branch, position of stud and pin-holes, thickness of metal at eye, width at small end, width of metal at body, width of body adjoining eye.
24	*Tap-Gauge for Lock-Screws, Trigger, Vent, and Bayonet-Clasp Screws:* Shows the length, diameter, and thread of each.
25	*Cover-Catch, Feed-Finger Spring, and Lock-Swivel Gauge:* Shows the profile of the cover-catch, length and thickness of foot, body, and head, shape of head, finger-spring, shape and width at bend for screw, shape and position of swivel-pin holes, position and size of arms, length of arms, and thickness of body.
26	*Feed-Finger Gauge:* Shows form of finger, position of stud, length, thickness at stud, thickness of body, width of finger.
27	*Magazine-Cover Gauge:* Shows form of cover, position of catch-notch, thumb-nail notch, position and distance between jaws, size of rivet-hole, thickness of jaws, round of jaws, chamfer of cover, thickness, diameter of jaws.

LEAF-SIGHT, MODEL OF 1859.

No.	
1	*Gauge for Base, No. 1:* Shows the profile of side of base, thickness of fence and distance between fences, length of base inside, width and form of curve at rear end, length of curve and position of screw-hole and steady-pin on under side, thickness of head, body, and diameter of the screw, length of screw.
2	*Gauge for Base, No. 2:* Shows the position of the screw and steady-pin holes and slot for the tenon, as in the barrel.
3	*Gauge for First Leaf:* Shows the length, width, and thickness, thickness of ears, distance between ears, and position as assembled.
4	*Gauge for Second Leaf:* Shows the form of the side of the 100-yard range, form of the side of 300-yard range, width of leaf, thickness, width of joint, and position as assembled; showing the form and position of notches, and the angle of inside and outside of leaf.
5	*Gauge for Joint-Screw:* Shows the length, diameter and thickness of head, diameter of body, and size of thread.

No.	MOUNTINGS, ETC.
30	*Butt-Plate Gauge, No.* 1: Receives the plate and shows its form, position of screw-holes, position and size of notch for patch-box.
31	*Butt-Plate Gauge, No.* 2: Shows thickness of heel, thickness of toe, thickness at corners, thickness of body, lateral curve across body, lateral curve across tang, longitudinal curvature of bottom of plate.
32	*Butt-Plate and Guard-Screw Gauge:* Shows form of head and reinforce, diameter and length of stem, the shape of thread.
33	*Band-Gauge:* Shows width and thickness of body, width and thickness of swivel-stud for middle band and guard-bow stud, round of stud, thickness of swivel and stud, size of swivel-wire.
34	*Band-Mandrel Gauge, No.* 1: Shows interior of upper band.
35	*Band-Mandrel Gauge, No.* 2: Shows interior form of middle band.
36	*Band-Mandrel Gauge, No.* 3: Shows interior form of lower band.
37	*Guard-Plate Gauge:* Receives the plate and shows its form, position of stud for trigger and slot, position of screw-holes, position of guard-bow holes and tang-screw hole.
38	*Guard-Plate and Bow-Gauge:* Shows diameter of trigger-stud, thickness of plate at bolsters, thickness of body, shape of exterior, profile across bolsters, position and size of trigger-slot, width and shape of upper and lower sides of bow, taken at the middle, width of swivel-joint, diameter of collar, diameter of stem, thickness at middle of bow, diameter between collar and swivel-stud, diameter of nut, thickness of nut, relative position of swivel-stud, collar, stem, and screw, screw-thread.
39	*Trigger-Gauge:* Receiving-slot, showing thickness and shape of blade, curve of finger-piece, position and size of pivot-hole, curve of under side of finger-piece, and thickness of metal at finger-end.
40	*Band-Spring Gauge:* Receiving-slot, showing size, form, and set of spring and position of wire and shoulder, three gauges for lengths of wire, thickness at shoulder, thickness of stem, width of stem, and diameter of wire.
41	*Washer-Gauge:* Shows countersink for screw-head, size of the hole for screw, diameter of washer, thickness of washer, and depth of countersink.
42	*Side and Tang Screw Gauge:* Shows diameter of head of side screw, diameter of stem, diameter of thread, length of both side screws, countersink for the shoulder

No.	MOUNTINGS, ETC.—*Continued.*
	of tang-screw, diameter of head, of stem, of thread, and length of screw.
43	*Rod-Stop-Gauge:* An iron pattern, complete.
	BAYONET.
44	*Receiving-Gauge:* Shows length, width, and set of blade.
45	*Socket-Gauge, No. 1:* Shows exterior diameter of socket below bead, and diameter of bead
46	*Socket-Gauge, No. 2:* Shows exterior diameter of socket at top and bottom.
47	*Mandrel-Gauge:* Shows form of socket at lower end, size of cut for stud, length of socket, size of grooves, position of clasp.
48	*Blade-Gauge:* Shows curve of front flute, the thickness of metal at commencement of front flute, at 7½ inches and 14½ inches from widest point of blade.
49	*Dimension-Gauge:* (To be applied before the clasp is put on.) Shows position and size of socket at clasp-stud, position and size of clasp-stud, relative position of bridge-bead and clasp-stud, distance from top of slot to top of socket.
50	*Neck-Gauge:* (To be applied before the clasp is put on.) Shows lower curve of neck, upper curve of neck, diameter of neck, and relative position of neck, bead, and bridge.
50½	*Neck-Gauge, No. 2:* Shows curves of junction of neck and socket.
51	*Blade-Gauge:* Shows profile of back of blade at the commencement of back flutes, at termination of bevel, at middle of blade, and 1 inch from point of blade, and the width of blade at the above-mentioned points.
	RAMROD.
52	*Rod-Gauge:* Shows profile of head, neck, and swell for 6¼ inches, diameter of head, diameter at 2.5 inches, diameter at 5 inches, diameter of body at 7 inches, 18.5 inches, 30 inches from large end, diameter at start of thread, and form of cup; the thread same as in model of 1840; length, 39.625 inches.
52½	*Rod-Holder:* Marks points at 2.5 inches, 5, 7, 18.5, and 30 inches from large end, at start of thread, and gives true length of rod.

STOCK.

No.

53 *Profile-Gauge:*
Shows the curve or shape, length, position of bands, tip, and shape of butt.

54 *Bayonet-Clasp Mandrel-Gauge:*
Shows exterior and interior size of clasp when the screw is in its place.

55 *Clasp-Dimension Gauge:*
Shows thickness of body, thickness at bridge, width of stud, width of body at notch, position of screw-hole, round of stud, receiving-tool for form and size of finished clasp, with position of bridge and notch.

56 *Tip-Gauge:*
Shows circular cut for barrel, cross-section of base of tip, with cut for rod-groove, profile of under side and barrel at end.

56½ *Tip-Gauge, No.* 2:
Shows inside of tip.

57 *Cone-Gauge:*
Shows size and thickness of collar, thread for screw, size of body, size of bottom of cone, size of tip, profile, size of top, throat, and lower part of vent-hole, upper surface, square and diameter of collar.

58 *Screw-Driver Gauge:*
Long branch: shows form of edge, form of end, width across centre below rivet, size of wrench, thickness of head, of body, of wrench, of end of blade.
Short branch: shows thickness of body, width of body, width of end, thickness of end, size of rivet-hole.

59 *Wiper:*
Shows the diameter of branches, thickness of head, form of head, size of thread.

60 *Ball-Screw:*
Shows length and form of screw, diameter of collar, diameter of body, size of thread for rod.

65 *Barrel-Gauge:*
Shows the number of threads and length of body for breech-screw, to be applied in the barrel.

66 *Tip-Screw Gauge:*
Shows the length, size of head, body, thickness of head and thread.

67 *Stock-Gauge:*
Shows thickness across end of centre of butt and bed of lock-plate, at the bands and tip, at flats near tang, and at end of box-mortise.

68 *Receiving-Gauge:*
Shows the form, size, and length of the stock, the shoulders for the butt end of the barrel, the bands, and the tip.

Gauges for Rifle, Model of 1855.

Nos. 1 to 4, 6, 7, 11 to 27, 30 to 33, 35, 37 to 43, and 57 are the same as for the rifle musket.

No.	GAUGES FOR RIFLE, MODEL OF 1855.—*Continued.*
5	*Barrel-Gauge:* Shows the diameter of the barrel at the muzzle and other points indicated by No. 65.
8	*Bayonet-Stud Gauge:* Shows length of stud, distance from muzzle to lower end of stud, thickness and form of stud
9	*Front-Sight Gauge:* Shows height and form of front sight.
10	*Sight-Gauge, No. 2:* Shows the position of the front sight and of the mortise and screw-hole for the rear sight.
34	*Band-Mandrel Gauge, No. 1:* Shows interior of upper band.
36	*Band-Mandrel Gauge, No. 3:* Shows interior of lower band
52	*Ramrod-Gauge:* Shows profile of head, neck, and swell, and diameter of head, neck, swell, and body.
53	*Profile Stock-Gauge:* Shows length and curve of stock, and position of bands and tip.
56	*Tip-Gauge:* Shows length of tip and exterior form at upper and lower end.
61	*Box-Spring Gauge:* Shows length, width, and thickness of spring, and position of rivet and screw holes.
62	*Box-Cover Gauge:* Shows profile of cover and position of screw-holes and rivet-hole for spring.
63	*Box-Cover Gauge, No. 2:* Shows curve of top and thickness of cover.
64	*Ramrod-Holder:* Shows gauging-points for ramrod.
65	*Barrel-Holder:* Shows gauging-points of barrel.
	SWORD BAYONET.
66	Shows profile of back of blade and back of hilt.
67	Shows width and thickness of blade.
68	Shows width and thickness of hilt.
69	Shows profile of back and front of hilt and guard.
70	Shows position and depth of slot in hilt.
71	*Finger-Piece Gauge:* Shows the diameter and length of body, diameter, length, and form of head, and thickness and length of finger-piece spring.
72	*Tompion-Gauge:* Shows length of head and body, diameter of head, neck, collar, and body.

SWORDS AND SABRES.

NOMENCLATURE.

Cavalry Sabre. (Plate 28.)

Blade.—Shoulder, back, edge, bevel, point, curvature, large groove, small groove; *tang*, riveting.

Hilt.—*Pommel*, (brass,) notch for the guard, back, rivet-cap, hole for the tang of the blade; *gripe*, wooden body, (birch or maple,) leather covering, (calf-skin blackened,) wires, (brass,) notch for the guard, ridges, shoulder, hole for the tang of the blade.

Guard.—*Front branch*, hook; *back branch; middle branch; plate*, mortise for the tang, flange, bead, lip.

Scabbard, (sheet steel.)—*Body*, back, front, sides, holes for the rivets; *mouth-piece*, rim, springs, rivet-holes; 2 *rivets;* 2 *bands*, knob, eye for the ring; 2 *rings; tip*, front branch, back branch.

Light Cavalry Sabre.

The nomenclature the same as the cavalry sabre.

This sabre differs from that above in being shorter and lighter.

Light Artillery Sabre. (Plate 28.)

The nomenclature is the same as the cavalry sabre, with the following exceptions:—

Blade.—Has but one groove.

Hilt.—*Guard*, one branch terminating in a scroll; the plate has 2 countersinks,—one for the gripe, the other for the scabbard.

Scabbard.—*Spring*, fastened to the back by 1 *rivet*.

Foot Artillery Sword. (Plate 28.)

Blade.—Straight, two-edged, narrower near the hilt than in the middle; *body*, (or blade proper,) shoulder, shoulder-rounding, ridges, point, bevels, edges; *tang*, its rounding and riveting, three holes for the gripe-rivets.

Hilt, (brass, in one piece.)—Cross, knob and panel of the cross, mortise for the tang, gripe, fillet, necks, swell, knob with an *eagle* on each side, bolster and hole for the tang-rivet, grooves and ridges, three holes and bolsters for the gripe-rivets; 3 *rivets*, (iron.)

Scabbard, (harness-leather, jacked, blackened, and varnished.)—*Body*, edges, inner and outer sides; *mountings*, (brass;) *ferrule*, stud, bead, cap;

safes, (buff-leather;) 4 *nails* for the ferrule and safes; *tip*, bead, knob; 4 *nails* for the tip.

Non-Commissioned Officer's Sword. (Plate 28.)

BLADE, (straight, cut and thrust.)—Back, edge, groove, bevel, point.

HILT.—*Pommel,* (brass,) notch for the hook of the guard, rivet-cap, shoulder for the ferrule, hole for the tang; 2 *ferrules; gripe,* wooden body, hole for the tang; *covering,* (sheet brass,) grooves and ridges.

GUARD, (in one piece.)—*Branch,* hook and its shoulder; *plate,* flange, bead; *knob.*

SCABBARD, (leather.)—*Ferrule and hook,* (brass;) *tip,* (brass,) body, front branch, back branch.

This sword is for the non-commissioned officers of *foot troops.*

Musician's Sword.

The same as the non-commissioned officer's sword, without the guard-*plate,* and with a blade six inches shorter.

Sabre for Staff and Field Officers. (Plate 28.)

BLADE.—Shoulder, back rounded, edge, bevel, point, tapering nearly equal from edge and back, curvature slight; large groove, small groove; *tang,* riveting; etched vine on back; letters "U.S.," guns, drums, colors and rays on left side; eagle, guns, colors, and rays on right side

HILT.—*Pommel,* (brass, gilded,) notch for guard, scrolled back, rivet-cap, hole for the tang of the blade; *gripe,* wooden body, (birch or maple,) seal-skin covering, (blackened,) wire, (fine brass, richly gilded,) notch for guard, ridges, shoulder, hole for the tang of the blade.

GUARD.—*Front branch,* hook; *back branch; middle branch;* letters "U.S." and open scroll-work between branches; *plate,* (brass, gilded,) bead, flange, scroll, lip, mortised for tang of blade and for strap of sword-knot.

SCABBARD, (sheet steel, browned.)—Interior lining well-seasoned bass-wood; *body,* back, front, sides, holes for screws; *mouth-piece,* (brass, gilded,) rim; 2 *bands,* (brass, gilded,) knob, eye for the ring, screws, and screw-holes; 2 *rings,* (gilded;) *tip,* (gilded,) screw, screw-hole, front and back branch.

Sword for Officers of the Staff and Staff Corps. (Plate 28.)

BLADE.—Straight, two edges, with an arris in the middle between the edges; etched scrolls, colors, and shield on the left side; eagle, guns, colors, and scrolls on the right side; *tang,* riveting.

HILT, (brass, chased and gilded.)—*Pommel,* an inverted frustum of a cone, with an eagle chased on one side.

GUARD.—*Principal branch*, chased, mortise for the sword-knot, shoulder for the lower ferrule; *fixed shell*, bearing an eagle and flags, chased; *movable shell*, plain; *button* for the spring; *cross-bar*. *Gripe*, (black horn,) wrapped spirally with gold cord; 2 *ferrules*, chased. Weight of sword, 1.2 lb.

SCABBARD, (steel or leather.)—The steel scabbard has 2 *brass bands and rings*, gilded and chased; *tip; mouth-piece*, (brass.) The leather scabbard has *brass ferrule* and *hook-tip*. Weight of steel scabbard, 0.69 lb.

Sword for Foot Officers. (Plate 28.)

The nomenclature is the same as for the staff officer's sword, except as follows:—

BLADE.—Etched, guns, colors, and rays on the left side; shield, colors, and rays on the right side.

GUARD.—It has no middle branch nor letters.

SCABBARD, (sole-leather, jacked, fluted, blackened, and varnished.)—*Body*, back, front, sides, boles for screws; *mouth-piece* and top band united, (brass, gilded,) rim, band, knob, eye for ring, screw, and screw-hole; *band*, (brass, gilded,) knob, eye for ring, screw, and screw-hole; 2 *rings*, (gilded;) *tip*, (brass, gilded,) fluted, screw and screw-hole, front and back branches.

Sabre for Cavalry Officers.

The same as the cavalry sabre, or light cavalry sabre, with gilt mountings.

Principal Dimensions and Weights of Swords and Sabres.

DIMENSIONS.	Cavalry Sabre.	Light Cavalry Sabre.	Light Artillery Sabre.	Foot Artillery Sword.	Non-Com. Officer's Sword.	Musician's Sword.	Staff Officer's Sabre.	Foot Officer's Sword.
	In.	In.	In.	In.	In.	In.	In.	In.
Whole length of the sword or sabre in its scabbard	43.25	42.35	38.6	26.	38.75	32.75	39.4	37.85
Length of the blade proper	36.	34.80	32.	19.	32.0	26.0	32.4	32.2
Length of the scabbard	37.25	36.05	33.	20.	32.8	29.0	32.2	31½&33
Width of the blade in the middle	1.1	1.	1.06	1.8	0.72	0.72	1.1	1.1
Versed sine of the curvature of the blade in the middle	1.5	1.42	2.32	....	....	....	0.4	0.4
Versed sine of the curvature of the blade in proof	7.5	7.20	6.5	....	6.5	....	....	....
WEIGHTS.								
	lbs. oz.	lbs. oz.	lbs. oz.	lbs. oz.	lbs. oz.	lbs. oz.	lbs. oz.	lbs. oz.
Weight of the sword or sabre complete	4 8	3 7	4 1½	3 3	2 5	....	3 10¼	3 0¾ / 2 15¼
Weight of the finished blade	1 9	1 6	....	1 9	....	....	....	
Weight of the scabbard	2 2	1 4	....	10	....	....	1 9¼	1 0¾ / 1 0¼

Proof and Inspection of Swords and Sabres.

1st. The dimensions and form of the *blade* are verified by comparing it with the model, and by applying the appropriate gauges and patterns, for the length, width, and thickness at several points, and the curvature, if any.

2d. The *blade* is then proved, as follows:—1st. The point is confined by a staple, and the blade is bent on each of the flat sides over a cylindrical block, the curvature of which is that of a circle 35 inches diameter, the curvature of the part next the tang being reduced by inserting a wedge 0.7 inch thick at the head, and 14 inches long. 2d. It is struck twice, on each of the flat sides, on a block of oak wood, the curvature of which is the same as the above. 3d. It is struck twice on the edge and twice on the back across an oak block 1 foot in diameter. 4th. The point is placed on the floor and the blade bent until it describes an arc having the versed sine indicated in the above table. After these trials, the blade is examined to see that it is free from flaws, cracks, or other imperfections, and that it is not *set*,—that is to say, does not remain bent.

The blade of the *artillery sword* is proved by striking each of the sides and edges twice on a flat block of hard oak wood.

The stamp of approval or condemnation is placed on the side of the blade, below the tang.

3d. The form, dimensions, and workmanship of the *mountings* are examined and compared with the model. After the blade is mounted, the sword is again examined, and it is struck four times on a hard block of wood, to test the strength of the mountings. The quality of the brass mountings may be tested by breaking a certain number, not more than 4 in each hundred, which should be taken from the pieces rejected for erroneous dimensions.

4th. The form, workmanship, and finish of the *scabbards* are examined and compared with the model, and their fitting to the blades tested. The sewing of leather scabbards, and the fastening of the ferrules and tips, will be particularly examined.

Steel scabbards are proved by letting fall on them, from a height of 18 inches, an iron weight of two pounds, 1 inch square at the base: 1st, on one side, just above the upper band; 2d, on the same side, 6 inches from the tip; 3d, on the opposite side, just above the lower band. In this proof the scabbard should not remain indented. The nature of the material (whether iron or steel) may be tested, if there be any doubt, by using nitric acid, which will leave a black spot on the steel but not on the iron.

Packing Swords and Sabres.

Packing-boxes for swords and sabres are made on the same principles as those for muskets and other small arms, being furnished with packing-boards, or partitions, made with grooves to receive the scabbards near the hilt and near the point; the swords are placed in their scabbards, with the hilts and points alternately toward each end of the box,—except the artillery swords, two of which are placed in the length of the box, their points resting on a packing-board in the middle.

Number packed in a box.

30 cavalry sabres.	50 artillery swords.
50 artillery sabres.	50 infantry swords.

Cleaning Swords and Sabres.

The iron and brass parts of swords and sabres are cleaned in the same manner as those of muskets. When the oil on the blade of a sword is dried up, it will leave a spot which may be removed by covering it with oil and rubbing it smartly, after a short time, with a linen rag. When a leather scabbard has become wet, draw the blade, and dry the scabbard slowly without heating it; wipe the blade dry, and pass an oiled rag over it and the scabbard before returning the blade. Oil the blades of arms in store, and also the scabbards, especially on the seams.

Spare Parts required for Repairs of 1,000 Swords or Sabres for one year in the field.

Parts.	Cavalry Sabre.	Light Artillery Sabre.	Non-com.Officer's or Musician's Sword.
Gripes	50	50	....
Gripes and ferrules	......	......	50
Heads	50	50	50
Guards	50	50	50
Bodies for leather scabbards	......	......	100
Mouth-pieces and springs	50	50	....
Ferrules and stud-hooks	......	......	75
Upper bands and rings	50	50	....
Tips	......	......	100
Lower bands and rings	50	50	....

ACCOUTREMENTS.

Infantry Accoutrements.

CARTRIDGE-BOX,* for .58-in. ball, (black bridle-leather,) *inner cover*, (light upper-leather,) with end pieces sewed to it to cover the ends of the box; *flap*, with a *button-hole strap* sewed near the bottom; *brass button*, riveted to the bottom of the box; *implement-pocket*, (light upper-leather,) sewed to the front of the box, with a *flap*, *strap*, and *loop; 2 loops* on the back of the box, near the top, for the *shoulder-belt* to pass through; 2 *upright loops* for the *waist-belt* to pass through, sewed, and riveted with 1 copper rivet No. 8 at each end; 2 *roller-buckles* No. 9, (japanned black,) for the shoulder-belt, sewed to the bottom of the box; 2 *tins*, each with 1 *lower division*, open in front, to contain 1 bundle of 10 cartridges, and 2 *upper divisions*, one to contain 6 and the other 4 cartridges. The edges of the tin are turned over and soldered down to prevent them from cutting the cartridges. All the tin linings should be made to slide freely in the boxes.

CARTRIDGE-BOX for .69-inch ball. It is like the above, except in dimensions, for which see page 230.

CARTRIDGE-BOX for. 69-inch round ball. The same as the above, except in dimensions.

CARTRIDGE-BOX PLATE, (brass.)—Oval, 3.5 inches by 2.2 inches, with the letters U. S. stamped on it; 2 *eyes* of iron wire, for fastening the plate to the flap of the box.

CARTRIDGE-BOX BELT, (black buff-leather.)—Width, 2.25 inches; length, 55.5 inches, clear of the 2 *billets* for buckles, which are each 4.25 inches long and 0.875 inch wide.

CARTRIDGE-BOX BELT-PLATE, (brass.)—Circular, 2.5 inches diameter, stamped with an *eagle; 2 eyes*, of iron wire.

CAP-POUCH, (black bridle-leather.)—Length and depth, 3 inches; width, 1.25 inch; *inner cover*, with end pieces; *flap*, made of the same piece as the back, with a button-hole strap at the bottom; *brass button*, riveted under the bottom of the pouch; 2 *loops*, sewed to the back, 2.25 inches long, to admit a waist-belt of 2 inches; *lining*, a strip of sheep-skin, with the wool on, 1.5 inch wide, glued with fish-glue, and sewed to the back, at the mouth of the pouch.

CONE-PICK, (steel wire No. 18.)—1.5 inch long, with a ring handle 0.5 inch diameter; it is carried in a loop in the inner left-hand corner of the cap-pouch.

BAYONET-SCABBARD, (black bridle-leather.)—Length, including the fer-

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* New boxes have been ordered to be made, with a view of substituting two small boxes for the one large one.

rule and tip, for the bayonets of the model of 1855 and 1840, 19.5 inches; for model 1820, 18 inches; *ferrule and tip*, brass; *frog*, (black buff-leather,) sewed and riveted with 2 copper rivets No. 8 to a socket of black leather which is fastened to the top of the scabbard; the frog slides on the waist-belt.

WAIST-BELT, (black buff-leather.)—Width, 1.9 inch; length, 38.5 inches; a *loop* at one end.

WAIST-BELT PLATE, (brass.)—Oval, 3.5 inches long by 2.25 inches wide, stamped with the letters U. S.; 2 *studs* and 1 *hook*, (brass.)

GUN-SLING, (russet bag-leather.)—Width, 1.25 inch; length, 46 inches; 1 *standing and* 1 *sliding loop; hook*, (brass,) fastened to the sling with 2 *brass rivets* No. 15 wire.

SWORD SHOULDER-BELT, for non-commissioned officers, (black buff-leather.)—Width, 2.3 inches; length of short branch, 17 inches; long branch, 40 inches; 1 *standing-loop* on long branch; *frog* for sword.

SHOULDER-BELT PLATE.—Like the cartridge-box belt-plate, except in having 3 *hooks*, instead of eyes.

SERGEANT'S AND MUSICIAN'S WAIST-BELT, (black buff-leather.)—Length, 36 to 40 inches; width, 1.9 inch; 1 *brass hook* on one end, fastened with 3 *brass wire rivets* No. 15; 1 *brass loop* sewed to the other end, to connect with the plate.

SERGEANT'S WAIST-BELT PLATE.—The same as the *sabre-belt plate.*

SCABBARD FOR NON-COMMISSIONED OFFICER'S SWORD, (light bridle-leather,) jacked, blacked, and varnished.—1 *ferrule*, (brass,) with 1 *hook* (cast brass) riveted to it by 2 *brass wire rivets* No. 15, fastened to the scabbard with glue and 4 *brass wire rivets* No. 15; 1 *tip*, (brass,) fastened to the scabbard with glue and 4 *brass wire rivets* No. 15.

SCABBARD FOR THE MUSICIAN'S SWORD.—The same as that for the non-commissioned officer's sword, except in length.

Rifle Accoutrements.

The same as for the infantry accoutrements, except the waist-belt for the sword-bayonet and the sword-bayonet scabbard.

WAIST-BELT FOR SWORD-BAYONET, (shoe-leather, dressed on the flesh-side.)—Length 42.5 inches, width 2.4 inches; 1 *billet* .9 inch wide, sewed on the inside at each end to hold the clasps in place; 1 pair *clasps*, 2 parts, (brass,) to slide on the belt; 2 *loops*, with eyes, (brass,) to slide on the belt; *frog* for sword-bayonet scabbard, with 1 *billet;* 1 *brass buckle* No. 10, and 1 *standing loop*.

SWORD-BAYONET SCABBARD, (black bridle-leather.)—Length, including ferrule and tip, 23 inches; 1 *ferrule* and 1 *tip*, (brass;) 1 *loop* (brass) on the ferrule for the frog-billet to pass through.

Cavalry Accoutrements.

CARTRIDGE-BOX FOR CARBINE.—Like the infantry cartridge-box, except in dimensions. 2 loops are placed upright on the back of the box, to receive a 2-inch waist-belt. Special boxes are made for the carbines now on trial in the hands of troops.

CAP-POUCH. }
CONE-PICK. } —The same as for the infantry.

SABRE-BELT, (buff-leather.)—*Waist-belt*, length 36 to 40 inches, width 1.9 inch; 1 *square loop* No. 46, 2 *D rings* No. 2 B, (brass,) for attaching the slings and the shoulder-strap; 1 *hook*, (brass,) riveted on one end by 3 brass wire rivets No. 15; 1 *loop*, (cast brass,) sewed on the other end to connect with the plate; 1 *shoulder-strap*, 41 inches long, 1.125 inch wide, with 2 *hooks*, (brass;) 2 *sabre-slings*, 1.125 inch wide; front sling 17 inches long, rear sling 34 inches; 4 *studs* (brass) for slings; 1 *sabre-hook*, (brass wire No. 7.)

SABRE-BELT PLATE, (cast brass.)—Rectangular, 3.5 inches long, 2.2 inches wide, with an *eagle* surrounded by a *wreath*, (German silver;) 1 *slot* at one end, to receive the belt.

SWORD-KNOT, (buff-leather.)—*Strap* 1 inch wide, 36 inches long; one end of the strap is fastened to a *tassel* 3 inches long; the other end is passed through the tassel after going round the guard of the sabre, and is fastened by one of the tags of the tassel; 1 *sliding-loop*.

CARBINE-SLING, (buff-leather.)—Length 56 inches, width 2.5 inches; 1 *buckle* and 1 *tip*, (brass,) *swivel* and *D* with *roller*, bright iron, 2.62 inches wide; *link* and *hook*, iron; *guard-spring*, steel.

Artillery Accoutrements.

FOR LIGHT ARTILLERY.

SABRE-BELT, (black buff-leather.)—Length 36 to 40 inches, width 1.9 inch; 2 *leather chapes* sewed on the outside of the belt for attaching 2 *brass loops* No. 6, for the slings; 2 *sabre-slings* and 4 *brass studs*, like those for the cavalry sabre-belt; 1 *sabre-hook*, (brass wire No. 7;) 1 *loop* (cast brass) sewed on one end to connect with the plates; 1 *hook* (brass) riveted to the other end with 3 *brass wire rivets* No. 15.

SABRE-BELT PLATE. }
SWORD-KNOT. } —Like those for the cavalry.

FOR FOOT ARTILLERY.

SWORD-BELT, (buff-leather,) made in three pieces, 1.9 inch wide, connected together by 2 *loops* (brass) No. 1 B. *Long branch* 24 inches long; *frog-piece* 4.5 inches; *short branch* 4 inches; 1 *frog*, 3.5 inches deep, 2.5 inches wide at top, and 2.3 inches at bottom, suspended to the loops by 2 *slings* 1.3 inch wide and 3.5 inches long; 1 *loop* (cast brass) sewed on one end to connect with the plate; 1 *hook* (brass) riveted to the other end with 3 *brass wire rivets* No. 15.

Sword-belt plate.—Like that for the cavalry sabre-belt.

Foot artillery sword-scabbard, (light bridle-leather,) jacked, blackened, and varnished.—Length, including the ferrule and tip, 20 inches; width, 2 inches; *ferrule* (brass) has 1 *stud* riveted to it, and is fastened to the scabbard by 4 *brass wire rivets* No. 15; 1 *tip* (brass) fastened to the scabbard by 4 *brass wire rivets* No. 15; 2 *safes* (black buff-leather) placed on the sides of the mouth of the scabbard.

Inspection of Accoutrements.

Examine the materials of which they are made.

The bridle, shoe, sole, calf, and russet leather should be tanned with oak bark: reject all that has heen tanned with hemlock, as such leather soon moulds, and the blacking turns of a reddish color.

The leather should be of the best quality, uniform in thickness, and free from cuts and fly-holes. Flesh split-leather is not admitted. The buff-leather should be soft and flexible, free from defects. When freshly cut, it should present a bright-yellow surface; a brownish-yellow color indicates that the hide has been burned by the lime in tanning. It should be firm without being horny, and not spongy.

See that the hooks of cast brass are free from flaws, and that the eyes are firmly fastened.

Dimensions of Cartridge-Boxes.

		Infantry.			Carbine.
		For .58-balls.	For .69-balls.	For .69 round.	
		In.	In.	In.	In.
Interior of box	Length	6.8	7.8	7.2	7.2
	Width	1.4	1.6	1.6	1.6
	Depth in front	5.2	4.7	5.8	5.0
Inner cover	Width	3.8	4.0	4.0	.....
Flap width	at top	8.0	9.0	8.0	......
	at bottom	8.3	9.4	8.5	......
Implement-pocket	Length	6.2	7.0	6.0	......
	Depth	3.5	3.7	3.5	......
Tins. Lower	Length	3.2	3.8	3.3	3.3
	Width	2.7	2.7	3.0	2.8
Tins. Upper	Depth	2.3	1.9	2.7	2.8
Tins. Upper. Small	Length	1.4	2.2	1.35	......
	Width	1.3	1.5	1.35	......
Tins. Upper. Large	Length	2.0	1.5	2.0	......
	Width	1.4	1.5	1.35	......
Box complete	Weight ... lbs.	1.67	1.76	1.76	.....

Copper Rivets.

	Head.		Body.	
	Diameter.	Thickness.	Length.	Diameter.
	In.	In.	In.	In.
No. 8	.45	.05	.5	.15
No. 12	.3	.04	.375	.1

Spare Parts for Accoutrements for one year in the field.

For 1,000 *Infantry Accoutrements.*

25 cartridge-box plates.
50 " " belt-plates.
100 waist-belt plates.
100 cone-picks.

For 1,000 *Cavalry carbine-slings.*

150 swivels.
150 swivel-springs.

MATERIALS REQUIRED FOR MAKING ACCOUTREMENTS.

Leather.

19 Infantry cartridge-box belts. 34 Waist-belts 1.9 in. wide. 34 Non-com. officer's sword-belts. 25 Shoulder sword-belts. 200 Bayonet-scabbard frogs. 15 Waist-belts for sword bayonet. 15 Cavalry sabre-belts. 20 Light artillery sabre-belts. 20 Foot artillery sword-belts. 20 Carbine-slings. 70 Sabre-knots.	Either of these can be cut out of one hide of buff-leather.
7 Cavalry sabre-belts. 8 Waist-belts for sword bayonet. 9 Carbine-slings.	Either of these can be cut out of one side of heavy upper shoe-leather dressed on flesh-side.

40 Gun-slings—out of one butt hide of bag-leather.
11 Infantry cartridge-boxes, except pockets and inner covers, out of one side of heavy bridle-leather.

27 Bayonet-scabbards. 22 Sword-bayonet scabbards. 22 Non-com. officer's sword-scabb'd. 25 Musician's sword-scabbards. 22 Foot artillery sword-scabbards.	Either of these can be cut out of one side of light bridle-leather.
50 Pockets for infan. cartridge boxes. 50 Inner covers for do. do. 40 Tops for cap-pouches. 40 Inner covers for cap-pouches.	Either of these can be cut from oue side of light upper-leather.

Thread.

100 Infantry cartridge-boxes	1.25	lbs.	No. 3. *White* shoe-thread, waxed with rosin-wax.
100 Gun-slings	.13	"	
100 Cap-pouches	.5	"	
100 Bayonet-scabbards	.3	"	
100 Sword-bayonet scabbards	.2	"	
100 Non-com. officer's sword-scabbards.	.3	"	
100 Musician's or foot artillery do	.2	"	
100 Carbine-slings	.08	lb.	No. 3. *Black* shoe-thread, waxed with rosin-wax.
100 Non-com. officer's waist-belts	.08	"	
100 Cavalry sabre-belts	.4	"	
100 Light artillery sword-belts	.3	"	
100 Foot artillery sword-belts	.8	"	
100 Sword bayonet waist-belts	.7	"	
100 Non-com. officer's sword-belts	.33	lb.	No. 3. *Black* shoe-thread, waxed with beeswax.
100 Waist-belts	.08	"	
100 Bayonet-scabbard frogs	.3	"	

Metals.

For 100 *sets of cavalry sabre-belt mountings.*

100 Sabre-hooks	4.5	lbs.	brass wire	No.	7.
100 Loops	4.65	"	do.	"	7.
200 Rings	6.8	"	do.	"	6.
100 Large hooks	7.	"	sheet brass	"	11.
200 Small hooks	5.	"	do.	"	14.
700 Rivets	.48	"	brass wire	"	15.
400 Studs	22.5	"	cast brass.		
100 Belt-plates and loops	(See below.)				

For 100 *infantry cartridge-boxes.*

For tins, 125 sheets single tin, 1 lb. soft solder.

For buttons, 4.9 lbs. cast brass. For burrs, .33 lb. sheet brass, 400 copper rivets.

For 100 *cavalry belt-plates.*

25. lbs. cast brass.
.2 " German silver, No. 33.
.5 " soft solder.

For 100 *infantry waist-belt plates.*

4.5 lbs. sheet brass No. 31, for plates.
8. " " " No. 14, for hooks.
.22 " brass wire No. 14, for rivets.
16. " soft solder.

For 100 *infantry cartridge-box plates.*

4.2 lbs. sheet brass No. 31, for plates.
.8 " iron wire No. 15, for loops.
14. " soft solder.

For 100 *ferrules for bayonet-scabbards.*

3.5 lbs. sheet brass No. 25, for tips.
5. " cast brass, for knobs.
.14 " copper wire No. 15, for rivets.
200 copper rivets and burrs (½ No. 8) to attach the frog.
.2 lb. spelter.
.3 " soft solder.

For 100 *sets hooks and rivets for gun-slings.*

2.8 lbs. sheet brass No. 14.
.18 " brass wire No. 15.

For 100 *sets of mountings of waist-belt for sword bayonet.*

100 prs. clasps, cast brass, 21.25 lb.
200 loops for clasps, sheet brass No. 14, 3.75 lbs.
200 sliders, cast brass, 14.8 lbs.
Spelter, .4 lb.

For 100 *buttons and cone-picks for cap-pouches.*

3.2 lbs. cast brass, for buttons.
.65 " sheet brass No. 19, for burrs.
.2 " steel wire, No. 18, for cone-picks.

For 100 *sets mountings for sword-bayonet scabbard.*

29 lbs. sheet brass No. 24, for ferrules and tips.
1.75 lbs. cast brass, for loops for ferrules.
6.25 " " for knobs for tips.
1.4 " copper wire No. 12, for 800 rivets.
.4 " spelter.
.3 " soft solder.

WEIGHT OF ACCOUTREMENTS.

100	Infantry cartridge-boxes and plates for .69-in. ball	176 lbs.
100	Infantry cartridge-boxes and plates for .58-in. ball	167 "
100	Infantry cartridge-box belts and plates	63 "
100	Cap-pouches and cone-picks	13 "
100	Bayonet scabbards and frogs	31 "
100	Waist belts and plates, 1.9 inch wide	50 "
100	Gun-slings	15 "
100	Non-commissioned officer's waist belts and plates	49 "
100	Non-commissioned officer's sword belts and plates (shoulder)	60 "
100	Rifle cartridge-boxes and plates for .54-in. ball	118 "
100	Rifle waist belts and plates, for bayonet-scabbard	59 "
100	Rifle sword-bayonet scabbards	49 "
100	Rifle-pouches	43 "
100	Rifle-flasks	81 "
100	Rifle flask and pouch belts	27 "
100	Cavalry sabre belts and plates	120 "
100	Carbine slings and swivels	110 "
100	Light artillery sabre belts and plates	95 "
100	Foot artillery sword belts and plates	81 "

CHAPTER NINTH.

GUNPOWDER.

Gunpowder for the military service is made by private contractors. It is distinguished as *musket*, *mortar*, *cannon*, and *mammoth* powder. They are all made in the same manner, of the same proportions of materials, and differ only in the size of the grain.

MATERIALS.

The materials required are saltpetre, charcoal, and sulphur. They should be of the greatest possible purity, both for the quality of the powder and the prevention of disastrous accidents in the manufacture.

Saltpetre.

Saltpetre (nitre, nitrate of potassa) is a transparent, white, crystallized salt, inodorous, anhydrous, of a cooling, pungent, and slightly bitter taste. It generally crystallizes in six-sided prisms terminated by six-sided pyramids, or in needles deeply striated, and sometimes contains mother-water in fissures in the longer axis of large crystals. It is composed of 53.45 nitric acid and 46.55 potassa. Specific gravity, 2.099 to 2.1. Unalterable in common air, it becomes deliquescent in an atmosphere nearly saturated with moisture. It melts at about 662° into a limpid, oily-looking liquid, and may be cast into moulds, forming a white, compact mass. It begins to decompose at about 716°, giving up its oxygen: at a white heat the decomposition is incomplete, peroxide of potassium remaining. If thrown upon burning coals, it melts and deflagrates violently. It is insoluble in absolute alcohol and oils; soluble in water,—more in warm than in cold: in dissolving it causes a fall in temperature; it raises the boiling-point of water, and increases its density by about 0.0077 for each part of saltpetre contained in 100 parts of water.

100 parts	of water	at 32°	dissolve	13.32	saltpetre,	and the	solution	boils at about	213.8.°
"	"	68	"	31.75	"	"	"	"	215.6.°
"	"	104	"	63.80	"	"	"	"	219.2.°
"	"	140	"	110.70	"	"	"	"	222.8.°
"	"	176	"	170.80	"	"	"	"	228.2.°
"	"	212	"	246.60	"	"	"	"	235.4.°
"	"	240.8	"	335.00	"	"	"	"	240.8.°

A saturated hot solution will consequently lose, in cooling, the greatest part of the salt dissolved.

Saltpetre occurs naturally in great quantities, as an efflorescence on the surface of the earth, in many of the warm countries,—particularly in India, where there is sufficient to supply the wants of the whole world. It also occurs as a saline crust in caverns in some parts of the globe; and in the vicinity of Monclova, Mexico, it is found in great purity in veins or mines.

It exists in certain plants, and is formed spontaneously by the decomposition of animal and vegetable substances when mixed with substances containing potash and kept at an even temperature in moist situations. On this principle artificial nitre-beds are made, from which large quantities of nitre are obtained, in France, Germany, Sweden, Hungary, &c. Saltpetre obtained from any of these sources may be separated from the greater part of the foreign salts and earthy matter by lixiviation with wood-ashes and evaporation. The nitrous earth of India yields about one-fifth of its weight of nitre; that of the nitre-caves, from one to ten pounds of nitre to the bushel. The best artificial nitre-beds afford annually about a quarter of a pound of nitre to a bushel of earth. All the saltpetre used in the United States for the manufacture of gunpowder is obtained from India, whence it is imported in a crystallized state, called *crude saltpetre*, containing generally from 15 to 18 per cent. of foreign salts, earths, and water.

TEST OF CRUDE SALTPETRE.

Crude saltpetre was formerly tested by washing it with water saturated with saltpetre, which dissolved the other soluble foreign salts without dissolving any of the saltpetre itself; the loss in weight by washing was taken as the weight of the impurities contained. This process was found to occasion serious error, from the fact that when water saturated with saltpetre has dissolved a portion of sea-salt, it acquires the property of dissolving an additional amount of saltpetre; besides, this mode of testing fails when there is present—as there is almost always—the chloride of potassium. The process of testing now used in this country, as well as in England and India, is that of analysis. The chlorides that the crude saltpetre contains are precipitated in the form of the chloride of silver by adding the nitrate of silver to the solution of a given weight of the sample to be tested. The sulphates are precipitated in the form of the sulphate of baryta by adding the nitrate of baryta to the solution of a given weight of the sample; the amount of these impurities can now be calculated.

REFINING SALTPETRE.

The purity of saltpetre used in making gunpowder is of the greatest importance, not only on account of the quality of the powder, but more particularly as diminishing the chances of explosion in the powder-mills.

Wash the crude saltpetre in a large shallow pan with about 40 per cent.

of cold water, stirring it well with rakes. At the end of 12 hours, withdraw the water, which takes away with it a portion of the chlorides. To free the saltpetre from earthy matters and the chloride of sodium, dissolve it by means of heat, in the least possible amount of water, in a large copper kettle. When it is entirely dissolved, clarify the liquid by pouring in a solution of glue in the proportion of $\frac{1}{10}$ per cent. of glue dissolved in five times its weight of water. The glue is added at two different times; and the liquid should be well stirred and the scum removed as it forms on the surface. When the scum has nearly ceased forming, check the boiling by adding cold water saturated with saltpetre, to precipitate the chloride of sodium, which is removed as it falls to the bottom. When the scum has ceased forming and the chloride of sodium is no longer precipitated, the liquid becomes limpid, and it is permitted to remain several hours, keeping up sufficient heat to prevent it from crystallizing in the kettle.

Remove the liquid gently, while at a temperature of about 230°, to the *crystallizing-pans*, and stir it continually with wooden scrapers to prevent the formation of large crystals. The scrapers in large establishments are moved by machinery. Draw the saltpetre, as it forms, to the sides of the pans, and when the liquid falls to a temperature of about 70° draw it off into other vessels: it will then have given up nearly all its saltpetre. Take the saltpetre from the crystallizing-pans to the *washing-troughs*, and wash it twice from the rose of a watering-pot with 50 per cent. of cold water saturated with pure saltpetre, the water being permitted to remain on the salt each time about two hours, and then drawn off: sprinkle it with 50 per cent. of pure water, which merely drains through and is carried off.

The saltpetre, after remaining in the washing-troughs three or four days, is taken to the drying-reservoirs, where it is dried and stirred from time to time with wooden shovels. It is then passed through a brass sieve, to separate any small lumps or foreign particles, and is ready for packing. It is now like fine sand, and as white as snow.

A 100-lbs. powder-cask will hold about 132 lbs. of saltpetre. The scum, mother-water, washings, etc., are collected, and the saltpetre extracted from them.

TEST OF REFINED SALTPETRE.

In order to be used in the manufacture of gunpowder, saltpetre should not contain more than 1-3000th of chlorides. To test this, dissolve 200 grains of saltpetre in the least possible quantity (say 1,000 grains) of tepid distilled water; pour on it 20 grains of a solution of nitrate of silver containing 10 grains of the nitrate to 1,033 grains of water, that being the quantity required to decompose 200-3000ths of a grain of muriate of soda, filter the liquid, and divide it into two portions; to one portion add a few drops of the solution of nitrate of silver; if it remain clear, the saltpetre does not contain more than 1-3000th of muriate of soda; to the other portion add a small quantity of solution of muriate of soda; if it become clouded, the saltpetre contains less than 1-3000th. By using the test-liquor in very small quantities, the exact proportion of muriate of soda may be ascertained. The saltpetre used in our best powder does not contain more than 1-18000th of chlorides; and that used in the best sporting-powder is refined a second time, and contains not more than 1-60000th part.

Charcoal.

(For general remarks on charcoal, see Chapter X.)

Of the three component materials of gunpowder, the charcoal has the greatest effect upon its quality, owing to the great difference in it, due to the kind of wood from which it is made, and to the mode of its preparation. Light, friable, and porous charcoal, which burns rapidly and leaves the least ashes, is the best adapted for making gunpowder. Charcoal from willow and black alder,—chiefly the former,—obtained by distillation in cast-iron cylinders, is used for powder for the military service.

The wood is cut in the spring, when the sap is running freely. Branches are selected of three to four years' growth, not more than three-quarters of an inch in diameter, stripped of its bark as soon as cut, and piled in dry and airy places. The larger branches are split lengthwise. All dead wood is rejected.

The dried wood is put in upright cast-iron cylinders, which are then closely luted. The heat is applied to the outside of the cylinder, and care is taken to prevent them from getting too hot. The gaseous and liquid products escape by an opening near one end. The progress of distillation is judged of by the color of the flame and smoke, and sometimes by *test-sticks* which are introduced through tubes prepared for the purpose. When the distillation is complete, the charcoal is removed into sheet-iron tubs.

About 35 per cent. of brown coal is produced, by this process, to 100 parts of dried wood.

Charcoal should be made only as it is required for immediate use, as it absorbs moisture readily from the air.

When freshly prepared, it absorbs and condenses gases: it heats, and, if in a heap of 30 lbs. or more, takes fire spontaneously.

The specific gravity of freshly-burned charcoal is about .380; when triturated in a moist state for a long time under heavy rollers, its specific gravity is increased to 1.100 and 1.400.

Sulphur.

Sulphur is found in abundance, in the native state, in the neighborhood of volcanoes, mixed merely with earthy matters. It may also be obtained from the sulphurets of iron and copper, and from other sources, but is not so pure in this case as the volcanic sulphur. The specific gravity of native sulphur is 2.072; that of sulphur which has been fused, 1.99,—which is still further diminished by trituration. Sulphur melts at 234° into a transparent and nearly colorless liquid which is lighter than the solid sulphur. As the temperature is increased, the sulphur becomes more yellow and less fluid; at 482° it is of a dark-brown color, and so thick as to flow with difficulty. From 500° to its boiling-point, 788°, it becomes more fluid. Sulphur takes fire at a temperature of 560°, and burns with a dull blue flame and suffocating fumes. It is soluble in oil of turpentine, and insoluble in water and alcohol.

The supply of sulphur for this country is brought principally from Sicily, in the crude state. It contains about 8 per cent. of earthy matter.

It is refined by distilling it in cast-iron retorts, and collecting the vapors in a large chamber, where they are condensed. The temperature of this chamber is kept at about 248°, and the liquid sulphur is drawn off, through iron pipes in the side of the chamber, into wooden moulds.

If the temperature of the chamber be kept as low as 180°, the vapors are condensed in a light dust, called flowers of sulphur: in this state the sulphur always contains sulphurous and sulphuric acids.

Pure sulphur should be of a beautiful citron-yellow color, slightly transparent, should show no acid reaction on test-paper, and should burn without any residuum.

Sulphur may be refined, but not so thoroughly, by being melted, skimmed, and decanted.

Manufacture of Gunpowder.

The buildings in which the different operations are carried on are separated from each other, and protected by trees or traverses as far as practicable.

There is great diversity in the manipulations of manufacture, not only in different countries, but even in different powder-mills of the same country,—each having some particular mode of its own, which is preferred to the rest. The principal operations consist in pulverizing the materials very finely, thoroughly incorporating them, pressing them into a cake, reducing the cake into grains, glazing the grains, drying and dusting the powder.

Pulverizing.—The saltpetre is usually pulverized sufficiently when it comes from the refinery. The charcoal is placed in large cast-iron barrels with twice its weight of bronze balls. The barrel has several ledges on the interior, and is made to revolve from 20 to 25 times in a minute. It is pulverized in 2 or 3 hours. The sulphur is placed in barrels made of thick leather stretched over a wooden frame, with twice its weight of bronze balls from .3 to .5 inch in diameter, and the barrel made to revolve about 20 times per minute.

The sulphur is pulverized in four to eight hours.

Proportions of materials.—All powder for the military service must be composed of the following proportions by weight,—viz.:

	76 parts of saltpetre,	14 of charcoal,	and 10 of sulphur;	
or,	75 parts "	15 "	10 "	

Incorporating.—The ingredients having been weighed out in the proportions above given, the charcoal and sulphur are put together in a rolling-barrel similar to that in which the sulphur is pulverized, and rolled for one hour. The saltpetre is then added, and rolled for three hours longer. In some mills this operation is omitted. It is now taken to the cylinder, or *rolling-mill.* This consists of two cast-iron cylinders rolling round a horizontal axis in a circular trough of about 9 feet diameter, with a cast-iron bottom. The cylinders are 6 feet in diameter, 18 inches thick on the face, and weigh about 8 tons each. They are followed by a wooden scraper, which keeps the composition in the centre of the trough.

A charge of 75 lbs. in some mills, and 150 lbs. in others, is then spread in the trough of the rolling-mill, and moistened with 2 to 3 per cent. of water, according to the hygrometric state of the atmosphere.

It is rolled slowly at first, and afterward from 8 to 10 revolutions of the roller per minute, for 1 hour for 50 lbs. and 3 hours for 150 lbs. of composition. A little water is added, as the process advances, if the composition gets very dry,—which is judged of by its color.

When the materials are thoroughly incorporated, the cake is of a uniform, lively, brownish red color. In this state it is called *mill-cake.*

The quality of the powder depends much on the thorough incorporation of the materials, and burns more rapidly as this operation is more thoroughly performed.

The mill-cake is next taken to the press-house, to be pressed into a hard cake.

Pressing.—The mill-cake is sprinkled with about 3 per cent. of water, and arranged in a series of layers about 2 inches thick, separated by brass plates. A powerful pressure is brought to bear on the layers, which are subjected to the maximum pressure for about 10 to 15 minutes, when it is removed. Each layer is thus formed into a hard cake about an inch thick.

Granulating.—The cake is broken into pieces by means of bronze toothed rollers revolving in opposite directions, their axes being parallel and the distance between them regulated as required. *Fluted* rollers are sometimes used. The pieces are passed through a succession of rollers, each series being closer together, by which the pieces are broken into others still smaller, which pass over a sieve to another roller, the small grains passing through the sieve into a receiver below, until the whole is reduced to the required size. The various-sized grains are separated by the sieves between the different rollers.

Glazing.—Several hundred pounds of the grained powder, containing from 3 to 4 per cent. of water, are placed in the glazing-barrel, which is made to revolve from 9 to 10 times per minute, and in some mills from 25 to 30 times per minute. Usually from 10 to 12 hours are required to give the required glazing. In this operation the sharp angles are broken off, thereby diminishing the dust produced in transportation, and the surface of the graiu receives a bright polish.

Drying.—The powder is spread out on sheets stretched upon frames in a room raised to a temperature of 140° to 160° by steam-pipes or by a furnace. The temperature should be raised gradually, and should not exceed 160°, ventilation being kept up.

Dusting.—The powder is finally sifted through fine sieves, to remove all dust and fine grains. The dust obtained in this and previous operations may be worked over to make other powders.

Packing.

Government powder is packed in barrels of 100 lbs. each. Powder-barrels are made of well-seasoned white oak, and hooped with hickory or cedar hoops, which should be deprived of their bark: the cedar is not so liable as hickory or white oak to be attacked by worms, and it should therefore be used in preference; or the hoops may be prepared by immersion in a solution of corrosive sublimate. The hoops should cover two-thirds of the barrel. Instead of a bung on the side, a screw-hole 1.5 inch in diameter is made in the head of the barrel, for mortar and musket powder: it is closed by a wood screw with an octagonal head which must not project beyond the ends of the staves; under the head of the screw is a washer of thin leather steeped in a solution of beeswax in spirits of turpentine. This screw-plug renders it unnecessary to take out the head of the barrel, and the hoops may therefore be secured with copper nails; for transportation, a piece of cloth should be glued over the head of the plug. Some barrels have been made with 6 copper hoops, and others with 4 copper and 8 or 10 cedar hoops: the copper hoops are 1 inch wide and $\frac{1}{8}$ of an inch thick, fastened with 2 rivets, and nailed each with 3 copper nails 0.625 inch long. Average weight of a hoop, $2\frac{1}{4}$ lbs.

Powder-barrels made of strong *sheet iron*, corrugated, the heads put in by folding them over with the metal forming the body, have been made, and are now on trial, with prospects of their answering a good purpose.

It has been found that lining powder-barrels with India-rubber cloth has an injurious effect on the powder, in consequence of the affinity of th caoutchouc for sulphur.

The heads of powder-barrels are painted *black*, in order to show the *marks* more plainly in dark magazines.

Dimensions of Powder-Barrels.

Whole length	20.5 inches.
Length, interior, in the clear	18 "
Interior diameter at the head	14 "
Interior diameter at the bilge	16 "
Thiokness of the staves and heads	0.5 inch.
Weight of the barrel with cedar hoops	25 lbs.

The barrels have generally 12 hoops, 14 to 16 staves, and 2 or 3 pieces in each head. The above dimensions are calculated so that with 100 lbs. of powder there shall be a vacant space in the barrel, allowing the powder to shake, in order to prevent its caking. The barrel would contain about 120 lbs. of powder settled by shaking.

Round powder, for immediate use, may be made in an expeditious manner as follows. Fix a powder-barrel on a shaft passing through its two heads, the barrel having ledges on the inside; to prevent leakage, oover it with close canvas glued on, and put the hoops over the canvas. Put into the barrel 10 lbs. of sulphur in lumps, and 15 lbs. of charcoal, with 60 lbs. of zinc balls, or of small shot, (down to No. 4, 0.014 inch in diameter nearly.) Turn it by hand, or otherwise, 30 revolutions in a minute. To 10 lbs. of this mixture thus pulverized add 30 lbs. of saltpetre, and work it two hours with the balls; water the 40 lbs. of composition with 2 quarts of water, mixing it equally with the hands; granulate with the graining-sieve. The grains thus made, not being pressed, are too soft. To make them harder, put them into a barrel having 5 or 6 ledges, projecting about 0.4 inch, inside; give it at first 8 revolutions in a minute, increasing gradually to 20. The compression will be proportionate to the charge in the barrel, which should not, however, be more than half full. Continue this operation until the density is such that a cubic foot of the powder shall weigh 855 oz.,—the mean density of round powder; strike on the staves of the barrel from time to time, to prevent the adhesion of the powder.

Sift the grains and dry the powder as usual: that which is too fine or too coarse is returned to the pulverizing-barrel.

This powder is round, and the grain is sufficiently hard on the surface; but the interior is soft, which makes it unfit for keeping, and may cause it to burn slowly. This defect may be remedied by making the grains at first very small, and by rolling them on a sheet or in a barrel, watering them from time to time, and adding the pulverized composition in small portions; in this way, the grains will be formed by successive layers: they are then separated according to size, glazed, and dried.

It appears from experiments that the simple incorporation of the materials makes a powder which gives nearly as high ranges with field-pieces as grained powder: the incorporated dust from the rolling-barrel may therefore be used in case of necessity. Gunpowder burns at the temperature of 575° to 600° Fahrenheit.

Inspection and Proof of Powder.

Before powder for the military service is received from the manufacturer, it is inspected and proved. For this purpose, at least 50 barrels are thoroughly mixed together. One barrel of this is proved by firing three rounds from a musket, with service-charge, if it be musket-powder; if cannon or mammoth powder, from an 8-inch columbiad, with 10 lbs. and a solid shot of 65 lbs. weight and 7.88 inches in diameter; if it be mortar-powder, from an 8-inch mortar, with 1.25 lb. and a shell 7.88 inches in diameter, weighing 47.5 lbs. The general character of the grain, and its freedom from dust, are noted.

General Qualities.—Gunpowder should be of an even-sized grain, angular and irregular in form, without sharp corners, and very hard. When new, it should leave no trace of dust when poured on the back of the hand, and when flashed in quantities of 10 grains on a copper plate, it should leave no bead or foulness. It should give the required initial velocity to the ball, and not more than the maximum pressure on the gun, and should absorb but little moisture from the air.

Size of Grain.—The size of the grain is tested by standard sieves made of sheet brass pierced with round holes. Two sieves are used for each kind of powder,—Nos. 1 and 2 for musket, 2 and 3 for mortar, 4 and 5 for cannon, and 6 and 7 for mammoth, powder.

Diameter of holes for	musket-powder:		No. 1, 0.03 in.;	No. 2, 0.06 in.
" "	mortar	"	No. 2, 0.06 in.;	No. 3, 0.10 in.
" "	cannon	"	No. 4, 0.25 in.;	No. 5, 0.35 in.
" "	mammoth	"	No. 6, 0.6 in.;	No. 7, 0.9 in.

Musket-powder.—None should pass through sieve No. 1; all through No. 2.

Mortar-powder.—None should pass through sieve No. 2; all through No. 3.

Cannon-powder.—None should pass through sieve No. 4; all through No. 5.

Gravimetric Density.—Is the weight of a given measured quantity. It is usually expressed by the weight of a cubic foot in ounces.

This cannot be relied upon for the true density when accuracy is desired, as the shape of the grain may make the denser powder seem the lighter.

Specific Gravity.—The specific gravity of gunpowder must be not less than 1.75. It is important that it should be determined with accuracy. Alcohol and water saturated with saltpetre have been used for this purpose; but they do not furnish accurate results. Mercury, only, is to be relied upon.

Mercury Densimeter.—This apparatus was invented by Colonel Mallet, of the French army, and M. Bianchi, and consists of an open vessel containing mercury, a frame supporting a glass globe communicating by a tube with the mercury in the open vessel, and joined at top to a graduated glass tube, which communicates by a flexible tube with an ordinary air-pump. Stop-cocks are inserted in the tubes above and below the glass globe, and a diaphragm of chamois-skin is placed over the orifice at the bottom of the globe, and one of wire-cloth over the upper orifice.

The operation consists as follows: Fill the globe with mercury to any mark of the graduated tube, by means of the air-pump; close the stop-cocks; detach the globe, full of mercury, and weigh it; empty and clean the globe; introduce into it a given weight of gunpowder; attach the globe to the tubes; exhaust the air till the mercury fills the globe and rises to the same height as before; shut the stop-cocks; take off the globe and weigh it as before. If we represent by a the weight of the powder in the globe, by P the weight of the globe full of mercury, by P' the weight of the globe containing the powder and mercury, and by D the specific gravity of the mercury, the specific gravity of the gunpowder will be expressed by the formula $d = \frac{a\ D}{P - P' + a}$.

A mean of two or three results will give the true specific gravity.

The density of some samples of powder has been brought up to 1.831.

Initial Velocity.—The initial velocity is determined by means of the Ballistic Pendulum, or by Captain Benton's Electro-Ballistic Pendulum. For the method of using this machine, see page 249.

Musket-powder	should	give	an initial	velocity	of	not less than	——	feet.
Mortar-powder	"	"	"	"	"	"	——	"
Cannon-powder	"	"	"	"	"	"	——	"

Strain upon the Gun.—This is determined by Captain Rodman's pressure-piston. For the method of using this instrument, see page 251.

Mortar-powder should not give a greater pressure than —— pounds on the square inch.

Cannon-powder should not give a greater pressure than —— pounds on the square inch.

Hygrometric Qualities.—If the powder be made of pure materials and have the required density, its hygrometric quality follows as a matter of course. It may be determined by exposing the powder to air saturated with moisture. For this purpose, samples of about 1500 grains weight may be placed in a shallow tin pan, 9 inches by 6 inches, set in a tub the bottom of which is covered with water. The pan of powder should be placed about one inch above the surface of the water, and the tub covered over. In this manner any sample of powder may be compared with another of known good quality. Good powder, made of pure materials, will not absorb more than $2\frac{1}{2}$ per cent. of moisture in 24 hours.

Inspection Report.—The report of inspection should show the *place* and *date* of fabrication and of proof, the *kind* of powder and its general qualities, as the number of grains in 100 grs., whether hard or soft, round or angular, of uniform or irregular size, whether free from dust or not; the initial velocities obtained in each fire; the amount of moisture absorbed; and, finally, the height of the barometer and hygrometer at the time of proof.

Marks on the Barrels.—Each barrel is marked on both heads (in white oil-colors, the head painted black) with the number of the barrel, the name of the manufacturer, year of fabrication, and the kind of powder,—*cannon*, *mortar*, or *musket*,—the mean initial velocity, and the pressure per square inch on the pressure-piston. Each time the powder is proved, the initial velocity is marked below the former proofs, and the date of the trial opposite it.

Analysis of Gunpowder.

Whatever may be the mode of proof adopted, it is essential, in judging of the qualities of gunpowder, to know the mode of fabrication and the proportions and degree of purity of the materials. The latter point may be ascertained by analysis.

In the first place, determine the quantity of water that the powder contains, by subjecting it to a temperature of 212°, in a stove or in a tube with a current of warm air passing over it, until it no longer loses in weight. The difference in weight, before and after drying, gives the amount of moisture contained in the powder.

To determine the quantity of Saltpetre.—In a vessel of tinned copper, like a common coffee-pot, dissolve 1,000 grains of powder, well dried before weighing, in 2,000 grains of distilled water, and heat it until it boils; let it stand a moment, and then decant it on a piece of filtering-paper, doubled exactly in the middle; repeat this operation four times; at the fourth time, instead of decanting, pour the whole contents of the vessel on the filter; drain the filter, and wash it several times with 2,000 grains of water heated in the vessel, using in all these operations 10,000 grains of water. After passing through the filters, this water contains in solution all the saltpetre, the quantity of which is ascertained by evaporating to dryness. Dry the double filter with the mixture of coal and sulphur, and take the weight of this composition by using the exterior filter to ascertain the weight of that on which the composition remains; this weight serves to verify that of the saltpetre and to estimate the loss in the process.

To determine the quantity of Charcoal directly.—To separate the sulphur from the charcoal, subject the powder, either directly or after the saltpetre has been dissolved out, to the action of a boiling solution of the sulphide of potassium or sodium, which dissolves the sulphur and leaves the charcoal, the weight of which may be easily determined.

It is important that the sulphides of potassium and sodium used in dissolving the sulphur should contain no free potassa or soda; for each of these alkalies would dissolve a part of the carbon,—particularly of the brown coal.

The sulphide of carbon also dissolves the sulphur contained in powder, and may be used to determine the weight of charcoal which it contains.

The charcoal, separated from the saltpetre and sulphur, is dried with care and weighed, and should then be submitted to analysis in an apparatus used for burning organic matters. The composition of the charcoal may be judged of by comparing it with the results obtained in the analysis of charcoal of known quality used in the manufacture of powder.

To determine the quantity of Sulphur directly.—Mix and beat in a mortar 10 grains of dry powder, 10 of subcarbonate of potash, 10 of saltpetre, and 40 of chloride of sodium; put this mixture in a vessel (capsule) of platinum or glass, on live coals, and, when the combination of the materials is completed and the mass is white, dissolve it in distilled water, and saturate the solution with nitric acid; decompose the sulphate which has been formed, by adding a solution of chloride of barium, in which the exact proportions of the water and the chloride are known. According to the atomic proportions, the quantity of sulphur will be to that of the chloride of barium used as 20.12 to 152.44.

Restoring Unserviceable Powder.

When powder has been damaged by being stored in damp places, it loses its strength, and requires to be worked over. If the quantity of moisture absorbed do not exceed 7 per cent., it is sufficient to dry it to restore it for service. This is done by exposing it to the sun.

When powder has absorbed more than 7 per cent. of water, it is sent to the powder-mills to be worked over.

When it has been damaged with salt water, or become mixed with foreign matters which cannot be separated by sifting, the saltpetre is dissolved out from the other materials and collected by evaporation.

Preservation, Storage, and Transportation.

In the powder-magazines the barrels are generally placed on the sides, three tiers high, or four tiers, if necessary. Small skids should be placed on the floor and between the several tiers of barrels, in order to steady them, and chocks should be placed at intervals on the lower skid, to prevent the rolling of the barrels. The powder should be separated according to its kind, the place and date of fabrication, and the proof-range. Fixed ammunition, especially for cannon, should not be put in the same magazine with powder in barrels, if it can be avoided. Fireworks should never be stored in powder-magazines.

In a room 13 or 14 feet wide, the barrels may be arranged in a double row in the centre, two alleys $2\frac{1}{2}$ feet wide, and 2 single rows 6 to 12 inches from the walls: in this way the marks of each barrel may be seen, and any barrel can be easily reached. In a room 12 feet wide, an equal number of barrels may be placed in two double rows, with a central alley of 3 feet, and 2 side alleys, next the walls, of about 10 inches each. There should be an unencumbered space of 6 or 8 feet at the door or doors of the magazine.

Should it be necessary to pile the barrels more than 4 tiers high, the upper tiers should be supported by a frame resting on the floor; or the barrels may be placed on their heads, with boards between the tiers.

Besides being recorded in the magazine-book, each parcel of powder should be inscribed on a ticket attached to the pile, showing the entries and the issues.

For the preservation of the powder and of the floors and lining of the magazine, it is of the greatest importance to preserve unobstructed the circulation of air, under the flooring as well as above. The magazine should be opened and aired in clear, dry weather, *when the temperature of the air outside is lower than that inside the magazine.* It should not be opened in damp weather if it can be avoided. The ventilators must be kept free; no shrubbery or trees should be allowed to grow so near as to protect the building from the sun. The magazine-yard should be paved and well drained. The moisture of a magazine may be absorbed by chloride of lime suspended in an open box under the arch, and renewed from time to time; quicklime is dangerous, and should not be used.

The sentinel or guard at a magazine, when it is open, should have no fire-arms, and every one who enters the magazine should take off his shoes, or put socks over them: no sword, or cane, or any thing which might occasion sparks, should be carried in.

The windows should have inside shutters of copper-wire cloth. Fire should never be kindled near the magazine for the repair of the roof or lightning-rod.

Barrels of powder should not be rolled for transportation: they should be carried in hand-barrows, or slings made of rope or leather. In moving powder in the magazine, a cloth or carpet should be spread; all implements used there should be of wood or copper, and the barrels should never be repaired in the magazine. When it is necessary to roll the powder for its better preservation and to prevent its caking, this should be done, with a small quantity at a time, on boards, in the magazine-yard.

In the spring an inspection of the barrels should be made, and the hoops swept with a brush wherever they can be got at, to remove the insects which deposit their eggs at this season.

In wagons, barrels of powder must be packed in straw, secured in such a manner as not to rub against each other, and the load covered with thick canvas.

In transportation by railroad, each barrel should be carefully boxed, and packed so as to avoid all friction. The barrels should have a thick tarpaulin under them. The cars should have springs similar to those of passenger-cars.

English Gunpowder.

English guupowder—particularly their sporting-powder—has long been noted for its excellence, which is due to the care taken in selecting the best materials, and the skill in combining them.

The woods used for making charcoal for gunpowder are the black dogwood, the alder, and the Dutch white willow.

The coal is made by distillation in iron cylinders.

The ingredients are separately reduced to an impalpable powder and passed through silk cloths or bolting-machines, then mixed in a tub in charges of 42 lbs. each, moistened with 2 or 3 pints of water, and incorporated in the cylinder-mill for 3½ hours. The iron cylinders of the cylinder-mill are 6 feet in diameter, weigh about 3 tons each, and make about 8 revolutions in a minute in a circular iron trough 7 feet in diameter. The incorporated material is subjected to a pressure of 75 tons to the square foot by means of a hydrostatic press, forming it into pressed cake, which is broken by toothed rollers and formed into grains as above described. It is glazed by rolling in a canvas cylinder, or large cask, making 40 revolutions per minute, for 1½ hours. It is dried in a temperature of 140° to 150°, raised by means of steam.

French Gunpowder.

The charcoal used by the French in making gunpowder is obtained by the combustion of *black alder* in the open air in iron pots.

At the powder-mills at Saint-Chamas, the charcoal is made by distillation, effected by passing a current of steam raised to a temperature of 540° to 600° into the iron cylinder containing the wood. Charcoal of an excellent quality is said to be obtained in this way.

The materials are pulverized separately in leathern barrels by means of bronze balls, and passed through a sieve to separate any foreign matters which may have accidentally fallen in and might cause explosions in trituration.

Two and three-fourths pounds of sulphur and the same of charcoal are weighed into a tub, moistened with 1½ quart of water, and mixed by hand for 5 minutes. It is then transferred to the composition-tray, 16½ lbs. of saltpetre are added, and the tray taken to the pounding-mill. The contents are emptied into a mortar and well mixed with the hand for several minutes, without further addition of water.

A pounding-mill contains usually from 16 to 24 mortars and pestles, arranged in two parallel rows. The mortars are hollowed out of a piece of oak, with bottoms made of a harder wood. The pestle is made of beech, and has on its lower end a bronze shoe with its angles well rounded. It weighs about 88 lbs., and falls through a height of 16 inches.

Each pestle gives in the beginning of the pounding from 30 to 40 blows per minute, and after 10 minutes the number of blows is increased to 55 or 60 per minute. The pounding is continued in this way for 12 hours, including the stoppages for shifting the charges from one mortar to the next,—which is done every hour. These changes are made to mix the materials more thoroughly, and to break the cakes which form at the bottom of the mortars. From the 6th to the 8th change, about ½ pint of water is added, or as much as may be necessary to give to the composition from 7 to 8 per cent. of moisture. During the last 2 hours no changes are made, so as not to interrupt the formation of cake. The composition is taken out of the mortar and dried from 1 to 3 days, till it contains only about 6 per cent. of moisture. It is then taken to the house for granulation. This operation is performed in a barrel made by stretching two pieces of wire-cloth over a wooden frame. The pieces of wire-cloth are placed one over the other,—the outer one fastened on by cords so as to be removed at pleasure, and replaced by another of different-sized meshes, the meshes being of the size of the grain required, of musket or cannon powder. The distance between the wires of the inner cloth is .28 inch. Balls of hard wood 2 inches in diameter, and 50 or 60 in number, are placed, with the composition to be grained, in the barrel, which is made to revolve about 30 times in a minute. The caked composition is broken by the balls, and, passing through the wire-cloths, falls into a tub beneath.

The contents of the tub are sifted in sieves which permit the small grains and dust to pass through.

The powder is moderately glazed by rolling it, while still containing from 5 to 6 per cent. of moisture, in a barrel from 10 to 30 minutes,—depending upon the kind of powder and the amount of moisture it contains. It is so conducted that the powder, when dry, should have a gravimetric density of between 820 and 860 ounces.

The powder is then passed through a standard sieve of parchment, and is dried either in the open air, spread out on sheets, on tables, or in a drying-room, spread on sheets stretched over the top of boxes, into the lower part of which heated air is forced and escapes by passing through the powder.

After drying, the powder is again sifted, to remove all dust.

Proportions of Ingredients.

		Saltpetre.	Charcoal	Sulphur.
	By the atomic theory..........	74.64	13.51	11.85
IN THE UNITED STATES:				
	For the military service......	76	14	10
		75	15	10
	For sporting...........	78	12	10
		77	13	10
IN ENGLAND:	For the military service......	75	15	10
	For sporting.....................	78	14	8
		75	17	8
IN FRANCE:	For the military service......	75	12.5	12.5
	For sporting.....................	78	12	10
	For blasting.....................	62	18	20
IN PRUSSIA:	For the military service......	75	13.5	11.5
IN SPAIN:	For the military service......	76.5	12.7	10.8

Captain Benton's Electro-Ballistic Pendulum.—(Plate 29.)

Description.—This instrument consists of a vertical arc of brass graduated into degrees and fifths, supported by a tripod with a thumb-screw at each foot. Levels are attached to the arc, that it may be kept in a vertical position. Two pendulums, with their axes in the same line passing through the centre, and perpendicular to the plane, of the arc, swing freely in front of and near to the arc. To the lower extremity of each is attached a piece of soft iron. The bob of the outer pendulum is adjustable. An electro-magnet is attached to each end of the horizontal limb of the arc, and holds the pendulums horizontal, or at 90° from the 0° or lowest point of the arc, when the soft iron of the pendulum is brought in contact with the magnet. The inner pendulum has at its lower extremity a movable point projecting toward the arc, the head of which is struck by a blunt steel point on the outer pendulum when the two pass each other, leaving a mark on the paper which is clamped to the arc for that purpose. Wire conductors lead from the magnet to the clamp-screws secured to the upright limb, where they are readily joined to the wires leading to the batteries and targets.

The adjustments.—1st. Level the instrument by means of the thumb-screws.

2d. See that the magnets are in such a position that each pendulum when brought up against them is exactly 90° from the lowest point of the arc. The magnets are held by clamp-screws to admit of this adjustment.

3d. Move the bob of the outer pendulum till the times of vibration of the two are the same. This is done by connecting the wire of the magnet to the poles of the battery, including the disjunctor in the circuit. Bring the two batteries to the same strength. Break the currents by means of the disjunctor, and see if the two pendulums meet exactly at the zero-mark.

The two batteries are known to be of equal strength when the pendulums meet at the zero-point, irrespective of the particular battery that works them.

The Disjunctor is an instrument used to test the working of the batteries and tell when they are operating with equal activity. There are several forms of this instrument, the essential point being to break the currents exactly at the same time. It is so arranged that by setting the trigger the currents are formed, and by pressing it they are broken. It should give the same point of meeting of the pendulums in six or eight trials made in quick succession.

To use the Pendulum.—Establish the wires as shown in Plate 29. Insert a piece of drawing-paper under the arc, and clamp it. Set the trigger of the disjunctor; raise the pendulums against their magnets; press the trigger; if the point of meeting is very near the 0°, set the trigger again; give the caution, "Ready;" raise the pendulum, and "fire." Read off the angle, which must be corrected, if the pendulum on the trial did not meet at the 0°, by *adding* the angle between the 0° and mark, if it be on the left, and by *subtracting* it if it be on the right. The angle thus corrected must be *doubled* for the time of passage of the projectile between the two targets.

To determine the initial velocity.—Let l be the length of the equivalent simple pendulum, and t the time of passing over any one degree beginning at an angle x from 0: then $t = \frac{2\pi l}{360 \sqrt{2gl \cos. x}}$.

By substituting for x different values, we get the times of passing over the different degrees, supposing the velocity to be uniform for the time of passing. In this way a table is formed which should give the times for the different degrees and tenths of degrees, and the sums of the times to each degree.

The value of l is determined by supporting the inner pendulum on the knife-edges, and noting the time required to make 500 or 1,000 vibrations. The length of the equivalent simple pendulum is obtained from the relation $l = t'^2 l'$, t' being the time of a single vibration as just determined, and l' being the length of the simple second pendulum at the place of experiment.

The machine is placed on a solid foundation, about 100 yards from the cannon. Grove's or Bunsen's batteries are best; Smee's has been used with good results. The power of the battery must be regulated according to the length and size of the wire. Copper wire No. 16 is about the size required. If the wire be small and long, the battery must be stronger.

The first target is placed about 20 feet from the muzzle of the gun, and the second from 70 to 120, according to the velocity of the projectile. The size of the target is no greater than is necessary to insure its being struck every shot, and the distance between its wires is regulated in the same manner. For small arms a much finer wire is used to form the target.

Captain Rodman's Pressure-Piston. (Plate 29.)

This instrument is used to determine the pressure of the gas on the sides of the bore of a gun. It consists of a *housing* of wrought iron, with a cylindrical *shank* at one end, chased with the threads of a screw, by which it is attached to the gun. This shank has a cylindrical *hole* through its axis, .37 inch in diameter, into which the piston fits closely. The head of the piston is terminated by a *cutter*, which is forced by the explosion of the charge into a piece of wrought copper, leaving a cut or indentation of greater or less length, according to the greater or less pressure on the sides of the bore.

The cutter is made broad and thin, so as to make a long cut compared with its breadth and depth, that pressures which vary but slightly may be distinguished more readily.

A strong *screw*, at the opposite end of the housing to the shank, holds the disk of copper on the cutter.

A *gas-check*, made of thin copper, is set up, by a die and punch, in the shape of a hollow, shallow cup. It is placed against the lower end of the piston, the open end toward the charge of powder.

A hole, .4 inch in diameter, is drilled into the bore of the gun at the seat of the charge; the outer part is counter-bored and tapped so as to receive the housing.

To use the pressure-piston.—Clean and oil the piston and the hole in the housing into which it works; insert the piston in the housing; put in the gas-check, pressing it down on the piston; place a thin copper washer in the hole in the gun, and screw the housing down firmly on it; place a disk of copper on the cutter; interpose between this and the head of the screw a second disk, and press it down hard on the cutter.

After each discharge, unscrew the housing, take out the gas-check, clean the hole in the gun, the piston and the hole in which it works; renew the gas-check as often as required; see that the copper disk is pressed hard on the cutter.

The actual pressure in pounds is determined by placing the cutter in the dynamometer, and applying a pressure until a cut is made of the same length in a similar piece of copper.

LIGHTNING-CONDUCTORS.

(Condensed from a "Circular Memorandum" issued by General Burgoyne, Inspector-General of Fortifications, British Army, from the researches of Sir Wm. Snow Harris, F.R.S., 1858.)

It appears to be established:—

That metal in a building, whether disposed in the form of a conductor or otherwise, never *attracts* lightning.

That, provided the surfaces of metals are not interrupted by bodies possessing a less conducting-power, a building entirely of metal will be the safest of all, and that such buildings require no further lightning-conductors than connections with the earth, over the masonry foundations on which they are often laid.

That, with regard to a building of brick or stone, the object must be to establish a sufficient number of lines of electrical conductors, extending from its most elevated and prominent points to the ground, and further bring the building into a condition similar to that of a metal building, by means of other conductors generally attached to more prominent lines of the building itself, such as the ridges, angles, and eaves.

There is no advantage, but the contrary, in endeavoring to insulate the conductors from the building.

The best material for conductors is copper, either in tubes 1½ to 2 inches diameter, and .125 inch thick, or in plates 3.5 inches wide and .125 inch to .2 inch thick.

All metal surfaces, whether lead, copper, or iron, on ridges, roofs, gutters, or coverings to doors or windows, to be connected by plates of copper with the conducting-system. Lead, on account of its low conducting-power, cannot be altogether depended upon.

One or more solid copper rods, to project freely into the air, about 5 feet above the highest points of the building to which the main conductors are applied. The summit of the rod to be pointed; but gold, gilt, or platinum tops are unnecessary.

The termination of the conductors below to be led into damp or porous soil, when the building happens to stand upon it; but, when the soil is dry, two or three trenches to be cut, radiating from the foot of the conductor, to a depth of 18 inches or 2 feet, and 30 feet in length, and either the conductor carried along the bottom of the trenches, or old iron chain laid in them, carefully connected with the foot of the conductor. The trenches to be then filled up to one foot in depth with coal-ashes, or other carbonaceous substance, and afterward with earth or gravel.

If it be possible, in regulating the surface-drainage, to lead a flow of water, during the rain which generally accompanies thunder-storms, over the sites of the trenches, it will be an additional precaution.

Tanks are useless, except where the water flows freely into them from the surrounding soil; and even then they are superfluous as appendages to the conductors.

The conductors for a brick or stone magazine with slate roof should consist of a sheet-copper strip 4 inches wide and .125 inch thick, covering the ridge and securely fixed to it by wrought-copper nails. At each end of the ridge a solid copper rod, .5 inch in diameter, is fixed to the conductor on the ridge, and projects about 5 feet above the highest point of the building; its upper end is pointed.

Copper strips, 3 inches wide, or copper tubes, 1 inch in diameter, pass down the angles of the hip, and are firmly secured to the copper eaves-gutter.

The descending water-pipes, made also of copper, and fastened to the face of the building by copper holdfasts, are connected at their lower end to the underground conductor by a piece of copper, 3 inches wide, wrapped around the lower end of the water-pipes and riveted to the underground conductor.

The underground conductor runs out from the building 4 feet, and then branches into two parts, each 8 feet long, 2 inches wide, and .125 inch thick. These conductors are about 2.5 feet from the surface of the ground at the lower end, and are covered with coal-ashes and earth.

The copper sheathings on the doors and windows are connected with the lower end of the water-pipes by flat copper strips, 2 inches wide, fixed to the water-table by copper nails driven into wood plugs about 10 feet apart.

When tubular conductors cannot be had of sufficient length in one piece, they are connected by a union joint, and strengthened by a small pipe or ferrule, about 4 inches long, inside the tube, and riveted to each end.

Buildings which have the eaves-gutters and down-pipes made of tin or zinc should have a main conductor communicating directly with the ground: it should also be connected with the eaves-gutter, and the down-pipe should connect by a metallic communication with the ground, running out some distance from the building.

In case of buildings situate on a dry or rocky soil, especial pains must be taken to lay down old chains or other conductors in various directions, to a distance of 10 to 15 yards, and from 1 foot to 1.5 foot below the surface of the ground; and, if possible, lead a flow of rain over the surface of the ground about or near the conductor. Let the conductor terminate in a large surface of moist earth whenever it can be effected.

If copper be not used for conductors, zinc is the next best material of which they can be made. If iron be used, it should be in the shape of galvanized wrought-iron pipe, not less than 2 inches in diameter, firmly screwed together in joints of extra thickness.

Copper tube, of a thickness of from .125 to .2 inch, is always to be preferred: it has more than five times the capacity for conducting electricity that iron has, and more than three times that of zinc.

CHAPTER TENTH.

AMMUNITION AND MILITARY FIREWORKS.

BUILDINGS.

In a large establishment for the preparation of ammunition and fireworks four separate buildings are required.

No. 1 should have a porch, and contain at least four rooms, viz.:

Cartridge-room, for making paper and flannel cartridges of all kinds.

Filling-room, for filling cartridges for cannon and small arms.

Packing-room, for putting up ammunition for transportation or storage.

Store-room, for materials and tools.

No. 2. Furnace or smith shop, should have three rooms,—two entirely cut off from the third by a partition-wall:

Driving-room, for driving rockets, fuzes, &c.

Mixing-room, for mixing compositions.

Furnace-room, for casting fuzes or bullets, and making compositions requiring the use of fire. The floors are laid with brick or flagging.

No. 3. Carpenter's shop.

No. 4. Magazine, for powder, fixed ammunition, &c.

All these buildings should be at a distance from inhabited buildings, apart from each other, and protected by trees or traverses of earth placed between them.

The size of the rooms must be regulated by the number of artificers to be accommodated. In small establishments the number of rooms may be reduced, as the same room may be used, at different times, for different purposes.

Fixtures and Furniture.

1. *Cartridge-rooms.*—A table for making cartridges for small arms, 12 feet long and 2½ feet wide, for twelve men or boys to work at, and the length in that proportion for any greater number; tables for cutting paper and flannel, and for rolling cases on; choker for rocket-cases; press for rocket and portfire cases; benches for cartridge-tables; stools. Closets should be partitioned off from these rooms, and furnished with cases, drawers, racks, and shelves for materials and tools.

2. *Filling-room.*—A shelf, 2 feet wide, for weighing on; other shelves, with closets under them; tables with raised borders, for filling, folding, &c.; budge-barrels, or powder-barrels with copper hoops and covers;

stools for seats; foot-stools; a step-ladder; stands and gutters for emptying powder-barrels.

3. *Packing-room.*—Tables, benches, and stools; platform balance.

4. *Store-room.*—Shelf for weighing on; shelves, drawers, and closets, tables, scales, stools, seats, step-ladder.

5. *Driving-room.*—Blocks set in the ground or pavement; benches and stools.

In favorable weather, a porch attached to the building, or a tent, may be used for a driving-room.

6. *Mixing-room.*—Tables with raised edges; sieves, &c.

7. *Furnace-room.*—Furnaces; workbenches; platform balance, or large scales; a tinner's bench and tools, with a vise, an anvil, and a chest for tools; a smith's forge, shovel, and poker; stools, &c.

8. *Carpenter's shop.*—Turning-lathe and tools; carpenters' benches and tools.

9. *Magazine.*—Shelves and frames for boxes and barrels.

Furnaces.

Two kinds of furnaces are used in a laboratory: in the first, the flame circulates around both the bottom and sides of the kettle; in the second, it comes in contact only with the bottom: the latter are used for compositions of which gunpowder forms a part.

Furnaces are built of bricks. The kettle is of cast iron, about 2 feet in diameter at the top, having a rounded bottom and a flange about 4 inches wide around the top, or else strong handles, to set it by. The bottom is 0.75 inch thick and the sides 0.5 inch. By setting it in an iron plate pierced with holes, encircling the bottom, a furnace of the first kind may be converted into one of the second kind by stopping the holes.

Furnace for reducing the oxide of lead, or dross.—This furnace is built in the open air, on a stone or brick foundation. It is composed of a cylinder of sheet iron, 16 inches by 30 inches, lined with refractory clay from 2 to 3 inches thick.

The interior has the form of an inverted frustum of a cone, terminating below in a basin, the bottom of which is inclined toward a tap-hole. The fire is made in the furnace, and the draught supplied by a bellows, the nozzle of which enters at the top of the reservoir. The dross, and the charcoal intended for its reduction, are thrown on the fire from the top of the furnace. The metal, as it is reduced, flows into the basin, and escapes through the tap-hole into an iron vessel, and is cast into bars or pigs as desired.

In the field, furnaces may be built with sods or sunk in the earth, if bricks cannot be readily procured.

Furnace built with sods.—Let the kettle rest on a trivet, the feet of which may stand on any piece of flat iron, such as the bottom of a shot-canister or stand for grape, the bottom of the kettle about 1 foot from the ground; build round it with sods. The door of the furnace is 10 inches square; the flue of the chimney, opposite to the door, 6 inches square, and commencing about 6 inches from the ground; the first part of the flue inclined at an angle of about 15°,—the rest vertical, and placed, if circumstances permit, against a wall; the top of the door and of the flue may be supported by small bars of iron.

Furnace sunk in the earth.—The edge of the kettle should be about 1 inch above the ground, and the bottom 12 to 15 inches above the hearth of the furnace; the earth is dug down vertically 1 foot from the kettle for the front of the furnace, and the door is cut out 10 inches square. The earth is removed and sloped out, so as to give access to the door; the flue is bored out on the opposite side with a crowbar: it commences 6 inches above the hearth and comes out of the ground 18 inches from the furnace, whence it is carried horizontally about 13 feet.

In furnaces of the second kind mentioned above, the trivet may be omitted, and the kettle may rest on the sod or earth for about 1 inch all round, and the earth rammed in against the sides of the kettle.

Precautions against Accidents.

Avoid, as much as possible, the use of iron in the construction of the buildings, fixtures, tables, benches, boxes, &c. of the laboratory; sink the heads of iron nails if used, and fill over them with putty, or paste several thicknesses of paper over them. Before the men go to work, cover the floor with carpets or tarpaulins, which are taken up carefully after the men leave and carried at least 50 yards from the building, and there shaken thoroughly and swept. During the work, have the carpets frequently swept.

Place the stores in cloth bags in the windows exposed to the sun. Prevent persons from entering with sabres, swords, or canes, &c., or with matches about their persons. Direct all who work where there is powder to wear moccasins or socks, and to take them off when they leave. Direct the men not to drag their feet in walking.

Make the doors and windows to open and close easily, without friction; keep them open whenever the weather permits.

Never keep in the laboratory more powder than is necessary, and have the ammunition and other work taken to the magazine as fast as it is finished.

Let powder-barrels be carried in hand-barrows made with leather, or with slings of rope or canvas, and the ammunition in boxes. Let every thing that is to be moved be lifted, and not dragged or rolled on the floor

Never drive rockets, portfires, &c., or strap shot or shells, in a room where there is any powder or composition, except that used at the time.

Loading and unloading shells, driving rockets, pulverizing materials, the preparation of compositions requiring the use of fire and in which the components of gunpowder enter, ought to be done in all cases, when possible, in the open air or under a tent, far from the laboratory and magazine.

Never enter the laboratory at night, unless it is indispensable, and then use a close lantern, with a wax or oil light carefully trimmed. Allow no smoking of tobacco near the laboratory.

In melting lead, be sure that it contains no moisture; put the pigs in carefully, and do not use more than will fill the pot two-thirds full.

Use the same precautions in melting fatty substances.

Applications for Burns.

Exclude the air by applying to the burn *fresh lard;* or bathe the part burned, and cover it with linen soaked in a mixture of 8 parts of sweet oil and 1 of hartshorn, well beaten together.

MATERIALS.

Saltpetre.

For use in the laboratory, saltpetre should be freed from all foreign substances and be reduced to a fine powder, or else to very minute crystals. It is best pulverized in the rolling-barrels at the powder-mills; but it may be pulverized by hand in the laboratory, as follows. Put into a *rolling-barrel* 50 lbs. of dry refined saltpetre and 100 lbs. of bronze balls; turn the barrel for two hours and a half, at 30 revolutions a minute, striking it, at the same time, with a mallet, to prevent the saltpetre from adhering to the sides. Separate the balls by means of a brass-wire screen, and the foreign substances with a hair-sieve.

Saltpetre may also be pulverized by pounding it in a brass mortar, or by solution, as follows. Put 14 lbs. of refined nitre, with 5 pints of clear water, in a broad and shallow copper pan, over a slow fire, and, as the nitre dissolves, skim off the impurities; stir the solution with a wooden spatula until the water is all evaporated,—when the nitre will be very white and fine. Should it boil too much, the pan must be lifted from the fire and set upon wet sand or earth, and the saltpetre should be stirred until it dries, to prevent it from adhering to the pan.

Charcoal

Is the residuum of the incomplete combustion or of the distillation of wood. Its composition and properties vary with the kind of wood from which it is made, and with the mode of carbonization used.

It is as much more dense and compact as the wood from which it is made is harder and of a closer texture; its density is nearly proportional to that of the wood, and its combustibility seems to be as much greater as its density is less.

The best charcoal for fireworks is that which is most inflammable and which leaves the least ashes, such as coals from black alder, willow, poplar, hazel-tree, hemp-stalks, &c. Hard woods, generally, give coals containing more ashes than light, soft ones; old trees more than young; dead trees more than living; in the same tree, the bark more than the sap-wood,—next the trunk, the roots, and, least of all, the branches.

In some cases, where long trains of fire are desired, charcoal from hard woods, such as oak, maple, or beech, is used. Charcoal for fireworks is best made in closed vessels. The different processes of carbonization are only more or less rapid distillations of the vegetable substance carried to a greater or less extent. The volatile matters which are disengaged and the fixed substances which remain vary at each moment, but in such a manner that the character of the former indicates that of the latter.

In a slow distillation by a progressive heat not exceeding 570°, bluish vapors are first disengaged, then carbonic and acetic acids, empyreumatic oil, and soot in dark clouds burning with a red flame. Carbonic oxide replaces, by degrees, the carbonic acid, the smoke becomes clearer, and the flame takes a violet tint. Afterward carburetted hydrogen is disengaged; the smoke becomes translucent; the flame passes from a violet to a yellow, then to a more and more shining white. Finally the smoke disappears, and the flame grows shorter and goes out.

If the operation be stopped when the flame of the gas becomes violet, about 40 per cent. of charcoal will be obtained. If the operation be continued till the flame becomes yellow, there will be had not more than 30 per cent. of coal. Finally, not more than 15 per cent. will remain after the flame goes out. In all of these cases, with slow distillation the carbonization is uniform from the surface to the interior of each piece of wood, and requires a longer time in proportion as the temperature is lower.

In a rapid distillation with a very strong heat, the gaseous products are disengaged simultaneously; the distillation on the surface of a piece of wood is finished before it is hardly begun on the interior. To obtain uniform results by this method, the distillation must be protracted till from 15 to 20 per cent. of coal only is obtained. By the rapid distillation a part of the incombustible matter is carried off, and the coal remaining contains less ashes. The carbonization in boilers, pots, pits, or heaps is nothing more than a rapid distillation.

Charcoal obtained by stopping the carbonization when the violet flame appears has a brown chocolate shade; its fracture is bright and even; it is flexible, in thin pieces; reduced to a powder, it has a greasy feeling and a velvetty appearance; it burns with a yellowish-blue flame, bright and without smoke; it gives out a heavy sound when broken, and dissolves almost entirely in potassa. Heated in a close vessel, it yields tar, pyroligneous acid, and 40 per cent. of gas. It is composed of carbon 0.735, hydrogen 0.288, and ashes 0.007.

Charcoal obtained from a protracted distillation, when only 15 per cent. is had, from dry wood, has a bluish-black color, is hard and coarse; it breaks easily, gives out a clear sound, burns without flame, and is with difficulty reduced to a powder; it is then dry to the touch, and does not easily form a cake by pressure: it is insoluble in caustic potassa. It is composed of carbon .906, hydrogen .076, and ashes .018.

All charcoals are embraced within the two preceding kinds, and approach more or less one or the other. Coal which has not reached the brown chocolate shade burns with smoke; it is called smoky coal: it is not yet charcoal. Charcoal takes fire at about 460°. Black charcoal, highly calcined, takes fire quickly, but is easily extinguished; red charcoal is longer in taking fire, but it keeps fire and burns up rapidly. This combustibility is as much greater as the charcoal is lighter. Charcoal at a red heat decomposes water to combine with its oxygen. Its absolute density is at least 1.5; the apparent density is very variable.

Charcoal does not become a conductor of heat and electricity unless it has been highly calcined at a white heat.

It absorbs moisture rapidly from the atmosphere,—particularly when in a state of fine powder. When freshly prepared and pulverized, it absorbs and condenses gases; it grows warm; and, if in a mass of more than about 60 lbs., it takes fire spontaneously. Black charcoal, highly calcined, may be set on fire, when in pieces, by a strong blow, or by friction.

To make a comparison between charcoals as to their action in compositions, make an intimate mixture of 5 parts of saltpetre and 1 of the charcoal to be tried, both well pulverized; drive a fuze with the composition, or press it in a metal tube of about one-quarter of an inch bore; take its weight and height, and determine the time of burning by a watch or pendulum. The rapidity of combustion, or the length of composition which burns in a second, measures the combustibility of the charcoal. Note also the weight of the residuum.

The rapidity of combustion is independent of the diameter of the tube and of the materials of which it is made: it varies very little with the greater or less compression of the composition, but varies much with the degree of trituration of the materials: it is therefore important, in comparing different coals, to mix the compositions precisely in the same way.

Sulphur.—When melted sulphur is to be used, care must be taken that it does not become thick,—which takes place at about 320°. It is pulverized by being rolled four hours in a rolling-barrel with twice its weight of balls, or by being pounded in a mortar and sifted. Roll-brimstone is used for melting, and flowers of sulphur may be used instead of roll-sulphur pulverized, but is not so good.

GUNPOWDER.—For compositions, gunpowder is *mealed*, either by rolling it for two hours with once and a half its weight of balls, or by beating it an equal length of time in a leather bag, or by grinding it with a muller on a mealing-table.

Mealed powder, and pulverized saltpetre, charcoal, and sulphur, are generally obtained from the powder-mills.

SULPHURET OF ANTIMONY is a gray solid, with a fibrous texture, very fusible, very volatile, and easily reduced to a powder. Density, 4.62.

It is found in the natural state, and can likewise be prepared by melting in a crucible equal parts, by weight, of antimony and sulphur pulverized and mixed. It is purchased in the state of a powder. Its purity is tested by treating a small sample (150 grs.) with concentrated warm hydrochloric acid. The residuum which is not dissolved ought not to exceed the sulphuret used, by 12 per cent.

CHLORATE OF POTASSA is a white salt, crystallized in white scales, anhydrous, not altered by exposure to the air. Soluble in water; more in warm than in cold; insoluble in alcohol. Density, 1.989. Fusible at about 662°; it is decomposed at about 720° into oxygen and chloride of potassium.

This salt is one of the most energetic of oxidizing bodies, because it parts with its oxygen readily, of which it contains a great quantity, (.3915 of its weight.) Thrown on burning coals, it melts quickly. It is ignited by simple contact with sulphuric acid: mixed with a combustible body, the mixture may be exploded by friction or by a blow. It should be purchased crystallized, and should not contain more than one-thousandth of its weight of chloride of sodium or potassium. Its purity is tested by means of the nitrate of silver dissolved in distilled water,—73½ grs. in one-quarter of a pint. Dissolve 77 grs. of the chlorate in 300 grs. of warm water, and let the solution get cold; the chlorate will be precipitated in crystals. Add to the liquid about two drops of the solution of the nitrate of silver. After filtering, the liquid ought not to give a precipitate by the addition of more nitrate of silver.

FULMINATE OF MERCURY is a white salt, crystallized in fine, silky needles. Soluble in water; more so in warm than in cold water.

The elements of this salt are held together so feebly that the least shock or friction causes its decomposition with an explosion. (For manner of making, see page 300.)

FULMINATING-POWDERS are compositions that detonate with great force by friction or by a blow. They are generally made of fulminate of mercury or a mixture of chlorate of potassa and sulphuret of antimony. The preparation and manipulation of these powders are very dangerous, and ought to be made, with the greatest precautions, far from the laboratory and magazines. The powder of chlorate of potassa and sulphuret of antimony cannot be manipulated without danger if it have not at least 20 per cent. of water with it. In this state a blow or friction explodes only the part struck or rubbed; the rest is dispersed without being set on fire.

The fulminate of mercury, with 30 per cent. of water, explodes partially when ground on marble with a wooden muller; but the explosion is not communicated to the rest. It should always be manipulated moistened with this amount of water.

LEAD is a bluish-white metal, bright, but tarnishes quickly in the air. Specific gravity, when pure, 11.48; melts at 600°, and volatilizes at a red heat

The purity of lead is judged of by its specific gravity. To determine this, after having weighed the pig, suspend it with a wire in a vessel of water, so that it shall be completely immersed, without touching the sides, and weigh it again. The weight in the air, divided by the difference between the weight in air and water, will give the specific gravity,—which ought to be 11.35 for lead of commerce.

Lead melted in contact with air is soon covered by a coat of gray oxide, which rapidly increases in thickness. The formation of this oxide, or dross, is prevented by covering the lead with powdered charcoal or rosin.

To reduce the oxide of lead.—Put in a kettle about 50 lbs. of lead, with $\frac{1}{10}$ of its weight of powdered charcoal or grease; cover the kettle, and raise to a red heat; stir the mass, and add gradually more coal, as it assumes a yellow color, using in all $\frac{1}{6}$ of the weight of oxide; dip out the lead with an iron ladle, and pour it into iron moulds or pans. After having obtained in this way two-thirds of the weight of oxide, in lead, throw the dross into a tub of water, and wash it, to separate the ashes and coal; dry the remaining oxide and grains of lead, and put them in a ladle with $\frac{1}{20}$ of their weight of rosin; raise it to a red heat, set fire to the rosin, shake the ladle, and pour off the lead. A further addition of rosin will produce more lead; $\frac{1}{14}$ of the weight of dross is generally used. Tallow may be used in place of rosin.

When the quantity of dross is considerable, it may be reduced, in a similar manner, in a small cupola-furnace. (See page 264.)

ACETATE OF LEAD (*Sugar of Lead*) is a white, efflorescent salt, of a sweetish taste, soluble in three or four times its weight of cold water. Specific gravity, 2.345. It may be made by heating a mixture of litharge and vinegar. The solution being concentrated and set aside to cool, the salt crystallizes in white, brilliant needles.

PLUMBER'S SOLDER is an alloy of lead and tin, in the proportion of 2 parts of the former to 1 of the latter.

ANTIMONY (*Regulus of Antimony*) is a grayish-white metal, very brilliant, with a highly-lamellated structure. Specific gravity, 6.7; melting-point, 809°. It is easily reduced to powder, and by its combustion with sulphur produces a strong light and heat, with a blue or white flame. Antimony is never found pure in the shops: that which is sold under the name of *regulus of antimony* always contains a little sulphuret of antimony, arsenic, and sometimes sulphuret of iron.

COPPER is a red, brilliant metal, possessing great tenacity, ductility, and malleability. Specific gravity, 8.9; fusible at about 1980°.

Copper, being but slightly acted on by saltpetre, is employed for powder-measures, utensils for refining saltpetre, &c. Copper vessels should not be exposed to a great heat, or used for heating compositions containing sulphur, as the copper would be rapidly oxidized.

In fireworks, copper-filings are used to givs reddish sparks and a greenish-blue flame.

BRONZE is used in the laboratory for utensils and implements which receive blows, or act by percussion, aud replaces steel and iron wherever there is danger of an explosion from a blow or from friction.

BRASS is an alloy of about 2 parts of copper and 1 of zinc. Brass wire is used for ligatures, for screens and sieves.

ACETATE OF COPPER (*Verdigris*) is a green salt, used sometimes to make slow-match, which burns with a strong coal and with a slightly green flame.

ZINC is a bluish-white metal; usually brittle, and its fracture shows a crystalline structure. Specific gravity, 6.9; melts at 680°, is volatilized at a red heat and takes fire in the air, burning with a white flame. At 400° it is easily reduced to a powder in a mortar. Granulated zinc is used to produce a bluish flame. An alloy of zinc and antimony pulverized gives beautiful blue drops. The oxide of zinc (*flowers of zinc*) produces the appearance called gold rain. It ought to be purchased in scales, not in a powder, as in this latter case it may be mixed with foreign substances.

IRON.—Filings and thin chips give very brilliant sparks and stars, the effects of which depend on the size of the particles used; the filings must be made when wanted, or be very carefully preserved from rust.

SHEET IRON.—Select the softest and most pliable. When it is substituted for tin, in strapping projectiles, it should be first annealed, by heating it to a dull red heat and letting it cool gradually under warm ashes, not exposed to the air.

CAST IRON.—Pulverized, it gives very large white sparks, in fireworks, (Chinese fire.) Select the white cast iron, or take the pieces of utensils with thin sides. To pulverize it more easily, heat it to a red heat and throw it into cold water.

STEEL.—In fireworks, filings and small pieces give ths most brilliant sparks.

PAPER.—*Musket cartridge-paper* should be homogeneous and without any trace of stalks, well sized, even, pliable, with a good body without being too thick, free from folds or rents.

The sheet, when moistened, ought to present a uniform hue, without spots or marblings. Taken out of the water and suspended a moment by the extremities of the short sides, it ought not to tear from its own weight. The sheet crumpled in the hand or pinched with the nails ought not to tear in the folds, and when torn the rent should be fibrous.

A strip of paper 4 inches wide ought not to break under a weight of 40 pounds, in the direction of its least strength.

In testing the strength of paper, the two ends are held by two vises of hard wood. Each vise is composed of 2 rectangular jaws, which can be brought against each other and held firmly by means of screws, or by tenons on one jaw passing through the other and keyed firmly to it. A strip of paper 4 inches wide is cut and inserted in the vises, so that the length between them shall be exactly 12 inches. The jaws are closed tightly, and one vise is suspended from a fixed point by means of a cord or hook, and to the other is made fast the pan of a balance. It is loaded gradually, with care, until the paper gives way. The strips should not be taken from the edges of the sheets only, but from all parts, and from the length and breadth successively, for in these two directions the strength is very different.

Five sheets are generally taken from each ream, in which only one sheet can have one-tenth less strength than that allowed. If this condition be not fulfilled, the ream is rejected.

Paper may be made by hand or by machine.

The other papers are tested in the same way, and should possess the same general characteristics.

Size and Weight of Paper.

No.		Size	Wt. of bundle.	Proof wt.
1.	For musket-cartridges	13 × 16½ in.		40 lbs.
2.	" " wrappers,	18 × 20 "	36 lbs.	101 "
3.	Blank cartridges	15 × 20 "	30 "	67½ "
4.	Portfires and rockets	19 × 28 "	65 "	180 "
5.	Fixed ammunition	23½ × 24 "	60 "	225 "
6.	Cannon-cartridges	19 × 23 "	70 "	315 "
7.	Fireworks	13 × 16½ "	20 "	85 "

The several kinds to be packed in bundles; Nos. 1, 2, 3, in bundles of 1,000 sheets each, the others in bundles of 500 sheets; all without folding. The dimensions given above are such as the sheets are required to have when trimmed for use.

Tow should be entirely of hemp or flax, clean, dry, sound, free from stalks and foreign substances.

Merino or Serge, for cartridge-bags, should be made entirely of wool; it should be strong, closely woven, twilled, and not frayed; the width should be even in the same piece; that $\frac{3}{4}$ yard wide is convenient and the most common. The colors are to be preferred in the following order,—green, gray, yellow, blue, red, white; reject black, which is almost always burnt and weak.

Canvas.—Take the strongest and closest woven; used for sacks for fire-balls.

Twine should be strong, smooth, and well twisted,—0.03 inch thick for bundling cartridges, &c., and for sewing fire-balls; from 0.06 inch to 0.08 inch for fixing ammunition, &c.

Thread.—For infantry cartridges, of unbleached flax, two strands, strong and even.

Rope should be even and well twisted; that most commonly used in the laboratory is *white hemp rope* from 1 inch to 1.5 inch in girth.

Thread and rope ought to be pliant, without being soft, made of hemp of good quality, water-rotted, and entirely freed from stalks; of a silvery color, pearl-gray, green, or yellow, not too deep, too black, nor stained with brown. Its size should be uniform throughout its whole length.

Gum Arabic should be transparent, yellowish-white, brittle, insipid, inodorous, soluble in water and vinegar, insoluble in alcohol. It is used in solution to give body and tenacity to compositions, or to make them burn more slowly. It should be prepared as required, for when in solution it undergoes a decomposition.

Glue should be hard, dry, transparent, of a brownish-red color, and free from smell.

Whiskey or Alcohol is used in moistening compositions into which saltpetre enters, as it does not dissolve saltpetre. It should be strong.

To prevent its being drunk, mix a little assafœtida with it. When whiskey cannot be had, vinegar may be used.

To prepare Pastes and Glue.

Flour Paste.—Sift the flour, and mix it with $8\frac{1}{2}$ times its weight of water; heat it gently, stir it, and let it boil for three-quarters of an hour; when it becomes ropy, pour it into bowls, and pass it through a sieve before it is quite cold. The flour yields 7 times its weight of paste. Time required to make it, one hour and a half. It is best made of rye flour.

Starch Paste.—Mix wheat starch with twice its weight of water; pour it gradually into $6\frac{1}{2}$ times its weight of boiling water, and let it boil for 10 minutes, stirring it all the time; then proceed as before. Starch yields 8 times its weight of paste. Time required, 1 hour.

Paste for Pasteboard.—Mix the flour or starch with 12 times its weight of water; this yields 9 times the weight of flour, and 11 times the weight of starch.

Paste mixed with Glue.—The addition of $\frac{1}{16}$th of glue makes the paste fit for pasting sheets of parchment together, or for pasting paper on wood. Dissolve the glue separately, and pour it into the cold water with which the flour or starch is mixed.

Cheese Paste is made of fresh white cheese and quicklime. Pound the cheese in a mortar with boiling water: let it stand, and decant it: repeat this operation three or four times. Pound together 3 parts of this cheese thus prepared and 1 part of quicklime, moistening it with pure water till the paste ropes like honey. Prepare only a little at a time. It is used in pasting parchment and parchment-paper.

These different kinds of paste should be used cold. A supply for not more than 2 or 3 days should be made at one time; but it may be preserved longer by adding alum in the proportion of $\frac{1}{10}$th of the weight of flour. The depredations of rats may be prevented by dissolving a like proportion of colocynth in the water with which the paste is made.

Glue is dissolved in its own weight of boiling water. A glue-pot with a water-bath should be used, to avoid burning the glue. Remove the pot from the fire as soon as the glue is entirely dissolved.

Trituration of Materials.

Materials intended for the preparation of fireworks are reduced to a powder by rolling them in a leathern barrel with bronze balls; or, if the barrel be not on hand, leather sacks, or mortars and pestles, may be used, attaching the pestle to an elastic rod.

During the trituration with the barrel, strike the bars of the barrel from time to time with a small mallet, to detach the materials which may adhere to the sides.

The materials taken from the barrel are first passed through a brass screen, to separate the balls, and then through a sieve. For certain purposes, as for signal-rockets, the charcoal should not be an impalpable powder. The trituration is then made in a leather sack.

The sack is filled and closed up: one man holds it by the mouth, lays it on an even block, and turns it frequently, whilst another strikes it with a billet of wood. After five minutes, the charcoal is taken out and passed over a silk screen, to get rid of the dust: what remains is then separated into three numbers.

No. 1. That which passes through the screen No. 1;

No. 2. That which passes through the screen No. 2;

No. 3. That which passes through the screen No. 3.

AMMUNITION FOR SMALL ARMS.

There are two kinds of cartridges used in service,—the ball-cartridge, made with a single elongated ball, and the buckshot-cartridge, made with fifteen buckshot.

Ball-Cartridges.

MAKING BALLS.—Lead balls are made by compression, by means of machines for that purpose. Balls thus made are more uniform in size and weight, smoother, more solid, and give more accurate results, than cast balls.

The lead is first cast into round cylindrical bars, .58 and .63 inch in diameter for the calibres .58 and .69 inch respectively, and 21 inches long, and then rolled to .46 and .56 inch in diameter for the same calibres respectively; length, 25 inches. These bars are fed to the machine, which cuts off a part sufficient for one ball and transfers it to a die, in which the ball is formed, with cavity and rings, the surplus metal being forced out in a thin belt around the ball in the direction of its axis. The balls are trimmed by hand, with a knife, and are then passed through a cylinder-gauge of the proper size.

A day's work.—One man can make with the machine 30,000 balls in ten hours, the bars of lead being prepared for him. One man can cast 1,500 bars in 10 hours, and can trim and roll 2,000 bars in 10 hours. A boy can trim and gauge 5,000 in 10 hours.

Bullet-moulds are provided to cast balls, where the pressed balls cannot be had.

The mould is so constructed as to trim the balls by a single operation before they are taken from the mould.

Buckshot are compressed by machines in a similar manner to balls. They are also readily obtained from private shot-works.

TO GREASE THE BALLS.—Place them on their bases on a tin frame capable of holding about 50 balls, and immerse it in a melted mixture of 1 part of tallow and 8 of beeswax, kept warm, until the cylindrical part of the ball is covered. Remove the frame, and let it stand till the grease hardens.

Three frames are required for each boy.

TO CUT THE PAPER.

WORKMAN.—1 *cutter.*

MATERIALS.—*Paper and pencil.*

IMPLEMENTS.—1 *cutting-board,* 30 inches square; 1 *iron ruler,* 33 inches long; 1 *lever,* 1 *cord,* 1 *large knife,* 1 *sandstone,* 1 *trapezoid of hard wood or iron.*

Cut the paper first into strips of a width equal to the length of a trapezoid, and then into trapezoids, using the pattern as a guide.

The paper and ruler are kept from moving by means of a lever, one end of which is fixed and the other is moved by the foot by means of a cord and treadle.

The knife is held in both hands.

From 6 to 8 reams may be cut at a time in this way.

A cutting-machine, like that used by bookbinders, facilitates the operation when many hands are employed.

When only a knife and ruler are used, about 12 sheets are cut at a time.

To Make the Cartridge.

Workmen.—1 *master*, 10 *boys*.

Implements *for each boy*.—2 *boxes* to hold cylinders, 20 inches long, 8 inches wide, and 4 inches high, in the clear, made of ½-inch boards, without a cover: they are placed on their sides, their backs inclined against the partition in the middle of the cartridge-table, the front resting on cleats nailed to the table; 1 *former*, cylindrical, of hard wood, of the same diameter as the ball, 6 to 7 inches long, one end pointed, almost as much as the ball, and marked with a shallow groove 4.0 inches from the end; 1 *sabot or frame*, tacked to the table, to hold balls, placed at the left hand of the boy; 1 *spool* of thread, turning on a vertical spindle fixed in the table near the balls; 1 *choking-string*, made of 4 or 5 cartridge-threads twisted together, about 9 inches long, with a wooden toggle at the end,—fastened to the edge of the table at the right hand of the boy; 1 *knife-blade*, 1½ inch long, hooked, driven into the front of the table below and near the choke-string.

To Form the Cylinder.—Lay the trapezoids on the table with the side perpendicular to the bases toward the workman, the broad end to the left.

Take the former in the right hand and lay it on a trapezoid, the groove in the former against the right edge of the paper, bringing the pointed end ⅛ inch from the broad end of the paper; envelop the former with the paper; then, with the fingers of the left hand laid flat upon the paper, turn the former and roll all the paper upon it; hold it with the left hand, and, with the choking-string in the right, take one turn around the cylinder at about ⅛ inch from the end; hold the former firmly in the left hand, and draw gently upon the choking-string, pressing at the same time with the left forefinger upon the projecting end of the cylinder, thus folding it neatly down upon the end of the former. Having choked the cylinder close, carry it to the right side, and, with the thread in the right hand, take two half-hitches firmly around the part that has been choked; cut the thread on the knife-blade, and press the choke in a cavity in the table; place the former, with a cylinder on it, on a second trapezoid; put a ball over the end of the former; roll the paper on the former and the ball; hold the cylinder in the left hand and choke and tie it as just described for the inner cylinder; withdraw the former, pressing the cylinder with the left hand, and place it in the box.

A day's work.—A boy can make 800 cylinders in 10 hours.

To Fill the Cylinder.

Implements.—1 *charger*, made of a cylinder of wood or brass pierced with two holes through its length, holding the exact charge of powder; a funnel attached to one end of the cylinder, and a discharge-pipe to the other. The holes in the cylinder are made to communicate and shut off, alternately, from the funnel holding the powder, and the discharge-pipe at the lower end, by a reciprocating motion given to the cylinder by the hands.

Fill the funnel with powder; insert the discharge-pipe in a cartridge, holding the charger in both hands, and turn the cylinder; the charge of powder is deposited in the cartridge: insert the pipe in the next, and turn the cylinder in the opposite direction; and continue in the same way for all the rest.

Cartridges may be filled with a copper charger made to hold the exact charge, pouring the powder by means of a small funnel which is inserted in the cartridge.

To Pinch the Cartridge.—Take the cartridge in the right hand, strike it lightly on the table to settle the powder; flatten the empty part of the cylinder, and bend it, flush with the top of the powder, at right angles to the cartridge, the oblique side of the trapezoid on top, the cartridge standing vertical on the table; fold the flattened part in the direction of its length with two folds from the exterior, meeting in the middle; bend this folded end back on itself, and strike it on the table to set the folds.

To Bundle Cartridges.

Utensils.—1 *box* without ends or top: width equal to 5 times the diameter of the ball, height equal to twice that diameter, and length that of the cartridge. It is tacked to the table, the sides parallel to and near the edge of the table.

Put a wrapper in the box, the long side perpendicular to the edge of the table, the middle of the paper in the middle of the box; place, parallel to the sides of the box, two tiers of cartridges of 5 each, the balls alternating; bring the short ends of the paper together, and fold them twice close down on the cartridges; insert a package of caps in the end of the bundle next to the ends of the lower tier; fold the wrapper on the ends, and tie the bundle, first in the direction of the length, then its breadth, with the twine fastened in a single bow-knot. The wrappers are of different colors, to distinguish the cartridges for the different arms.

Cases for Percussion-Caps.—These are rolled on a former, .54 inch in diameter, choked at one end and tied. Twelve caps are put in, and the case is closed by twisting the open end of the case.

Packing Cartridges.—Cartridges are packed in boxes containing 1,000 each. Five tiers of bundles are laid flat in a single row along one side of the box; the rest are placed on edge, the caps alternately up and down. *Blank cartridges* are packed in boxes containing 2,000 each; the bundles are placed on end, the caps alternately up and down.

Packing-boxes.—The boxes are made of white pine boards, dovetailed and nailed together, and are furnished with wooden brackets or handles nailed to the ends with wrought nails, clenched on the inside; the lids fastened with six 1.75 inch screws. They are painted different colors, to indicate the kind of cartridges. The boxes should be lined with strong paper, and the bundles of cartridges must be packed closely, so as not to shake in transportation. Each box should be marked, on each end, with the number and kind of cartridges, and on the inside of the cover with the place and date of fabrication.

Blank Cartridges.

MATERIALS.—*No.* 2 *paper; paste; powder.*

Cut the paper into trapezoids as for ball-cartridges; roll the trapezoid on the former, one turn; fold down this much of the paper on the head of the former with the left hand; roll the rest of the paper; fold down the rest of the paper; touch the fold with a little paste on the finger; press the end of the former on a ball imbedded in the table for the purpose; remove the cylinder from the former; place it in a box to dry.

Fill the cylinders as described for ball-cartridges.

A day's work.—One boy can make 2,000 cylinders in 10 hours.

Packing Musket-Balls.

Balls are packed in boxes with tow or sawdust, to prevent their bruising. The boxes are made of 1-inch boards, and contain 1,000 balls.

They are marked on both ends with the number and kind of balls, and on the inside of the cover with the place and date of fabrication. The cover is fastened with six 2-inch screws, and the boxes must be hooped with iron for transportation. They are not painted.

Cartridges for Small Arms.

KIND OF CARTRIDGE.	EXPANDING BALL.			BLANK.	ROUND BALL.		ELONGATED BALL.			
Kind of Arm.	Musket of 1842.	Musket and Rifle, 1855.	Cadet Musket, 1857.	Musket and Rifle, 1855.	Musket, 1842. Ball.	Musket, 1842. Buckshot.	Pistol Carbine.	Revolver, Army.	Revolver, Navy.	Sharpe's Carbine.
Calibre ....in.	.60	.58	.58	.58	.69	.69	.58	.44	.38	.54
Ball. Diameter ....in.	.685	.5775	.5775		.65	....	.5775	.46	.39	.56
Ball. Weight ....grs.	730	500	450		412	....	450	216	145	475
Charge of powder ....grs.	70	60	50	60	110	110	40	30	17	50
Trapezoid. Height ....in.	4.33	4.12	4.12	3.75	4.33	5.5	4.1	2.75	2.4	3
Trapezoid. Long base ....in.	4.5	4.0	4.0	4.16	5.25	5.0	4.0	3.25	2.5	3.25
Trapezoid. Short base ....in.	2.7	2.5	2.5	2.5	3.0	3.0	2.5	1.6	1.6	2.25
No. of trapezoids in 1 sheet	12	16	16	24	12	9.	16	30	40	24
Wrapper. Length ....in.	10.	9.	9.	....	9.	....	9.	8.	7.5	10.
Wrapper. Width ....in.	8.	6.5	6.5	....	6.5	....	6.5	6.5	4.9	6.8
Wrapper. No. in a sheet	4	6	6	....	6	....	6	6	12	4
Wrapper. Color	Ordinary color.	Ordinary color.	Red.	Ordinary.	Green.	Red.	Blue.	Ordinary.	Blue.	Ordinary.
Thread for 1,000 ....oz.	0.5	0.5	0.5	....	0.5	0.5	0.5	0.5	0.5	0.5
Weight of 10 cartridges ....oz.	19.5	13.5	13.	....	13.2	....	12.5	6.	5.	13.5
Bundles of 10. Length ....in.	2.5	2.6	2.5	....	2.6	3.1	2.4	2.3	2.20	2.6
Bundles of 10. Width ....in.	3.4	2.9	2.9	....	3.1	3.1	2.9	2.0	1.9	2.5
Bundles of 10. Depth ....in.	1.45	1.15	1.15	....	1.35	1.35	1.15	.85	.85	1.1
Size of packing-boxes for 1,000 cartridges. Length ....in.	14.0	14.75	....	*15.5	15.5	15.	....	†13.1	†10.5	14.75
Size of packing-boxes for 1,000 cartridges. Width ....in.	12.0	10.75	....	11.0	11.75	10.75	....	4.6	3.8	8.9
Size of packing-boxes for 1,000 cartridges. Depth ....in.	7.0	6.38	....	6.25	6.75	6.38	....	3.5	3.25	5.2
Weight of box packed ....lbs.	135	98	....	....	107	....	....	28.5	16.5	78.
Color of box	Lead.	Olive	Gray.	Olive.	Blue.	Red.	Yellow.	Olive.	Blue.	Olive.
Packing-boxes for 1,000 balls. Length ....in.	9.75	8.25	8.25	....	7.25	....	5.25	....	....	....
Packing-boxes for 1,000 balls. Width ....in.	9.75	8.25	8.25	....	7.25	....	5.0	....	....	....
Packing-boxes for 1,000 balls. Depth‡ ....in.	5.25	5.0	4.25	....	5.0	....	4.25	....	....	....
Packing-boxes for 1,000 balls. Weight ....lbs.	107.	73.	59.5	....	65	....	59.5	....	....	....

* For 2,000 cartridges. † Contains 600 cartridges: box made of .75-in. boards. If the balls be packed in tow, add ½ in. to the depth of the box.

Burnside's Cartridges.—Box 14.4 × 11.2 × 6.2. Weight, 87.5 lbs.

AMMUNITION FOR FIELD AND MOUNTAIN SERVICE.

The ammunition for field and mountain service consists of—

Shot for the 6 and 12 pdr. guns.

Shells for the 12-pdr. guns, and 12, 24, and 32 pdr. howitzer and mountain howitzer.

Spherical case shot for the 6 and 12 pdr. guns, and 12, 24, and 32 pdr. howitzer and mountain howitzer.

Canisters for the 6 and 12 pdr. guns, and 12, 24, and 32 pdr. howitzer and mountain howitzer.

The projectile is attached by straps of tin to a wooden *sabot*, to which is also fastened the *cartridge-bag* containing the charge, for the guns, the 12-pdr. howitzer, and the mountain howitzer, making together *a round of fixed ammunition*. The cartridge for the 24 and 32 pdr. howitzers is not attached to the sabot, but to a *cartridge-block*, and is separate from the projectile.

Cartridge-Bags.

The cartridge-bag is a cylindrical bag with a circular bottom, made of merino or serge. The material should be composed entirely of wool, free from any mixture of thread or cotton, and of sufficiently close texture to prevent the powder from sifting through: that which is twilled is preferred. Flannel is used when the other materials cannot be conveniently obtained.

To Cut the Cloth.

Implements.—2 *tables; patterns*, of hard, well-seasoned wood, or of sheet iron or tin, for the rectangles and bottoms; *shears; chalk* or *colored crayons*.

A marker and assistant spread out the cloth on the table in two thicknesses, and make it fast at each end of the table on three or four hooks driven in the ends of the table, or by means of weights, drawing it sufficiently to take out the folds, and no more.

They mark out the rectangles and bottoms with the patterns and ruler, so disposing and combining them as to cut the cloth to the best advantage.

The length of the rectangle (development of the cylinder) should be taken in the direction of the length of the stuff, as it does not stretch in that direction. The selvage, if there be any, ought to be at the mouth of the bag. The cutter takes a piece thus marked to another table and cuts out the rectangles and bottoms with a pair of shears. The bottoms may be cut out with a hollow punch of the proper size.

Sewing.—Marks for the seam are traced on the rectangles and bottoms, by means of patterns of the proper size. The seam should be at least a half-inch from the edge. The bag is sewed with woollen yarn, with a back-stitch, 12 to the inch. The edges are turned down on the same side of the seam and basted, to prevent the powder from sifting through; the edges of the bottom are basted down upon the sides. Bags may be sewed advantageously by the sewing-machine. Bags for fixed ammunition are sewed to within 3 inches of the mouth for 12-pdrs.; to within 2.75 inches for 6-pdrs.; all others, up to the mouth. A bag is given as a model to sew by.

Cartridge-bags, when filled, should pass through the small shot-gauge of their calibre; those used for patterns should be thus verified. The empty bags should be measured by laying the bag, flattened out, between two marks on a table, showing the width of the pattern-bag; a variation of 0.1 inch, greater or less, is allowed. Reject those sewed with too large stitches.

Bags for practice or for blank cartridges may be formed by sewing together two rectangular pieces with semicircular ends; the cloth is marked, for cutting and sewing, with stamps made of 1-inch boards of the dimensions of the cutting-stamp, with a strip of tin or copper fastened to the edge of the board, and projecting about $\frac{3}{4}$ inch perpendicular to the side; another strip parallel to the first is inserted in a groove $\frac{1}{2}$ inch from it: the edges of these strips are made rough, to retain chalk or paint used in marking. A handle is placed in the middle of the face opposite to the marking-strips. Width of cutting-stamp for 12-pdr., 7.6 inches; for 6-pdr., 6 inches. Length, including semicircular ends, for 12-pdr., 10.5 inches; for 6-pdr., 8.5 inches.

Packing.—Cartridge-bags are preserved from moths by being packed with pounded camphor and black pepper, or dipped in water with arsenic dissolved in it, or a solution of sulphate of copper, 1 lb. of sulphate to 25 lbs. of water. Or they may be sealed up, in bundles of 50, in cases made of cartridge-paper, carefully closed with strips of thin paper pasted over the seams. Each bundle is marked with the number and kind of bags.

They may be preserved from moisture by being enveloped in water-proof paper.

Sabots and Cartridge-Blocks.

Sabots and cartridge-blocks are made of poplar, bass-wood, or other light, close-grained wood: it must be well seasoned, and should be clear of knots and splits.

The assistant saws the scantling to the proper length for a sabot, roughs it out, and marks its centre.

The turner puts it in the lathe, and turns, first the exterior and grooves, and then the cavity for the projectile.

The holes for the handles are bored with a bit, and countersunk on the inside to receive the knot on the end of the cord. Distance between them for shells is 1.5 inch; for canisters, 2.3 inches. Length of cord for handles, for shells, 12 inches; for canisters, 20 inches. Diameter of cord, .15 inch.

The cartridge-blocks and sabots for shot and spherical case shot for guns have one groove. Sabots for gun-canisters and for the 12-pdr. howitzer and mountain-howitzer shells, spherical case shot and canisters, have *two* grooves. All the grooves are .3 inch wide and .15 inch deep. They are .8 inch apart, from centre to centre, for guns, and .5 inch for howitzers. The corners and bottom of the grooves are slightly rounded.

The dimensions of finished sabots and blocks are verified with appropriate gauges. For dimensions, see page 280.

A day's work.—One man can make 350 sabots for 6 or 12 pdr. gun,
or 300 " " field-howitzers,
or 600 cartridge-blocks, small charge,
or 700 cartridge-blocks, large charge.

Straps.

Straps are made of sheet tin. For *shot* there are two straps crossing at right angles, one passing through a slit in the middle of the other. For *shells* there are four straps fastened to a ring of sheet tin, pierced with 4 slits, through which the ends of the straps are passed and folded down on the under side.

The sheet of tin is first cut to a length equal to that of the straps, and if the straps are for shot, a line is drawn, dividing it into two equal parts, to mark the place for the slit. The straps are cut with circular shears. If such be not at hand, the width of the strap is marked on the sheet, is cut with tinner's shears, and straightened on a bench with a mallet.

The slits are made with a cold chisel on a block of lead, and a strap not slit is passed through, and set flat by a blow of the hammer.

Rings.

Rings are cut from sheet tin by means of two punches, the first having the diameter of the exterior and the other that of the interior of the ring. The slits are made with a cold chisel, and the required concavity to fit the ball is given by hammering on a block of lead having a concave surface. The ends of the straps are passed through the slits, folded down, and set flat. *Dimensions* of rings: exterior diameter, 3.25; interior diameter, 1.75.

Strapping Shot and Shells.

IMPLEMENTS.—1 *bench;* 2 *pans*, containing *nails* 0.55 inch long, with strong, flat heads 0.2 inch diameter; *boxes* and *barrels*, for straps and sabots; 4 *hammers*, for strapping; 1 *common hammer;* 4 *punches; shot-gauges*, of each calibre; 1 *gauge* for each calibre, 0.04 inch greater than the largest shot-gauge, through which the shot should pass after it is strapped; *tow* or *rags*, for wiping balls; 1 *wheelbarrow;* 1 *tarpaulin*, if the shop have not a plank floor.

A helper knocks off the scales from the balls with a hammer, cleans and dries the interior of the shells, if requisite, wipes the balls, and gauges them both before and after they are strapped.

The workman, sitting astride the bench, places the shot or shell in the cavity of the sabot, the roughest part of the shot down, the fuze-hole of the shell on top, in the axis of the sabot. The ball should rest on the bottom of the cavity, (it can be told from the sound, by striking on the bottom of the sabot with a hammer;) if it do not, the sabot is rejected. The workman places the junction of the straps in the axis of the sabot, or the ring concentric with the fuze-hole of the shell; beginning with the strap which is not slit, he forces the end of it into the groove of the sabot with the back of the hammer, punches it, and nails it; he then draws the other end tight, punches it, and nails it, in the same manner. He disposes the other strap perpendicular to the first, nails it to the sabot as he did the first, cuts off the superfluous length, and with the hammer and side of the cold chisel sets the straps in close to the ball at the top of the sabot.

The sabots for 32 and 24 pounder field-howitzers having no groove, each strap is fastened by 1 nail on the side and 2 under the bottom of the sabot.

A day's work.—Two men can strap, in 10 hours, 130 shot, or 75 shells, cutting the tin from the sheet.

THE BOXER MODE.—Bore a hole, .2 inch in diameter, .15 inch deep, in the shot; enlarge the hole at bottom. Take a copper rivet .2 inch diameter, hollow out the end, leaving the length of the rivet .25 inch greater than the least thickness of the sabot; bore a hole in the centre of the sabot for the rivet, with a countersink for the head; place the shot in the sabot, the hole down; insert the rivet in the sabot, making it enter the hole in the shot; strike the head of the rivet a blow with a hammer to upset the end of the rivet and fasten the sabot.

Another mode.—If tin or sheet iron cannot be procured, straps may be made of *strong canvas*, 1 inch wide, sewed at the point of crossing. The part of the ball which is to be inserted in the sabot is dipped in glue; the straps are also glued to the ball; the ends are doubled into the groove and secured by 2 nails in each end. Another method is to wrap round the ball a band of canvas 1 inch wide, one half of which is glued to the ball, the other to the sabot; or the shot may be kept in place by merely tying the cartridge-bag over the top of it.

Charging Shells.

MATERIALS.—*Rifle or musket powder; plugs; fuzes; chalk.*

IMPLEMENTS.—1 *funnel; powder-measures,* to hold the required charges; 1 *wooden straight-edge; large bowl; fuze-wrench.*

The shells, having been properly cleaned, dried, tapped to receive the plug and the fuze, and attached to the sabots, are placed in two rows. The workman fills the measure with powder, strikes it level with the straight-edge, and pours it in the shell; the assistant holds the funnel, and marks the shell with chalk when filled, to prevent mistakes. The assistant screws in the plug. The workman puts a little white lead on the threads of the fuze, punches 4 or 5 small holes in the tin disk, and screws the fuze firmly into the shell, the assistant holding the shell to prevent it from turning.

Spherical Case Shot.

The shot having been cleaned and inspected, the upper part of the fuze-hole is tapped to receive the fuze; the small hole is tapped to receive the plug.

To Fill the Shell.

Materials.—*Spherical, leaden balls,* calibre .69 inch; *sulphur; linseed-oil.*

Utensils.—1 *kettle;* 1 *ladle;* 1 *iron funnel,* the neck chased with the threads of a screw, to fit the small part of the fuze-hole.

Filling the Shell.—Cover the lead balls with linseed-oil, and fill the shell with them, pushing the upper balls aside with the fingers or a stick, to get in as many as possible. Warm the shell gently, and screw the neck of the funnel into the fuze-hole; pour in the melted sulphur, filling the shell.

To Make the Chamber for the Charge.—Chuck the shot in a lathe; screw the funnel into the fuze-hole, to protect the threads from being injured by the auger, and with a common screw-auger bore a hole in the axis of the shell to the bottom. Diameter of the auger, .75 inch.

Lacker the shot and strap it; paint the ring around the fuze-hole *red.*

To Charge the Shot.—Fill the chamber with musket-powder, ramming it slightly with a wooden drift and light mallet; screw in the iron plug, leaving its top flush with the bottom of the large portion of the fuze-hole, and lay over it a thin leather washer with a hole in the centre; fill the hole in the plug and washer with rifle-powder; punch 4 or 5 small holes in the tin disk in the bottom of the fuze; put a little white lead on the threads of the fuze, and screw the fuze firmly into the shell.

Fix the spherical case shot the same as round shot.

Canisters. (Plate 31.)

A canister for field-service consists of a tin cylinder attached to a sabot and filled with cast-iron shot. For the dimensions of *Canister-Shot,* see Chapter II.

Canisters for the mountain-howitzer are filled with lead balls.

Materials.—*Sheets of tin,* 0.02 inch to .025 inch thick, (double tin;) *soft solder; rosin; culots* of rolled iron, .25 inch thick; *covers* of sheet iron, 0.07 inch thick for the guns and 12-pdr. howitzers, and .1 inch thick for the 24 and 32 pdr. howitzers; *sabots; tacks.*

UTENSILS.—*Patterns; tracing-point; shears; cylinder* of hard wood; *mallet; gauges; furnace; soldering-iron; hammer; punch.*

TO MAKE THE CYLINDER.—The workman marks out the rectangle on the sheet with the pattern; cuts it, and traces the line for the lap; he draws a line parallel to the long side of the rectangle, .4 to .5 inch from it, for the length of the slits. It is then bent round the *former*, the edge brought to the line of the lap, clamped and soldered.

If lumps of solder be left, they are filed down. The cylinder is made round, and gauged on the exterior with the large shot-gauge of the calibre, and the interior with a cylinder of a diameter 0.02 inch less than that given in the table, which should enter the canister: if it be not of the right size, it is unsoldered and soldered over again.

The slits are made, and the sabot inserted and nailed with 6 to 8 nails.

Before filling the canister, dip the tin cylinder into a lacker of beeswax dissolved in spirits of turpentine, to prevent it from rusting. Coat the balls and the plates with paint or coal tar.

FILLING CANISTERS.—The workman, sitting astride the bench, places the canister upright in front of him, inserts the iron bottom and places it flat on the sabot, puts in a tier of balls, fills the interstices with dry, sifted sawdust, packs it with a pointed stick so that the balls will hold by themselves, and throws out the loose sawdust; he places another tier of balls, each ball lying in the interval between two balls of the lower tier, and proceeds in the same manner until the canister is filled; covers the upper tier with sawdust; puts on the cover, places on it one of the iron bottoms furnished with a handle, and strikes it with a small mallet in order to compress the sawdust; then removes this bottom, and turns down the slit pieces of the canister over the cover, with a hammer. In the canisters for the 6 and 12 pdr. guns the centre ball of the last tier is omitted. When the canister is finished, verify its diameter with the large shot-gauge of the same calibre.

Cylinders and Caps.

For the greater security of field ammunition, the cartridges are covered with paper cylinders and caps. The cap is drawn off at the moment of loading the piece, and in using solid shot it may be placed over the shot, to diminish the windage. A cylinder and a cap are formed together by folding the paper over a *former*, which allows a lap of about 0.75 inch for pasting. The requisite length for the cylinder is cut off from the smaller end; the rest forms the cap, which is *choked*, at the end from which the cylinder is cut, on a *cylindrical former* which has a groove around it marking the length from the rounded end for cutting the cap. The former should be bored through the axis with a .5-inch hole to facilitate drawing off the cap.

The caps for shells are stained *black;* for spherical case shot, *red;* for shot, not colored.

Fixing Ammunition.

IMPLEMENTS.—*Barrels* for powder; 1 *funnel;* 1 *set of powder-measures;* 1 *straight-edge,* to strike the measures with; *barrels; tubs,* formed of barrels sawed in two, or *boxes* for the cartridge-bags; 2 *tarpaulins;* 2 *benches;* 12 *choking-sticks,* 6 with holes in them and 6 slit; 6 *knives;* 6 *hand-barrows,* with four legs and a box, and *tarpaulins* to cover them; *calibre-gauges,* for the cartridge-bags and for fixed ammunition; (they may be made of wood;) 6 *stools;* 1 *wheelbarrow;* 1 *mallet;* 1 *copper chisel;* 1 *copper drift,* or a *wrench,* to open powder-barrels.

FIXING SHOT, OR SPHERICAL CASE, FOR FIELD-GUNS.—The bags should be filled in the small magazine or filling-room. The assistant holds the pipe of the funnel in the mouth of the bag with both hands, the bag pressed close against the pipe. The gauger heaps up the measure with powder, strikes it level with the straight-edge, and pours it into the funnel. When about 25 bags are filled, the gauger takes a filled bag with one hand, squeezing the bag upon the powder; he gives it a blow with the other hand on the top and bottom of the bag, twisting the mouth of the bag down upon the powder at the same time; he then tries it with the small gauge, through which it should pass with not more than 0.25 inch play; should it not do this, the bag is emptied and rejected. These bags, filled and gauged, are placed upright in a tub or box, and carried by the gaugers into the finishing-room, where the men are placed in pairs, sitting astride on a bench, facing each other. One of them opens a bag and levels the powder, the other inserts the sabot of a strapped shot square upon the powder and draws up the end of the bag over the shot; the first man passes about four feet of twine through the pierced stick, and makes two turns and a double hitch with the end at the top of the sabot; he makes a knot in the end of the twine, inserts it into the slit in the other choking-stick, and tightens the double hitch by rolling the twine on the sticks and bearing upon the sabot; he then takes out the end of the twine from the slit, ties it in a hard knot, which he tightens with the assistance of the choking-stick, and cuts the twine off near the knot. The second man turns down the mouth of the bag over the sabot, and the first makes a similar tie in the groove; he makes another tie below the sabot, the twine being lodged between it and the powder, to prevent the latter from sifting in between the bag and the sabot; he then runs the paper cylinder over the cartridge and sabot, leaving about two inches of the end of the cartridge uncovered, and he makes a tie, similar to the others, in the groove of the sabot. He now holds the shot in the left hand and examines it, striking the sabot with the right hand, if necessary, to bring it straight; if the shot be properly fixed, the sabot and the bag will have the same axis; the seams should be between two straps, and the knots should be neither on the seams nor on the straps.

The assistants pass the cartridges through the large gauge, which is 0.04 inch larger than the large gauge for the shot. If the size be correct, they put on the paper cap, lay the cartridges on their sides in the box of the hand-barrow, and carry them to the magazine. Those which will not pass through the gauge are handed back to the fixers, who cut the strings and put them up anew.

Canisters for Field-Guns are fixed in the same manner as shot, except that the first tie is made in the upper groove of the sabot; the cylinder is tied in the lower groove. The caps must be cut somewhat shorter than those for shot-cartridges.

For the 12-*pdr. Field-Howitzer.*—The shells, spherical case, and canisters are fixed in the same manner as the gun-canisters.

For the Mountain-Howitzer.—The sabots having but one groove, the first tie is omitted, and the cartridge is covered with a cap only.

For the 32-*pdr. and* 24-*pdr. Howitzers.*—The cartridge is not attached to the projectile. The cartridge-block is inserted with the grooved end next to the powder, and a tie made in the groove; the mouth of the bag is then turned down, and another tie is made between the cartridge-block and the powder; the superfluous part of the bag is cut off, and the cartridge is covered with its cylinder and cap, as in other cases.

When the shot is attached to the sabot by a single band of canvas, or when it is placed in the sabot without any strap, the cartridge-bag is drawn over it and tied on top; for this purpose, the bag should have an additional length of from 2½ to 3 inches.

When sabots cannot be obtained, place upon the powder a layer of tow about 0.2 inch thick, forming a bed for the shot; tie the bag over the shot and around the tow; the bag requires to be 1 inch longer than for strapped shot.

Packing Field-Ammunition.

Packing-Boxes for field-ammunition are made of well-seasoned stuff, (generally white pine,) 1.25 inch thick, dovetailed, with the tenon on the ends. The top of the box is fastened with six 2-inch screws; the box has two handles of 1¾-inch rope, attached to brackets at the ends.

The boxes are painted on the outside different colors, to indicate the contents of the box. Those containing shot are painted *olive;* shells, *black;* spherical case shot, *red;* and canisters, a *light drab.* The kind of ammunition is marked on each end, in large white letters. The place and date of fabrication are marked on the inside of the cover.

Manner of Packing Ammunition-Boxes.

For Guns.—*Shot, Spherical Case, and Canisters, fixed.*—Laid in two tiers across the box, the shot or canisters alternating with the cartridges at each side. The shot or canisters of the upper tier rest on those of the lower, and not on the cartridges.

For 32-pdr. and 24-pdr. Howitzers.—*Shells and Spherical Case Shot.*—Placed upright, the balls down, resting on strips of wood about .25 inch thick, placed lengthwise of the box and nailed to the bottom, so as to prevent the fuzes from bearing on the bottom of the box. The balls are held down by small strips of wood tacked with sprigs to the sides of the box, over the sabots. The cartridges are laid on top of the sabots.

Canisters are packed in the same manner, omitting the strips of wood in the bottom of the box.

For 12-pdr. Field and Mountain Howitzers.—*Shells and Spherical Case Shot, fixed.*—Placed upright, the balls down, resting on strips of wood, as for the other howitzers.

Canisters are packed in the same manner, resting on the bottom of the box.

For Rifled Guns.—*Case Shot, fixed.*—Placed upright, the balls down, resting on strips of wood, as for the howitzers. The iron part of the balls rests against strips of wood 4 inches wide and .25 inch thick, nailed to the side and ends of the box at the bottom, and similar strips placed between the rows of the balls, to prevent the soft-metal cups from bearing against the box or against each other and being bruised.

Canisters, fixed, are packed in the same manner as the case shot, omitting the strips of wood on the bottom of the box.

In all the boxes, the small stores are placed in the vacant spaces on top of the ammunition.

A layer of tow is placed in the bottom of each box, and the whole contents are well packed in tow, filling the box so as to be pressed down by the cover. About 3 lbs. of tow are required for a box.

Ammunition for Field and Mountain Service.

		12-pounder. Shot.	12-pounder. Shell.	12-pounder. Spher. case.	12-pounder. Canister.	6-pounder. Shot.	6-pounder. Spher. case.
Charge of powder. Weight	lbs.	2.5	2.0	2.5	2.	1.25	1.25
Charge of powder. Height	in.	5.	4.	5.	4.	4.	4.
Cartridge-bag. Rectangle. Length*	"	14.2					11.4
Cartridge-bag. Rectangle. Width	"	10.0					7.25
Cartridge-bag. Bottom, diameter	"	5.25					4.37
Loading shells and spherical case. Weight of powder†	oz.		7.	1.			.5
Loading shells and spherical case. " sulphur	"			10.5			4.5
Loading shells and spherical case. Number of balls				82			41
Sabot. Height of... whole	in.	2.			2.25	1.55	
Sabot. Height of... conical part	"	....			......	....	
Sabot. Height of... cylindrical part	"	....			.5	....	
Sabot. Diameter... greatest	"	4.35			4.52	3.35	
Sabot. Diameter... at bottom	"	4.15			4.15	3.2	
Sabot. Diameter... of cylinder	"	....			4.47	....	
Sabot. Diameter... bottom of cone	"	....			......	....	
Sabot. Cavity for ball... Depth	"	1.5			......	1.	
Sabot. Cavity for ball... Radius	"	2.26			......	1.8	
Sabot. Dist. fr. mid. lower groove of sab. to bottom	"	0.4			0.4	0.4	
Cartridge-block. Height	"	....			......	....	
Cartridge-block. Diameter	"	....			......	....	
Cartridge-block. From middle groove to bottom	"	....			......	....	
Straps. Length	"	12.75	6.		......	10.	5.5
Straps. Width	"	.45	.45		......	....	
Rings. Diameter... Exterior	"	......	3.25		......	3.25	
Rings. Diameter... Interior	"	......	1.75		......	1.75	
Weight of sabot, straps, rings, nails	oz.	6.5	6.5		9.5	4.	
Weight of shot or shell, ready for fixing, &c.	lbs.	12.75	9.52	12.17	14.8	6.28	5.72
Canisters. Cylinder. Length, including lap	in.	....			14.40	....	
Canisters. Cylinder. Height	"	....			6.65	....	
Canisters. Cylinder. Interior diameter	"	....			4.45	....	
Canisters. Diameter of top and bottom plate	"	....			4.40	....	
Canisters. Thickness of sheet-iron cover	"	....			.07	....	
Canisters. Number of... shot in each tier		....			7	....	
Canisters. Number of... whole of shot		....			27	....	
Canisters. Whole height, including sabot	in.	....			8.	....	
Canisters. Weight, finished, " "	lbs.	....			14.8	....	
Diameter of gauges for fixed ammunition	in.	4.57					3.64
Paper for a cylinder and cap. Length, developed	"	14.4					11.6
Paper for a cylinder and cap. Height	"	12.5					11.5
Height of cylinder, large charge	"	5.					4.
" " small "	"	4.					3.5
Formers for cylinders and caps. Length, handle excluded	"	15.					13.
Formers for cylinders and caps. Width at large end	"	6.71					5.25
Formers for cylinders and caps. " small end	"	6.6					5.17
Formers for cylinders and caps. Thickness	"	0.15					0.15
Cylindrical former for choking caps. Length	"	10.					10.
Cylindrical former for choking caps. Diameter	"	4.3					3.3
Distance from end of former to groove	"	6.			5.	5.	
Fixed ammunition. Whole height, cap included	"	10.4	10.4	10.4	12.4	8.43	8.43
Fixed ammunition. Height of charge	"	5.	5.	5.	4.	4.	4.
Fixed ammunition. Weight of whole	lbs.	15.4	12.17	14.7	16.91	7.6	7.
Packing-box‡. Interior dimensions... Length	in.	17.5	17.5	17.5	18.4	24.	24.
Packing-box‡. Interior dimensions... Width	"	10.5	10.5	10.5	12.5	8.75	8.75
Packing-box‡. Interior dimensions... Depth	"	9.5	9.5	9.5	9.5	7.75	7.75
Packing-box‡. Weight... Empty	lbs.	23.	23.	23.	24.	25.	25.
Packing-box‡. Weight... Packed	"	148.	121.	142.	161.	133.	125.
Packing-box‡. Contents of each box... Number of rounds		8	8	8	8	14	14
Packing-box‡. Contents of each box... Friction-primers		12	12	12	12	21	21
Packing-box‡. Color		olive	black	red	drab	olive	red

* One inch allowed for the seam in length of rectangle and diameter of bottom: half an inch
21 ounces; the 24-pounder, 16 ounces; and the 12-pounder, 8 ounces. ‡ One portfire
‖ Six small and one large cartridges.

Ammunition for Field and Mountain Service.—Continued.

6-pdr.	HOWITZERS.											
	32-pounder.			24-pounder.			12-pounder.			12-pdr., mountain.		
Canister.	Shell.	Spher. case.	Canister.	Shell.	Spher. case.	Canister.	Shell.	Spher. case.	Canister.	Shell.	Spher. case.	Canister.
1.	3.25	3.25	2.5	2.5	2.5	2.0	1.	1.25	1.0		0.5	
3.25	6.25	6.25	5.0	5.0	5.0	4.0	3.25	4.0	3.25		2.25	
		14.2			14.2			11.4			10.42	
		10.0			10.0			7.25			5.0	
		5.25			5.25			4.37			4.0	
	16.	1.4		12.	1.2			1.		7.	1.	
		22.			20.			10.5			10.5	
		245			175			82			82	
2.25	2.4		4.75	2.4		4.45	3.2		4.45	2.7		3.75
......	2.4		4.	2.4		3.75	2.		2.75	2.		2.55
.5	....		.75	....		.7	....		.5	....		.5
3.58	5.6		6.24	5.3		5.68	4.27		4.52	4.2		4.52
3.2	4.5		4.5	4.6		4.6	3.2		3.2	2.8		2.8
3.53	....		6.19	....		5.63	....		4.47	....		4.47
......	4.5		4.5	4.6		4.6	3.6		3.6	3.24		3.24
......	1.5		......	1.5		......	1.3		......	1.3		
......	3.12		......	2.84		......	2.26		......	2.26		
0.4	....		......	....		......	0.4		0.4	0.55		0.55
......	2. or 0.75		......	1. or 0.5								
......	4.15		......	4.15								
......	0.4 or 3.75		......	0.4 or 0.25								
......	10.5		......	9.0		......	7.5		......	7.5		
......	.6		......	.55		......	.45		......	.45		
	3.25			3.25			3.25			3.25		
	1.75			1.75			1.75			1.75		
4.5	10.		26.	9.5		24.	7.		12.5	5.5		9.5
7.32	24.64	32.72	28.5	18.8	24.64	21.25	9.35	12.2	10.8	9.35	12.2	11.2
11.5	....		20.	....		18.3	....		14.4	....		14.4
5.4	....		7.1	....		6.3	....		5.2	....		4.
3.53	....		6.19	....		5.63	....		4.45	....		4.47
3.48	....		6.14	....		5.58	....		4.40	....		4.42
.07	....		.1	....		.1	....		.07	....		.07
7	....		12	....		12	....		12	....		37
27	....		48	....		48	....		48	....		148
6.75	....		10.5	....		9.55	....		8.75	....		6.85
7.32	....		28.5	....		21.25	....		10.8	....		11.2
		6.31			5.74			4.57			4.57	
		14.4			14.4			11.6			10.	
		12.			10.			8.			4.55	
		5,25			3.5			3.			none.	
		5.			3.			3			none.	
		15.			15.			13.			6.	
		6.71			6.71			5.25			4.5	
		6.6			6.6			5 17			4.45	
		0.15			0.15			0 15			0.15	
		10.			10.			10.			9.	
		4.3			4.3			3.3			2.9	
4.		6.5			4.5			4.				
10.3	......	......	......	......	......	......	10.	10 5	12.3	8.17	8.17	9.4
3.25	6.25	6.25	5.0	5.0	5.	4.	3.25	4 0	3.25	2.25	2.25	2.25
8.4	27.7	35.82	31.6	21.5	27.	23.6	10.5	13.65	11.85	9.9	12.6	11.8
25.5	12.75	12.75	12.75	17.25	17.25	17.25	22.5	22 5	22.5	27.5	27.5	27.5
10.5	12.75	12.75	12 75	11.5	11.5	11.5	9.25	9 26	9.25	9.25	9.25	9.25
7.75	12.	12.	15.5	11.5	11.5	14.75	10.5	11.	12.5	8.5	8.5	9.5
26.	23.	23.	25.	25.	25.	26.	27.	27 5	28.5	31.	31.4	32.
146.	136.	168.	158.	155.	190.	170.	133.	185.	148.	154.	184.	175.
14	4§	4	4	6	6	6	12	12	12	12	12	12
21	6	6	6	9	9	9	18	18	18	18	18	18
drab	black	red	drab	black	red	drab	black	red	drab	black	red	drab

allowed for the seam in height.
and half a yard of slow-match in each box.

† Powder required to fill the 32-pounder shell is
§ Four small and one large cartridges.

AMMUNITION FOR SIEGE AND GARRISON SERVICE.

Ammunition for siege and garrison service consists of *cartridges*, of sizes varying according to circumstances, and the following projectiles, viz.:

Shot for 10 and 8 inch columbiads, (model 1861,) 42, 32, 24, 18, and 12 pdr. guns.

Shells for 10 and 8 inch columbiads, 42, 32, 24, 18, and 12 pdr. guns, 13, 10, and 8 inch mortars, 8-inch siege and 8 and 10 inch sea-coast howitzers.

Spherical case shot and *canister* for 10 and 8 inch columbiads, 42, 32, 24, 18, and 12 pdr. guns, 8 and 10 inch sea-coast and 8-inch siege howitzers.

The shells and spherical case shot (except for the 8-inch siege-howitzer) and the 8-inch siege and sea-coast howitzer canisters are attached to sabots; the other projectiles are not strapped.

Cartridges.

The charge of powder for siege and garrison guns is enclosed in a cartridge-bag made of merino, serge, cotton, or paper, or of paper with woollen bottoms. Bags made of woollen materials are preferable, as they are not so liable to leave fire in the guns, and are more durable; but they are much more costly.

Merino or cotton bags are cut in two pieces in the form of a rectangle with semicircular ends, and sewed together to form the bag, as described in making bags for field-service. See page 271 for the manner of making and preserving them.

Paper bags.—The paper is cut into rectangles to form the cylindrical part of the bag,—the length of the rectangle being the development of the cylinder, allowing .5 inch on each side for the lap,—and into circles for the bottoms. The sides of the rectangle are lapped and sewed with woollen yarn; one end of the bag is slit with longitudinal cuts, 1 inch long, 0.75 inch apart, and these strips are pasted on the paper bottom over a cylindrical former; or a circular piece of merino is sewed in the end of the paper bag forming the bottom.

To close a paper bag after being filled, the open end is folded down about .75 inch wide, and this fold is rolled on itself down to the powder, and the part which projects beyond the cylinder is turned in on the top of it. Two turns are taken with strong twine around the cartridge in the direction of its length, 90° apart, and then tied.

For mortars, cartridge-bags may be made in the same manner as for guns, their dimensions corresponding to those of the chamber of the mortar. But, as the charge is generally poured loose into the chamber, the bag being used only for carrying it to the mortar, a gun-cartridge bag of any convenient size may be used for mortar-service.

For firing hot shot, cartridge-bags are made double, by putting one bag within another: care must be taken that the bags are free from holes.

For ricochet firing, or other occasions when very small charges are required, a cartridge-bag for a piece of an inferior calibre may be used. Or else, after the charge is poured into the bag, place on it another bag filled with hay, pressing it with the hands to reduce the diameter; after having shaken this bag down and rolled and flattened the empty part of the two bags, tie them with woollen yarn, like a bundle of musket-cartridges, placing the knot on top.

For proving ordnance, cartridge-bags are made of cotton cloth. They should be of the full diameter of the bore or chamber.

Sabots.

Sabots are required for the 8-inch canisters, for siege and sea-coast howitzers, and all shells and spherical case shot, except for 8-inch siege-howitzers. For canisters and the smaller guns the sabots are turned in a lathe; for the larger calibres they are sawed from thick pine or poplar planks, and the cavity cut in a lathe, or the cavity is first cut by a tool of the proper curvature attached to the shaft of the Daniel's planer, and the sabot afterward sawed out with a circular saw.

A day's work.—One man can make 350 sabots for a 42 or 32 pdr. gun, or 10-inch columbiad, in 10 hours; or 400 sabots for a 24 or 18 pdr. gun or 8-inch columbiad.

Cartridge-Blocks.

Cartridge-blocks are required for the columbiads, model 1844, and the sea-coast howitzers, when firing with reduced charges. They are made as prescribed for field-service, (see page 272,)—their length being such as always to make the cartridge fill the chamber. The length of the block for any charge is easily deduced from the length occupied by 1 lb. of powder, as given in the table. (See page 288.)

Strapping Shells.

The straps are cut and made as prescribed for *shot* for field-service, changing their dimensions. Two rings or loops of tin, 0.38 inch diameter, are attached securely to the slit strap of the howitzer and columbiad shells, for the purpose of attaching a handle made of cord 0.15 to 0.25 inch thick. A slit is made in the strap, through which the ends of the tin loop are passed and soldered on the under side of the strap. For the handle, pass a piece of marline through both loops and tie the two ends together, leaving such length that the hand can embrace both branches.

The shells are placed in the sabot, and the straps put on in such a manner that the fuze-hole may fall in one of the angles, between two straps, and that the axis of the fuze-hole may stand at an angle of about 45° with that of the sabot. The eyes of the shell should not be covered by the straps. The straps are fastened at each end with 2 *nails* in the side and 2 in the bottom of the sabot.

In loading the piece, care must be taken to place the fuze-hole in the upper part of the bore.

Canisters.

They are made and filled like canisters for field-service, except their dimensions, and, instead of being attached to a sabot, the lower end of the cylinder is slit with longitudinal cuts .5 inch long and from .25 to .38 inch apart, according to the calibre; the strips thus formed are turned down over a cast-iron bottom plate 0.5 inch thick.

The cover for these canisters is of sheet iron, .1 inch thick; it has a handle 3.75 inches long by 1.75 inch wide, made of iron wire No. 9, fastened to the cover by a strap of sheet iron, 2 inches long, 1.75 inch wide, secured by two rivets 0.15 inch thick.

Canisters for 8-inch siege and sea-coast howitzers are attached to sabots. the former with a hemispherical bottom to fit the bottom of the bore.

Grape.

A stand of grape consists of 9 shot, put together by means of 2 *cast-iron plates*, 2 *rings*, and 1 *bolt* and *nut*. (See Plate 31.)

The square of the nut is 2 diameters of the bolt; its thickness, 1 diameter. The head of the bolt is countersunk flush with the bottom of the lower plate, which has a *slot* to prevent the bolt from turning when the nut is screwed on. Each plate has on the inside 3 beds for the shot, of a depth equal to half the thickness of the plate; they are made in the form of a spherical segment, the curvature of which is the same as that of the shot; their centres are on equidistant radii, midway between the edge of the bolt-hole and that of the plate. In the upper plate are 2 holes 0.25 inch diameter, placed opposite to each other at 0.5 inch from the edge of the plate, to receive a rope handle.

For the 8-inch sea-coast howitzer the stand of grape must be attached to a conical sabot. The sabot is 4.25 inches long, 7.85 inches diameter at the large end, and 6.4 inches at the small end. The sabot may be fastened to the lower plate with screws, or the bolt may be made long enough to pass through it, or else the sabot may be inserted into the piece separately from the stand of grape.

Filling Shells.

Workmen.—1 *man to fill*; 1 *helper*.

Materials.—*Powder; cylinders of rock-fire; loaded fuzes; fuze-plugs; tow.*

Implements.—1 *pair of shell-hooks*; 1 *handspike*; 2 *hand-hammers*; 2 *scrapers*, (pieces of sword-blade;) 2 *tow-hooks*; 2 *pairs of pincers; rags*; 1 *chisel* and 1 *mallet*, to clean the shells and break up any hard substance that may be found in the interior; 2 *searchers*, for sounding cavities; *shell-gauges;* 1 *grate*, to dry the shells on; 1 *fuze-saw;* 1 *gimlet;* a *ring of rope*, or a hollow block; 1 *funnel; powder-measures;* 1 *tub*, or vessel for powder; 2 *baskets*, for the composition and fuzes; 1 *rasp;* 1 *fuze-setter;* 1 *mallet;* 1 *fuze-reamer.*

The shells are cleaned inside and out, gauged, and examined that they have no defects that would cause their rejection; that the fuze-hole is not defaced: if there be water in the cavity, the shell is dried by a gentle heat and cooled slowly.

To Fill Shells for Guns or Howitzers.—The helper places the shell on the block or ring of rope, the fuze-hole uppermost, inserts the fuze-plug and drives it in till the top is flush with the surface of the shell: the principal reams out the hole to its proper size, the helper holding the shell to prevent it from turning. The helper inserts the pipe of the funnel in the fuze-plug, and the principal pours in the powder and closes the hole with a wad of dry tow rammed in securely, leaving a portion of it projecting out.

When cylinders of rock-fire or other combustibles are used, they are inserted before the fuze-plug is driven.

To Fill Mortar-Shells.—Shells are generally filled and the fuzes driven in the battery-magazines, as they are required.

The helper places the shell on a ring of rope and inserts the pipe of the funnel in the fuze-hole; the principal pours in the bursting-charge, introduces the cylinders of rock-fire, and pushes them aside with a small stick, that they may not be in the way of the fuze when driven in. He then inserts the fuze, which should enter to within half an inch of the top, and with a mallet and fuze-setter drives it so that the end of the fuze shall project not more than 0.2 inch.

To Cut the Fuze.—The fuze is cut to the proper length, according to the range, before it is driven into the shell, by resting it in a groove made in a block to receive it and hold it steady, the saw running in a cut made for it; or the fuze may be bored through to the composition with a gimlet, at the proper length.

To fire 6 or 12 pdr. Shells from Mortars of large Calibre.

This kind of fire is intended only for short distances, as in the defence of a breach, and supersedes the use of the stone mortar.

Take a strong tub or half-barrel, provided with two strong rope handles, and add a second bottom on the outside, bringing it flush with the ends of the staves to which it is nailed.

To this bottom nail another, made of a single piece of wide 2-inch plank, of sufficient length to support the ends of the staves. A block of light, dry wood, of the diameter and length of the bore, is attached to the bottom of the barrel or tub by nails, and the lower end of the block which goes next to the charge is covered with sheet iron.

The fuzes of the shells are cut, driven, uncapped, and the shells placed in the barrel, the fuzes turned down. When the bottom tier is finished, a second one is laid; and so on to the last, which is covered over with hay which is rammed in to keep the projectiles in place.

The charge of powder is put in the mortar, the proper elevation and direction are given, and the barrel or tub, loaded, is raised by the handles, the block wiped clean and introduced into the bore and set home.

Wads.

Wads are used in firing hot shot, and to prevent the ball from rolling out in firing at a depression.

MATERIALS.—*Junk* or *hay*, *marline*.

IMPLEMENTS.—1 *wad-mould*, with two holes for each calibre, made of cast-iron cylinders set in oak, or of two strong pieces of oak strapped with iron and joined by a hinge; 1 *drift* for ditto; 1 *maul*.

TO MAKE WADS.—The hay or junk, after having been picked, is compressed by being beaten in the smaller mould until it assumes the requisite dimensions; it is then taken out, by raising the upper part of the mould, and wrapped closely with rope-yarn passed over it in the direction of the axis of the cylinder and fastened by a few turns round the middle of the wad; after which it is placed in the large mould and again beaten with the maul and drift; the diameter of the wad when finished is verified with a wooden gauge corresponding to the large gauge of the shot.

In firing hot shot, a dry wad is put next to the powder, and then a wad which has been soaked in water for a quarter of an hour and has been permitted to drip for several minutes, is placed between the dry wad and the ball; or the wet wad may be replaced by one of clay. It should be made one calibre in length, of clay free from sand or gravel, slightly moistened and kneaded.

Ring-wads or *grommets* are to be preferred where the object of a wad is merely to retain the ball in its place. They consist of a ring of rope-yarn, about 0.7 inch thick, with two pieces of strong twine tied across it at right angles with each other. The size of the ring is the full diameter of the bore, in order that it may fit tight. These wads may be attached with twine to the straps, or to the balls; or they may be inserted, like other wads, after the ball. These wads may be made of straw formed into rings of the proper size and wrapped with twine and tied to the ball.

Sabots of Shavings.

In positions where the pieces of sabots might prove dangerous to our own troops, as in firing over their heads when making an attack, sabots made of thick shavings of soft wood or pasteboard are used. For this purpose select black walnut, pine, or fir, not too dry, and as free as possible from knots.

Pieces of the proper length and width are dressed out, and by means of a coarse plane shavings are cut .06 inch in thickness. Each shaving is rolled in a circle on a cylinder of iron in which a longitudinal groove is cut. One end is thinned down, moistened, and inserted in the groove, and the shaving is rolled on the cylinder, the smooth side turned outward: one man turns the cylinder by a crank making three revolutions, the other holds the shaving so as to roll it evenly on itself, pulling it tight.

The different turns are then tacked together, the tacks being riveted on the inside against the iron cylinder: the end is thinned down with a rasp, and the sabot taken from the cylinder is immersed in a warm bath of thin glue. Pasteboard may be used instead of shavings of wood. The sabot is attached to the shell by means of four pieces of tape 1 inch wide. Each piece is folded around the sabot, and the ends sewed together: the seam is turned on the inside of the sabot and is made fast to it by tacks, the four pieces of tape being attached to the sabot at the extremities of two diameters perpendicular to each other. The sabot is laid down on the table and the shell placed in it, the fuze-hole down; the ends of the tape are then drawn together and tied on top of the shell with a piece of strong twine.

Fuze-Plugs.

Fuze-plugs are made of brass, or of close-grained wood, well seasoned. They are turned to a size a little larger than the fuze-hole, but of the same taper, 2.5 inches long; a hole is bored through its axis and reamed out to receive the paper fuze, and the large end is counterbored to receive the water-cap. The plug is reamed out after it is driven, and the recess for the water-cap is tapped with 12 threads to the inch.

If wooden plugs be used, a short, hollow cylinder of brass, .5 inch long, .15 inch thick, is inserted in the recess before the plug is driven, and afterward tapped to receive the water-cap.

The water-cap is a brass plug, .5 inch long, .6 inch in diameter, chased with 12 threads to the inch: one end has a shallow recess cut in it, .1 inch deep, larger at bottom than at top: a hole, .1 inch in diameter, is bored through the middle of the cap, and a hole is bored from either end into this transverse hole, but meeting it at points .25 inch or more apart: these and the recess in the end are filled with mealed-powder paste.

Dimensions.—Diam. of hole at bottom of recess, .53 in.; at small end, .4 in.

Ammunition for Siege, Garrison, and Sea-Coast Service.

		Columbiads.			
		10-in. 1844.	8-in. 1844.	10-in. 1861.	8-in. 1861.
Charge of powder, ordinary service.. Weight	lbs.	14.	8.	15.	10.
Charge of powder, ordinary service.. Height..	in.	8.82	7.84	6.30	7.0
Length of 1 lb. in cartridge	in.	.63	.98	.42	.7
Diameter of cartridge	in.	7.5	6.0	9.	7.
Cartridge-bags (merino) — Rectangle with circular ends — Length	in.	20.	16.	19.	15.
Cartridge-bags (merino) — Rectangle with circular ends — Width	in.	12.7	10.35	15.2	12.7
Cartridge-bags (merino) — Diameter of cylindrical former	in.	7.5	6.0	9.	7
Cartridge-bags (merino) — Material (1.25 yd. wide) for 100 bags	yds.	36	23	47	30
Sabot — Height — whole	in.	2.	2.	2.	2.
Sabot — Height — of cylinder	in.	....	....	2.	2.
Sabot — Diameter — Greatest	in.	8.41	6.79		
Sabot — Diameter — at bottom	in.	7.75	6.15	9.75	7.8
Sabot — Diameter — of cylinder	in.	....	....		
Sabot — Cavity for ball — Depth	in.	1.	1.	1.	1.
Sabot — Cavity for ball — Radius	in.	4.93	3.93	4.93	3.93
Sabot — Diameter of cylinder to roll on	in.	9.3	7.3	9.3	7.3
Straps, 2 for each — Length	in.	29.	23.5	29.	23.5
Straps, 2 for each — Width	in.	1	.75	1.	.75
Canisters — Cylinder — Length, including cap	in.	....	....	....	....
Canisters — Cylinder — Height	in.	....	....	....	....
Canisters — Cylinder — Interior diameter	in.	....	....	....	....
Canisters — Diameter of plates		....	....	....	....
Canisters — Number of — tiers of shot		....	....	....	....
Canisters — Number of — shot in a tier		....	....	....	....
Canisters — Number of — whole shot		....	....	....	....
Canisters — Finished canister — Height	in.	....	....	....	....
Canisters — Finished canister — Weight	lbs.	....	....	....	....
Canisters — Charge of powder for firing					
Filling shells — Powder — to fill shell	lbs.	3.25	1.75	3.25	1.75
Filling shells — Powder — to burst shell	lbs.	1.38	1.	1.38	1.
Filling shells — Powder — to blow out fuze-plug*	lbs.	.62	.5	.62	.6
Filling shells — Powder — Ordinary charge	lbs.	3.	1.8	3.	1.8
Filling shells — Rock-fire, No. of cylinders		6.	6.	6.	6.
Stand of grape — Plates — Diameter	in.	....	7.85	....	7.85
Stand of grape — Plates — Thickness	in.	....	.6	....	.6
Stand of grape — Rings — Interior diameter	in.	....	6.55	....	6.55
Stand of grape — Rings — Diameter of iron	in.	....	.6	....	.6
Stand of grape — Bolt — Length	in.	....	14.7	....	14.7
Stand of grape — Bolt — Diameter	in.	....	.6	....	.6
Stand of grape — Height of, from outside of plates	in.	....	9.85	....	9.85
Stand of grape — Weight of plates	lbs.	....	13.6	....	13.6
Stand of grape — " bolt, nut, and rings	lbs.	....	4.75	....	4.75
Stand of grape — " stand complete	lbs.	....	75.6	....	75.5
Wads — Diameter and height	in.	9.7	7.8	9.75	7.8
Wads — Weight	lbs.	16.5	8.6	16.5	8.5
Wads — Junk, for 100	lbs.	165.	850.	165.0	850.
Moulds for wads — Diameter, large hole	in.	9.75	7.8	9.75	7.8
Moulds for wads — " small hole	in.	9.4	7.5	9.4	7.5
Moulds for wads — Thickness of upper block	in.	10.	8.	10.	8.
Moulds for wads — " lower block	in.	6.	4.	5.	4.
Moulds for wads — Width of block	in.	17.	15.	17.	15.
Moulds for wads — Cylindrical drift — Diameter	in.	8.5	7.3	8.6	7 3
Moulds for wads — Cylindrical drift — Length	in.	24.	24.	24.	24.

* When a wooden fuze-plug is used.

Ammunition for Siege, Garrison, and Sea-Coast Service.—Continued.

Guns.					Howitzers.				
							Sea-Coast.		
42-pdr.	32-pdr.	24-pdr.	18-pdr.	12-pdr.	Siege, 8-in.		10-in.	8-in.	
9.	8.	7.	5.	4.	4.		12.	8.	
8.82	9.28	10.15	8.76	8.0	6.		9.96	7.84	
.98	1.16	1.45	1.75	2.0	2.		0.83	0.98	
6.	5.6	5.	4.6	4.2	4.2		6.5	6.0	
16.6	18.	16.5	16.26	14.	14.		18.	15.	
10.35	9.55	8.75	8.15	7.6	7.6		11.15	10.35	
6.	6.5	6.	4.6	4.2	4.2		6.6	6.0	
24	25	19	17	14	14		31	20	
2.	1.6	1.6	1.5	1.6	0	4.68‡	2.	2.	6.0‡
2.	1.5	1.5	1.5	1.5	......	.75	....	......	.75
						7.85	7.75	6.79	7.85
6.58	6.0	5.43	4.92	4.36	...	hemi-sphere	6.75	6.15	6.4
	•					7.8	....	......	7.8
.1.	0.75	0.75	0.76	1.	....		1.	1.	
3.42	3.12	2.84	2.68	2.26	....		4.93	3.93	
6.4	5.8	6.2	4.7	4.	7.3		9.3	7.3	
21.	19.	17.5	16.	14.	....		29.	23.5	
.65	.6	.65	.5	.45	....		1.	.75	
21.5	20.	18.3	16.7	14.4	25.1		....	25.1	
9.6	9.	8.25	7.7	6.75	8.6		....	8.6	
6.78	6.19	5.63	6.12	4.47	7.8		....	7.8	
6.73	6.14	5.58	6.07	4.42	7.75		....	7.75	
4	4	4	4	4	4		....	4	
7	7	7	7	7	12		....	12	
27	27	27	27	27	48		....	48	
8.7	8.1	7.35	6.8	6.	12.03		....	12.35	
48.	37.	29.	23.	15.	63.5		....	64.6	
1.5	1.31	1.0	.69	.6	2.56†		5.†	2.56†	
.75	.69	.5	.44	.31	1.		2.	1.	
.38	.12	.12	.09	.06	.25		.31	.25	
1.25	1.	.75	.62	.44	1.75		3.	1.75	
6.	....	....	....	....	6.		6.	6.	
6.83	6.24	5.68	6.17	4.52	....		....	7.85	
.6	.5	.5	.4	.4	....		....	.6	
6.73	5.16	4.75	4.26	3.8	....		....	6.55	
.5	.5	.38	.38	.32	....		....	.6	
9.25	8.7	7.88	7.18	6.12	....		....	14.7	
.5	.5	.38	.38	.32	....		....	.6	
8.75	8.2	7.5	6.8	5.8	....		....	9.85	
10.2	8.	6.76	4.56	3.44	....		....	13.6	
2.8	2.5	1.81	1.12	.69	....		....	4.75	
51.25	39.75	30.61	22.15	14.84	FOR 6-PDR.		....	76.5	
6.8	6.2	5.65	5.12	4.48	3.5		....	7.8	
5.62	4.38	3.	2.38	1.5	.82		....	8.5	
562.	438.	300.	238.	150.	82.		....	850.	
6.8	6.2	5.65	5.12	4.48	3.55		9.76	7.8	
6.5	5.9	5.3	4.8	4.1	3.2		9.4	7.5	
7.	6.4	5.8	6.3	4.6	3.7		10.	8.	
4.	4.	4.	4.	4.	4.		6.	4.	
13.	12.	11.5	11.	10.	9.		17.	15.	
6.2	5.6	5.	4.5	3.8	2.9		8.5	7.3	
24.	24.	24.	24.	24.	24.		24.	24.	

† Mortar-shells:—13-inch shell holds 11 lbs. powder; service-charge, 7 lbs.; to burst shell, 6 lbs
‡ For canisters.

MATCHES, FUZES, AND PRIMERS.

Slow-Match.

Slow-match is prepared rope which is used to keep and carry fire: it burns slowly, with a firm, hard coal, and is not easily extinguished.

MATERIALS.—*Hemp* or *flax rope* of 3 strands, slightly twisted, about 25 yards long, and of a uniform diameter of .6 inch; *acetate of lead*, (sugar of lead;) *water*.

UTENSILS.—1 *kettle;* 1 *tub;* 2 *wooden spatulas; levers; twisting-winch; mats*, or *hair-cloth*.

METHOD WITH ACETATE OF LEAD.—Boil the rope for 10 minutes in water holding in solution $\frac{1}{20}$ of its weight of acetate of lead; remove it with spatulas into the tub, or let it remain in the *cold* solution until it is thoroughly saturated. First twist it over the kettle, and then, by attaching one end to the hook of a twisting-winch, twist it hard, keeping it stretched by means of a stick passed through a loop at the other end, at the same time rubbing it smartly, always in the same direction, from the hook, with coarse mats, hair-cloth, or cuttings of buff-leather, until the diameter of the match is reduced 0.1 inch and it has a uniform twist and hardness. Stretch it on poles or on a fence to dry, and put it up in neat coils, well secured.

Match thus prepared burns 4 inches in an hour.

METHOD BY LEACHING.—If sugar of lead cannot be procured, the rope may be simply leached. For this purpose, it is put into a leach-tub, and steeped in pure water for 12 hours; this water is then drawn off and replaced by lye prepared in a boiler, with a quantity of ashes equal to half the weight of the rope, to which 5 per cent. of quicklime is added. This lye, with the ashes, is put, after being warmed, into the hopper of the tub, and when it has run through and remained some time in the tub it is drawn off, heated again, and poured back on the ashes. This operation is repeated several times in the course of 24 hours, which is the time required for the rope to be well leached. After being taken out and twisted with sticks, it is steeped for 5 minutes in hot water, being stirred at the same time, and the operation is finished as before. Match prepared in this manner burns 5 inches in an hour.

Cotton rope, well twisted, forms a good match without any preparation.

A slow-match may be made of strong paper by immersing it in a warm solution of nitre, of about 1 pound to 2 gallons of water. When dry, roll each sheet separately, pressing it firmly, and pasting the last turn.

A half-sheet thus prepared will keep fire for *three hours*.

Slow-match weighs from 3 to 5 ounces to the yard.

PACKING.—Slow-match is packed in tight casks or boxes. A cask 40 inches high, 24 inches diameter, (weighing 60 pounds,) contains 150 pounds of match. The casks and boxes should be marked with the kind and quantity of match, place and date of fabrication.

Dimensions of a box to hold 200 pounds hemp or 220 pounds cotton match.—44 inches long, 28 inches wide, 18 inches deep; weight, 87 pounds. It is made of boards 1 inch thick, ends 1¼ inch, and has corner-pieces of hard wood, 2.25 inches square.

Quick-Match.

Quick-match is cotton yarn, of several strands, saturated and covered over with an inflammable composition: it is used for communicating fire from point to point in fireworks, etc.

Materials.—*Mealed powder; cotton yarn,* wound in loose balls of convenient size, (say 1 pound, which will measure about 1,000 yards,) such as is used for candle-wick; when doubled and slightly twisted in the fingers, it should be about .07 inch in diameter. *Gummed brandy* or *whiskey,* in the proportion of 1 ounce of gum to ½ gallon of spirits: the gum is first dissolved in the smallest quantity of hot water or vinegar, and afterward mixed with the whiskey. *Strips of paper; thread.*

1,000 yards of quick-match require 1 pound of cotton yarn, 8 pounds of mealed powder, 1¼ gallon of spirits, and 2½ ounces of gum arabic. Weight, when dried, 9 pounds.

Utensils.—*Wooden or copper bowls;* 1 *quart-measure; funnel* or *frame; reel.*

Preparation.—Steep the balls of yarn in the gummed whiskey until they are thoroughly saturated.

Make a paste of mealed powder, by mixing 1 quart of gummed whiskey to 2 pounds of powder, and put a layer of it about ½ inch deep in the bowl; on this spread a coil of the cotton by unrolling the ball and distributing it equally on the surface of the paste until there are 5 or 6 yarns over one another; put another layer of the paste; and proceed in this manner until the bowl is full, taking care not to entangle the strands: the last layer of paste should be a little deeper than the others. After the cotton has been 3 or 4 hours in the bowl, wind it on a reel, or stretch it on nails 40 or 50 feet apart, making it pass through a funnel, or the hand, filled with the paste, and taking care that the several turns of yarn do not touch each other. Before it is dry, dredge it with mealed powder; let it dry slowly, then cut it off from the reel or nails and put it in bundles.

During the winter, quick-match should be made in a warm room.

Match thus prepared should be hard and stiff, and the composition should hold firmly on. 1 yard burns, in the open air, 13 seconds.

By using *vinegar,* a match is made which burns less rapidly, in the proportion of 4 to 5; and with pure water, in the ratio of 4 to 6. *Alcohol* makes a quicker match; but it cannot be gummed, and the composition does not stick.

A slow kind of match is made by adding sulphur to the mealed powder: with one-sixth of sulphur, 1 yard of match burns 22 seconds; with one-fifth, 33 seconds; with one-third, 53 seconds; with one-half, 162 seconds.

Quick-match enclosed in tubes burns more rapidly than in the open air, and more so in proportion as the tubes are smaller. To communicate fire very rapidly, it is enclosed in paper tubes called *leaders*.

Portfires.

The portfire consists of a cylindrical paper case filled with a composition that burns slowly. It is used for firing rockets, etc., and, in cases of necessity, for discharging cannon.

To Make the Cases.

Materials.—*No.* 4 *paper; paste.*

Required for 100 cases,—50 sheets, 13 pounds of paper.

Utensils.—*Formers*, steel, turned smooth, 22 inches long, 0.5 inch diameter; a hole 0.2 inch diameter is made through one end, to withdraw it from the case; *hand-rolling board; rulers; knives.*

To Make the Case.—Cut the paper into rectangles 18 inches long, and from 10 to 14 inches wide, according to the thickness of the paper, to make the exterior diameter of the finished case 0.65 inch. Roll the rectangle on the former, pasting it after the first turn; press the case firmly by rolling it on a table with a hand-rolling board; withdraw the former, and place the cases in a box to dry.

To Drive Portfires.

Materials.—*Cases; composition for* 100 *cases*, (13 pounds nitre, 4.5 pounds sulphur, and 2.5 pounds mealed powder;) *scrap paper.*

Utensils.—*Portfire-moulds*, made of brass, in two parts, which are held together by a socket at bottom, and by 4 strong bands. The moulds are 18 inches long, 1 inch exterior diameter at top, 1¼ inch at bottom, with a bore of 0.65 inch diameter. 3 *drifts*, steel, .4 inch diameter, 22, 15, and 10 inches long, with brass tips, .5 inch long, upon the lower end: 4 *spiral grooves*, making one-half of a turn in 22 inches, are cut upon the surface of the drifts; the handles of the drifts are 6 inches long, and .75 inch diameter, with a head 1.25 inch diameter. *Mallets*, turned, of hard wood, weighing 1 pound; *funnels; ladles.*

Driving.—Put the case in the mould, and drive on the rings; insert a piece of paper, and push it to the bottom of the case with the long drift; insert a small funnel in the top of the case; pass the long drift through the funnel to the bottom of the mould; fill the funnel with composition and strike the drift about three blows every second, raising the drift about half an inch, with the fingers of the left hand, between the blows. In this way the composition finds its way around the sides and through the grooves of the drift to the bottom, and is uniformly and compactly driven. The shorter drifts are used as the case is filled.

Portfires should not be primed with mealed powder; after they are driven, the top of the case should be turned in and beaten down: thus both ends of the composition are secured.

Portfires made as above described burn 10 minutes each, or 1¾ inch per minute.

A day's work.—A man can drive 120 portfires in ten hours.

PACKING.—Portfires are packed in boxes containing 100 or 200 portfires. The contents of the box should be marked in white letters on each end, and the place and date of fabrication on the inside of the cover.

Fuzes for Mortar-Shells.

The hard, close-grained woods are best adapted for making fuzes: beech or ash is generally used. It should be dry, sound, free from sap, knots, worm-holes, or shakes.

TO TURN THE FUZE.—The helper saws the plank into lengths equal to that of the fuze, and then into prisms, taking off the edges, and centring it on each end. The turner puts the fuze thus roughed out in the lathe, turns its exterior, and graduates it, by means of a steel gauge, into inches and tenths of an inch commencing at the bottom of the cup. When a number have been turned, the turner puts each fuze into a chuck, bores it, and makes the cup, with a tool for that purpose.

The fuzes should be carefully inspected, and verified with gauges, and those rejected which have splits, knots, or worm-holes, or which have not the proper dimensions.

A day's work.—One turner can turn 500 fuzes, or turn and bore 250, in ten hours.

TO DRIVE FUZES.

MATERIALS.—*Empty fuzes; fuze-composition,* dry; *mealed powder,* dry; *paste; paper.*

UTENSILS.—*Driving-blocks* with holes of the size of the fuze; *benches; mallets,*—for the 13 inch, 10 inch, and 8 inch fuzes weighing 1 lb., for smaller fuzes weighing ½ to ¾ pound; *steel drifts* shod with copper, the shortest with a mark 0.2 inch from the end; *copper ladles* to contain sufficient composition to make a height, when driven, equal to 1 diameter of the bore; *copper pans; brushes.*

PREPARATION OF THE COMPOSITION.—The composition for 8 and 10 inch light mortar-fuzes is 2 parts of nitre, 1 of sulphur, and 3 of mealed powder; for 10 and 13 inch heavy mortars, 2 of nitre, 1 of sulphur, and 2¼ of mealed powder. The composition must be thoroughly ground and mixed with a muller, or in a leathern barrel with brass balls. The time of burning will vary according to the quality of the materials used (especially of the mealed powder) and the degree of their admixture. Trials should be made with each composition by driving several fuzes and getting their time of burning. There should not be any great variation in the times of burning of the different fuzes, of the same composition. Fuze-composition should be prepared only a short time before being used, and should be preserved in close vessels in a dry place.

Driving.—The workman is seated, his driving-block in front of him, and a bench to hold a pan of composition at his right hand. He takes a fuze, cleans it of all foreign matter, inserting the drift to the bottom of the bore: he then drops the fuze into the driving-hole, takes a ladleful of composition, passing the drift along the edges of the ladle to strike off the surplus; pours the composition into the fuze, strikes it two gentle blows with the mallet, inserts the drift, pressing it down on the composition, giving the fuze two slight blows to settle the composition. The workman strikes the drift 21 blows in volleys of 3, raising the mallet about 1 foot each blow, and moving the drift after each volley. He puts in another ladleful and continues as for the first. Care should be taken to put in equal charges of composition each time, and to give to each ladleful the same number of blows and with the same force.

Fuzes may be driven by pressure in a screw-press.

Priming.—Fuzes are all driven to the same height by means of a mark on the short drift, or the composition is bored out with a gouge to the same depth. They are primed with mealed powder for about 0.2 inch driven with the same force as a ladleful of composition. The cup is filled with a paste of mealed powder and spirits of wine or strong whiskey, and laid aside to dry: it is then covered with a small piece of paper, over which is pasted a cap of strong, water-proof paper, marked with the number of seconds the fuze burns to the inch.

Fuzes for Heavy Guns.

The fuze consists of a *paper case* charged with fuze-composition: it is inserted, at the time of loading the gun, into a brass or wooden plug previously driven into the fuze-hole of the shell.

To Make the Cases.

Materials.—*Lag paper*, or thin drawing-paper; *isinglass*.

Utensils.—*Pattern* of wood, in the form of a rectangle joined to a trapezoid; *iron former* 0.35 inch diameter; *knife, glue-pot, brushes.*

Making the Case.—The paper is cut to the proper size by means of the pattern. The whole length of the strip must be determined, by trial, for each kind of paper, to give the case the proper diameter. The strip is rolled hard on the former, beginning with the large end, and is glued after the first turn.

When the case is dry, it is smoothed with a fine file or sand-paper.

PREPARATION OF THE COMPOSITION.—There are three different compositions used, one inch burning 10 seconds, 14 seconds, and 20 seconds, respectively.

The following are about the proportions required to make these compositions; but, as their time of burning is subject to considerable variation, according to the quality of the ingredients and the manipulation in mixing them, the exact proportions must be determined by experiment.

No. 1.—26 nitre,	9 sulphur,	14	mealed powder.
No. 2.—26 "	9 "	12	"
No. 3.—26 "	9 "	10	"

The composition is carefully mixed, as described on page 293, and several fuzes are first driven and their times of burning determined, and the proportions varied, if necessary, to produce the required result.

To DRIVE THE FUZE.

MATERIALS.—*Empty cases; fuze-composition.*

2 lbs. of composition are required for 100 fuzes.

UTENSILS.—*Brass moulds* in two parts, which are held together by a wedge or cam: the moulds have holes for 4 or 5 fuzes; *steel drifts*, 0.35 inch diameter; *knife; mallet*, weighing ½ lb.

DRIVING.—The mould is put together and secured; the empty cases are inserted and driven gently in; their upper ends projecting above the mould are slit with a knife into 4 parts. The composition is put in and driven as described on page 294, giving 15 blows to each ladleful, which will make 0.25 inch in length of the fuze.

CUTTING.—The fuze is inserted in an iron gauge, the bore of which is of the same size and taper as the fuze, and its width is the true length of the fuze, 2 inches. The projecting ends of the fuze are first sawed off with a fine saw and then trimmed with a knife.

The fuze is stained the proper color according to the composition used,—fuzes of No. 1 composition being yellow; No. 2, green; and No. 3, blue,—and the number of seconds that one inch will burn is marked on each fuze.

PACKING.—Fuzes are put up in bundles of 10 each; fuzes of the same color being put in the same bundle, which is labelled with the kind of fuze and its rate of burning.

Fuzes for Field-Guns and Mountain-Howitzers.

The fuze for shells and spherical case shot for field and mountain service is that known as the "Bormann fuze." It consists of a circular disk of soft metal containing an annular space charged with mealed powder. The outer circumference of the disk is chased with the threads of a screw to secure it in the shell. The annular space for the composition is concentric with the outer circumference, and connects at one end by a hole with a small magazine in the centre of the disk, filled with rifle-powder and closed on the under surface by a thin disk of tin. The fuze is charged from the under side, by pressure, and a ring of the same metal is pressed firmly on the composition.

The composition is thus securely protected from accidents, and the fuze is screwed into the shell in the laboratory; the metal covering the composition on top, being left thin, is easily cut with a knife or cutter, at the moment of loading, and the composition exposed at the required point to the action of the flame. The graduations into seconds and quarter-seconds are marked on the upper surface of the disk. The time of burning of the whole length of fuze is 5 seconds.

To Cast the Fuze.

Materials.—*Tin* and *lead* in equal parts; *rosin; tallow.*

Utensils.—*Moulds* for the fuze, *moulds* for the ring, *hacksaw, nippers, mallet, kettle, ladle.*

Casting.—Melt the lead and tin together: heat the moulds so as not to chill the metal in casting. Fill the mould with the melted metal, and tap it gently with the mallet to make the metal fill the small parts. Cut off the gate with the saw, and the ends of the ring with the nippers.

It has been found convenient in opening and closing the moulds to attach the two parts of the mould for the fuze and also for the ring to the jaws of a bench-vise, so that both moulds are opened and closed by the same movement of the screw. The fuze-mould is kept hot by means of iron disks which are heated and hung on the arbor which supports the moulds.

A mould of more approved pattern has been devised, by which the casting is expedited.

To Charge the Fuze.

Materials.—*Mealed powder; musket-powder; rifle-powder; disks of tin.*

Utensils.—A strong *screw-press, annular charger* the size of the ring, *annular drift, flat drift, round drift.*

Take the mould in which the fuze was cast; place the fuze in the parts of the mould containing the screw and the upper or graduated side, and secure the mould by a ring driven on it.

Draw up the piston, and fill the charger by pressing it into the mealed powder contained in a shallow pan. Place the charger over the groove, and force down the piston, transferring the powder into the fuze. Insert the button in the magazine and the pin in the priming-hole, to preserve their shapes: place the ring on the powder, and with the annular drift force it down by means of a strong screw-press, bringing the ring flush with the surface of the fuze: rivet the ring in its place with another drift. Withdraw the button and pin; charge the priming-hole with rifle-powder and fill the magazine with musket-powder; cover the magazine with a disk of tin, and rivet it in place by means of first a flat drift and then a round one which turn down a part of the metal of the fuze over the disk.

Remove the fuze from the mould, place it in a screw-chuck made to fit it, and turn off in a lathe the lower surface smooth and to the proper thickness.

The powder of the fuze is now perfectly sealed up from the air. The fuze may be varnished.

Fuzes.

Dimensions and Weights.			Wooden Fuzes. 13-in.	Wooden Fuzes. 10-in.	Wooden Fuzes. 8-in.	Paper Fuzes.
Fuze	Whole length	in.	10.8	9.4	6.3	2.
Fuze	Diameter at top	in.	1.85	1.7	1.25	.53
Fuze	Diameter at bottom	in.	1.25	1.0	0.9	.4
Fuze	Diameter of bore	in.	.4	.3	.3	.35
First cone.	Length	in.	2.8	2.25	1.25	......
First cone.	Diameter at lower end	in.	1.65	1.55	1.15	......
Cup	Depth	in.	.6	0.5	0.4	......
Cup	Diameter at top	in.	1.25	1.0	0.75	......
Cup	Diameter at bottom	in.	0.9	0.8	0.6	......
Thickness of wood at bottom of fuze		in.	1.2	0.9	0.9	......
Length of composition		in.	9.0	8.0	5.0	2.0
Drifts.	Diameter	in.	.36	.27	.27	.3
Drifts.	Length, exclusive of handle, 1st	in.	9.	8.	8.	......
Drifts.	Length, exclusive of handle, 2d	in.	4.5	4.	4.	......
Weight	of composition for 100 fuzes	lbs.	8.	4.	2.5	2.
Weight	of 100 fuzes complete	lbs.	54.	33.	16.	......
Paper for the case.	Whole length	in.	......	......	......	19.
Paper for the case.	Length of rectangle	in.	......	......	......	6.
Paper for the case.	Width of rectangle	in.	......	......	......	2.25
Paper for the case.	Width of small end	in.	......	......	......	0.4

Bormann Fuze.

Diameter of fuze, including threads	1.65 in.
Thickness	.45 in.
No. of threads to the inch	12
Diameter of plug, including threads	1.07 in.
Thickness for field-guns	.3 in.
Number of threads to the inch	12

Packing-Boxes for Portfires.

	Length.	Width.	Depth.	Weight.
For 100 portfires	18	9.1	5.1	38
" 200 "	18	9.1	10.1	70

Friction-Primers for Cannon.

The friction-primer for cannon is a small brass tube filled with gunpowder, which is ignited by drawing a rough wire briskly through friction-composition, contained in a smaller tube inserted into the first near the top and soldered at right angles to it. *A lanyard*, with a hook attached, is used to ignite the primer.

The friction-primer is composed of 1 *large tube;* 1 *short tube;* 1 *wire rubber; friction-composition; musket-powder; wax.*

The long tube is made from a circular disk of No. 19 sheet brass, 0.62 inch in diameter, by means of a series of 5 punches and dies, gradually diminishing in size to the last, which is of the required size of the tube. The brass must be annealed before each punching.

The tube is cut to the prescribed length, measuring from the closed end, by means of a circular saw, and the holes for the short tube and wire rubber are drilled, and the burrs removed. Length of the long tube, 1.75 inch; exterior diameter, .19 inch; interior diameter, .175 inch; diameter of holes, .15 inch and .06 inch.

The short tube is formed from the long one by using two additional punches and dies, reducing the size each time. It is cut to the proper length by circular saws placed at the required distance apart, and the burr removed by rolling in a barrel. Length of the short tube, 0.44 inch; exterior diameter, 0.15 inch; interior diameter, .133 inch.

One end of the short tube is dipped into a solution of chloride of zinc, inserted in the hole drilled in the long tube, heated to redness in the flame of a spirit-lamp, and soldered with soft solder; it is then washed and dried.

The wire rubber is made of No. 16 brass wire, annealed, cut to the proper length, and pressed flat at one end by a machine for that purpose. The flat end is trimmed by a punch and die with dentated edges, and the tip is annealed in the flame of a spirit-lamp. Length of wire, 3.4 inches; length of flattened end, 0.65 inch.

The friction-composition is made of 2 *parts* of the *sulphuret of antimony* and 1 *part* of the *chlorate of potassa*, moistened with *gummed water*,—50 grains of gum arabic in 2 ounces of water to 1 pound of composition.

The materials are first pulverized separately, mixed together dry, moistened with the gum-water, and ground in an iron mill, such as is used for grinding paint.

CHARGING AND VARNISHING.—The small tube is charged by pressing the open end in the friction-composition spread on a flat piece of iron and brought to the consistency of soft putty, the long tube being closed its whole length with a wooden or metal plug.

A conical hole is made in the composition, while yet moist, with a conical drift, and the surplus composition removed; the wire rubber is passed through the short tube and through the small hole in the long tube, the round end first, leaving the annealed tip projecting out of the open end, which is then closed by pressing the top and bottom together firmly with pincers, and bending the tip against the bottom.

The end of the wire rubber is doubled on itself and twisted, leaving a loop 0.2 inch diameter, and then bent alongside the long tube for packing.

The head of the long tube, including the short tube and the joint, is dipped into shellac varnish colored with lampblack.

When dry, the long tube is filled with musket-powder and closed with beeswax mixed with $\frac{1}{3}$ its weight of pitch.

Both ends are touched with varnish and the tube thoroughly dried.

Packing.—The tubes are first put up in bundles of 10 each, wrapped in water-proof paper; 10 bundles are packed in a tin box painted or japanned: 100 tin boxes are packed in a box made of 1-inch white pine boards, dovetailed.

The contents of the tin box, place and year of fabrication, are stamped on the lid, and the number of the box marked on the front side. The contents of the wooden box are marked on each end.

Dimensions of the tin box:—	Length, 4.5 in.;	width, 2.35 in.;	depth, 2.35 in.
" (interior) wooden box:	" 20.5 "	" 12.0 "	" 9.5 "

Weight of tin box containing......	100 primers,	.8347 lb.
Weight of wooden box "	10,000 "	105. "

MATERIALS REQUIRED FOR 10,000 FRICTION-PRIMERS.

66 lbs. sheet brass No. 19. } About 36½ lbs. are returned in scraps.
20 " brass wire No. 16. }
1.25 lbs. solder.
2.33 " chlorate of potassa.
4.66 " sulphuret of antimony.
.65 " beeswax and pitch.
11.0 " musket-powder.
1.25 quart varnish (0.75 lb. shellac, 1 qt. alcohol, 0.25 oz. lampblack.)
44 sheets of common tin are required for 100 tin boxes.

Percussion-Caps for Small Arms.

The cap for small arms is made of copper. It is very slightly conical, with a rim or flanch at the open end; it has four slits, extending about half the height of the cap.

The cap is charged with *fulminate of mercury*, mixed with half its weight of *nitre;* the object of the nitre being to render the fulminate less explosive and to give body to the flame. To protect the percussion-powder from moisture, and also to secure it from falling out, it is covered over, in each cap, with a drop of pure shellac varnish.

The copper for making the caps is obtained in sheets 48 inches long and 14 inches wide, weighing 3 lbs.: a variation of 4 ounces, more or less, is allowed. The copper should be pure, free from seams, holes, or blisters, well annealed, and as evenly rolled as possible, with straight and smooth edges.

The copper is cleaned by immersion in a pickle made of 1 part (by measure) of sulphuric acid and 40 parts of water; it is scoured with fine sand and a hand-brush, and washed clean in running water,—after which it is well dried in clean sawdust and rubbed over with a cloth slightly oiled: it is then ready for the machine.

To Prepare the Fulminate of Mercury.—Dissolve, in a glass retort capable of holding about a half-gallon, 10 oz. of pure mercury in 5 lbs. of nitric acid of the specific gravity of 1.40. The solution is made by placing the retort in a water or sand bath of about 120°, or exposed to the sun's rays on a warm day. The vapors which come over are very deleterious, and should not be inhaled.

When the solution is complete, pour the liquor into a wide-mouthed glass vessel capable of holding 8 to 10 gallons, into which 5.675 lbs. of alcohol (about 6½ pints) of the specific gravity of 0.85 have been previously poured. Care must be taken to *pour the nitrate of mercury on the alcohol*, as the reverse mode of mixing is dangerous. Great heat is evolved during the effervescence which ensues from the mixture, and the glass vessels used should be well annealed and of a form to bear a high heat without breaking. Carboys of thin flint-glass, without mouth-rings or any abrupt change in thickness, are best. The operation should be performed at a safe distance from the fire, as the vapors of ether disengaged are highly inflammable. When reddish fumes begin to appear, they must be reduced by adding alcohol in small quantities.

The proportion of alcohol used in the whole operation varies according to the strength of the acid and alcohol, and also with the state of the weather. The proper quantity is that which is just sufficient to keep down the reddish fumes, and is determined by trial with the materials used.

When the effervescence has ceased, the fulminate of mercury is found at the bottom of the vessel as a brownish precipitate. A small quantity of water is poured in, and the contents transferred to the washing-tub, where it is repeatedly washed in soft water, until the water no longer reddens litmus-paper.

The fulminate is in the form of very small crystals, of a light-gray color and brilliant surface. If the operation be well performed, no metallic mercury will be reproduced. The weight of the fulminate when dried is about 14 per cent. greater than that of the mercury used.

If the proper proportions be not used, (or if the materials be not of good quality,) the product will be, instead of fulminate, an impalpable, yellow powder, which is incombustible. When this is observed, the result may generally be corrected by varying the proportion of alcohol in the mixture.

The fulminate of mercury is kept under water, in stone jars, which should be preserved from frost.

A day's work.—In a warm, clear day, 1 master and 2 assistants can make, and partially wash, 100 lbs. of fulminate in 10 hours.

To Prepare the Percussion-Powder.—Take about 2 lbs. of the wet fulminate in an earthen dish; drain the water from it, and spread it on sheets of blotting-paper until it is sufficiently dry to assume the granular form and retains only 20 per cent. of moisture. In this state add to it 60 per cent. of its weight of refined pulverized nitre, and thoroughly mix the ingredients, on a wooden table, with the hand and a wooden spatula, and pass it several times through an iron sieve No. 3; spread it on sheets of paper in quantities of ½ lb. each, and dry it in the sun or in a room warmed by flues. When quite dry, pass the ½-lb. parcels through a fine hair sieve, by rubbing it with the hand, and put each parcel in a separate box, made of paper, varnished on the inside and outside with shellac varnish and having a loosely-fitting cover. The boxes should be kept in a small magazine standing apart from other buildings, upon shelves covered with cloth, to prevent friction in moving, and be issued one at a time to the person having charge of the cap-machine.

Making and Filling the Caps.—Both of these operations are performed by the same machine. The sheet of copper is adjusted on the table of the machine. The hopper is filled with the percussion-powder, and the machine put in motion. The *star* or blank is cut by a punch and transferred to a die, where it is formed into a cap by a second punch. The cap is caught in the notches of the revolving horizontal plate, and carried, first under the hopper containing the percussion-powder, where it receives its charge of ½ grain, and then under a punch, which presses the charge firmly into the cap, and lastly to the drop-hole, where it falls into the receiving-drawer.

The hopper is supplied from time to time from the ½-lb. box, while the machine is at rest, using a small copper scoop for the purpose, and the box returned to its special closet, at least one yard from the machine and above its level, before the machine is put in motion.

As a cap is occasionally exploded under the punch in charging, all dust of percussion-powder should be frequently removed, and only a small quantity of percussion-powder kept in the hopper. The receiving-drawer should be emptied after each sheet of copper is completed: 2,314 caps are made from each sheet 48 inches long and 14 wide.

A day's work.—The average work of ten hours, including all necessary stoppages, is 31,000 caps for each machine.

To Prepare the Varnish.—Dissolve 1 lb. of the best gum shellac in 1 qt.

of rectified alcohol containing 95 per cent. of pure spirit. The solution is made most readily at a temperature of about 120°. It must be stirred frequently until all the gum is dissolved. It is made and fit for use in 4 hours.

The varnish is best made and kept in glass vessels. 1 qt. of alcohol and 1 lb. of shellac make 1.46 qt. of varnish. A small quantity of alcohol is occasionally added to thin the varnish when it is used.

Eighteen quarts of varnish are required for 1,000,000 caps. Two quarts of alcohol are required for thinning the varnish.

To Varnish the Caps.—The caps are put into holes in counting-plates made of sheet brass, 15 inches by 12 inches, .05 inch thick, held in a frame of brass rods .35 inch square. This is quickly done by taking a parcel of caps on the plate and shaking it sideways: the caps settle themselves in the holes. When the plate is filled, the defective caps and those which have lost their charge are easily detected by the eye, and are replaced by perfect ones. The plate is placed in its bed in the varnishing-machine, which is worked by hand, and each row of caps is brought in turn under a row of wires, which are alternately dipped into a pan of varnish and then into the caps, leaving in each a drop of varnish.

The quantity of varnish placed in each cap can be regulated by the size of the wires, or by the depth to which they enter the varnish. The caps remain in the plate 30 to 40 minutes, when the varnish is sufficiently set to allow of their being turned into a tray for drying. These trays are of wood, 18 inches long, 12 inches wide, and 1 inch deep, and contain 2,500 caps. The caps remain in the trays for 3 days in a room heated to about 100°. They are then put into bags, and kept at the same temperature for 10 days longer, before they are packed in boxes.

A day's work.—One boy can count and varnish 7,000 caps per hour.

Packing.—The caps are put into bags of strong cotton duck, 10,000 in a bag, and ten bags are packed in a wooden box. The box is lined with thick paper, the bags are packed in tow, and the cover is fastened with six 2-inch wood-screws.

Bags and Packing-Boxes.—The bags are 6 inches in diameter and 13.5 inches deep. They are made with circular bottoms, like cartridge-bags for field-service.

They are marked with the number of the bag, the contents, the place and date of fabrication.

The packing-boxes are made of 1-inch white pine, dovetailed; they have brackets for rope handles on the ends, are painted olive color, and marked on the ends with the number and kind of contents, and on the inside of the cover with the place and date of fabrication.

Interior Dimensions.—Length, 28.75 inches; width, 12 inches; depth, 8.5 inches.

Weights.—Of 1,000,000 caps, 944 lbs.
Of bag with 10,000 caps, 9.625 lbs.
Of packing-box, 25 lbs.
Of box packed with 100,000 caps, 127 lbs.

MATERIALS REQUIRED FOR 1,000,000 CAPS.

For the Caps.—1,300 lbs. sheet copper, of which about one-third is returned in scraps.

For the Powder.—42 lbs. mercury.
336 lbs. nitric acid.
382 lbs. alcohol.
24 lbs. nitre.

For the Varnish.—10 lbs. gum shellac.
12 qts. alcohol.

For Bags.—31 yards of cotton duck, .75 yard wide.

For Boxes.—150 feet white pine boards.

NOTE.—Experience has shown that it is not safe to try to wash the percussion-powder from partly-filled caps. A lot of unvarnished caps, imperfectly filled, being soaked in water for several days, became coated with a substance much more explosive than the original fulminate.

The percussion-powder must be burned out, and the cap polished by rolling in a dust-barrel.

INCENDIARY COMPOSITIONS, LIGHTS, AND SIGNALS.

Rock-Fire.

Rock-fire is a composition which burns slowly, is difficult to extinguish, and is used to set fire to buildings, ships, etc. That which is put into shells is cast in cylindrical cases of paper having a priming in their axes.

MATERIALS.—*Rosin,* 3 parts; *sulphur,* 4; *nitre,* 10; *regulus of antimony,* 1; *mutton-tallow,* 1; *turpentine,* 1.

UTENSILS.—A *furnace* of second kind, (page 260,) or *large kettle* in the open air; *spatulas; ladle* with long handle; *balance* and *weights; sieves.*

PREPARATION OF THE COMPOSITION.—Pulverize the sulphur, nitre, and antimony separately; mix them with the hands, and pass them through sievé No. 2; melt the tallow first, then the rosin, stirring the mixture with spatulas; add the turpentine, and next the other materials, in small quantities at a time, stirring the whole constantly with large spatulas.

Let one portion of the composition be melted before more is added, and work with great precaution to prevent it from taking fire. When the composition becomes of a brown color, and white vapors are disengaged, the fire is permitted to go down; and when the composition is sufficiently fluid, the cases are filled with the ladle not more than three-fourths full.

Paper Cases and Priming-Tubes.—The cases are made of rocket-paper, in the manner described for portfire-cases. The priming-tubes are made of cartridge-paper, pasted after the first turn, and rolled hard.

Filling the Cases.—The cases are arranged in a frame, the lower end of each inserted in a socket, in the centre of which is a spindle to support the priming-tube.

The upper ends of the cases are held in place by short cylindrical spouts attached to the lower side of a reservoir which rests on the top of the frame. The composition is poured into the reservoir, and the frame is gently shaken to settle the composition in the cases until they are filled.

When the composition has become solid, the cylinders are taken out of the frame and trimmed; the priming-tubes are charged with composition No. 1 for mortar-fuzes, driven the same as mortar-fuzes; the ends of the cylinders are last dipped in mealed powder.

When rock-fire cannot be had to put into shells, the paper cases may be filled with portfire-composition, driven as usual; or pieces of portfire may be inserted in the shells.

Pitched Fascines.

Pitched fascines are fagots of dry twigs covered over with an incendiary composition, and used to set fire to buildings or to light up a work.

To Make Pitched Fascines.

Materials.—*Dry branches,* about 0.5 inch diameter, or other light, combustible wood; *iron wire,* about 0.5 inch diameter.

Utensils.—4 *pickets,* 40 inches long and 1¼ inch diameter; *cylindrical sticks,* 20 inches long, 1¼ inch diameter; 2 *trace-ropes;* 1 *rope* for a capstan; 2 *levers;* 1 *small cord;* 1 *flat punch;* 1 *saw* or *bill-hook;* 1 *block.*

To Make the Fascine.—Form two crotches, 1 foot apart, with the 40-inch pickets; cut the branches 20 inches long, and tie them in the middle of their length, and about 2 inches from their ends, with annealed wire, and place in the axis a cylindrical stick, intended to preserve a vacant space: draw the branches tightly together, that they may hold the composition better, and cut off the ends square.

To Pitch the Fascines.

Materials.—*Pitch; tar; mutton-tallow; linseed-oil,* in a bowl; *sawdust,* in a barrel; *rock-fire* for priming.

Utensils.—2 *pots* in a furnace of the first kind; 2 *spatulas;* 1 *ladle* with a long handle; 1 *small iron fork,* with a long wooden handle; 2 *tubs; planks.*

The fascines receive two coats of composition.

First coat.—Melt 20 parts of pitch and 1 of tallow in the pots, filling them not more than half full. Having first well oiled the cylindrical stick, plunge the fascine into the liquid with the fork, first one end, then the other, each time pouring on the upper end two ladlefuls of the composi tion. Let the composition harden, holding the fascine over the pot, turning it slowly, and then immerse it in the tub of water.

The assistant, with his hands covered with oil, fashions the fascine, rolling it on the bottom of the tub, and places it on the planks.

Second coat is put on 24 hours after the first; it is composed of equal parts of pitch and rosin, melted and mixed together in the pot. The cylindrical stick is taken out, and the fascine immersed in the composition, as with the first coat: it is permitted to drip, and is then laid in sawdust and powdered all over with it. A fascine requires about 1.1 lb. of each composition. Fascines should be primed only a short time before being used. For this purpose dip each end, for a distance of a half-inch, into a kettle holding melted rock-fire.

When used for incendiary purposes, fascines are placed in piles, and pieces of quick-match and portfire scattered over them to make the whole mass take fire at once.

Torches.

Torches are made of a number of strands of twine slightly twisted, or old rope, covered with a composition to give light.

MATERIALS.—*Hemp twine*, slightly twisted, about 0.08 inch diameter; *cartridge-thread; mutton-tallow; yellow wax; rosin; glue; quicklime.*

UTENSILS.—1 *pot;* 2 *spatulas;* 1 *ladle; glue-pot* and *bath; knife;* 1 *mould.*

PREPARATION.—Melt in the pot 1 part of tallow, 2 of yellow wax, and 8 of rosin, stirring it with spatulas. The twine is formed in hanks of about 40 threads, 3 feet long, cut at one end, and tied with twine, forming a handle, at the other.

The hanks are immersed for ten minutes in the composition, and then drawn through a mould of the proper size. They are suspended by the handle in a shady place to harden; 24 hours after, they are painted over with a warm solution of a half-pound of quicklime and $\frac{7}{8}$ of an ounce of glue to a quart of water.

With old rope.—Boil the rope, well beaten and untwisted, in a solution of equal parts of nitre and water; when dry, cut it in pieces 4 feet long; tie 3 or 4 of these pieces around a piece of pine wood, 2 inches in diameter and 4 feet long; cover the whole with a mixture of equal parts of sulphur and mealed powder, moistened with brandy; fill the intervals between the cords with a paste of 3 parts of sulphur and 1 of quicklime. When it is dry, cover the whole torch with the following composition:

Pitch, 3 parts; Venice turpentine, 3 parts; turpentine, $\frac{1}{2}$ part.

Tarred Links.

Tarred links are made of old rope, covered over with a composition to give light.

MATERIALS.—*Old slow-match or rope; cartridge-thread; ends of rope.* One link requires ½ lb. of tow and 1 to 1¼ lb. of composition.

UTENSILS.—*Mallet; knife.*

TO MAKE THE LINKS.—The old rope is well beaten with mallets; the short ends are tied together with cartridge-thread. The links are formed by coiling the soft rope around the hand, in coils of 3 inches interior and 6 inches exterior diameter, loosely tied with thread.

TO TAR THE LINKS.—The links are covered with composition as described for fascines.

Tarred links burn one hour in calm weather, half an hour in a high wind, and are not extinguished in the rain. Two of them are put in a rampart-grate on a bed of shavings. The grates are placed about 250 feet apart.

Fire-Balls.

Fire-balls are projectiles of an oval shape, formed of sacks of canvas filled with combustible composition. They are used to light up the enemy's works, and are loaded with shells, to prevent them from being approached.

MATERIALS.—*Strong, close canvas,* (sail-cloth;) *rope; cartridge-thread; red chalk; slow-match; loaded shells; pitch.* A composition of 8 parts of saltpetre as it comes from the refinery, 2 of pulverized sulphur, and 1 of antimony, passed through sieve No. 2. These materials are mixed in the hands, passed through sieve No. 4, moistened with $\frac{1}{30}$ their weight of water, and passed again through the same sieve.

UTENSILS.—The necessary utensils for grinding and preparing the composition: *Wooden pattern, red chalk,* 1 *pair shears, collar-needles, mallet, small gauge* of the calibre of the fire-balls, *scoop, tarred links,* 1 *wooden mould,* 2 *wooden drifts* 20 inches long, one of them 1¼ inch and the other 2½ to 4 inches in diameter; 2 *wooden pins* 4½ inches long, the small end the size of a paper fuze.

TO MAKE THE SACK.—Mark out the pieces by means of the pattern, and cut them with the shears; baste two or three thicknesses together, according to the strength of the canvas; sew three or more together, enough to make the sack; leave one end open, forming a mouth for charging; turn the bag to bring the seams on the inside. The mouth may be made fast to an iron hoop, large enough to admit the shell, with which the fire-ball is loaded.

TO PREPARE THE SHELL.—Charge the shell with powder, and put in a slow fuze. Dip the tarred link into the melted rosin, pitch, and tallow, and fasten it with twine to the shell, around the fuze-hole.

TO CHARGE THE SACK.—Place the sack in the mould, and secure the mouth to it. Put the shell with the tarred link in the bottom of the sack, the fuze-hole downward, and fasten the shell down with twine passed through the sides of the sack, or with a piece of canvas secured to the sides; put in the composition with a scoop, and ram it, first with the small drift, and, when it is half the height of the projectile, with the large drift, driving it with the mallet. Continue in this way till the sack is filled to the top. Close the mouth of the sack, sewing the pieces together.

THE IRON BOTTOM.—The ball is furnished with an iron bottom, to prevent it from being broken by the force of the charge in the mortar. To make the bottom, the iron, .2 inch thick, is cut in a circular form, heated and partly shaped with a set hammer, in a concave wooden former; it is again heated, and finished in an iron former. It is then put into a lathe, where the outer edge is trimmed and chamfered to the thickness of $\frac{1}{8}$ inch.

The iron bottom is attached to the ball with the cement, page 175; the bottom is filled about one-third full with the cement, and the loaded end of the fire-ball is inserted in it and left to cool.

The ball is next covered and strengthened with a net-work made of spun yarn or cord, from 0.25 to 0.5 inch thick, according to the size of the ball. This net-work is commenced at the bottom of the sack, and terminates at the top in a strong loop, which forms a handle for carrying the ball. Fire-balls are dipped in a composition of equal parts of pitch and rosin, made warm. The ball, when finished, should pass through the large shell-gauge.

TO PRIME THE BALLS.—Make 4 holes, about 3 inches below the top, by driving in the greased wooden pins 2 inches deep. When the ball is to be primed, take out these pins and fill the holes with fuzes, and with two strands of quick-match, held fast by the composition; leave room in the priming-hole for coiling the quick-match, and cover it with a piece of canvas fastened with 4 nails.

The balls are not primed until they are to be fired.

Light-Balls.

Light-balls are made in the same manner as fire-balls, except that there is no shell in them, as they are used for lighting up our own works.

Blue-Lights.

MATERIALS.—*For* 100 *lights.*—*Saltpetre*, 9 lbs. 10 oz.; *sulphur*, 2 lbs. $6\frac{1}{2}$ oz.; *red orpiment*, 11 oz. The materials should be pure, well pulverized, and thoroughly incorporated, rubbing them in the hands and passing them several times through a fine hair sieve. *Hemispherical cups* of well-seasoned wood, (beech, linden, etc.,) with a handle 10 inches long, $1\frac{3}{4}$ inch diameter; *quick-match*, *paper*, *paste*.

UTENSILS.—The necessary utensils for pulverizing and mixing the composition.

PREPARATION.—Fill the cup with composition and press it firmly in;

prime the cup with quick-match, and cover the whole with cartridge-paper pasted to the bottom of the cup.

The brilliancy of the light depends on the purity and thorough incorporation of the materials.

Signal-Rockets.

Rockets for signals are composed of a paper *case* charged with composition, a *pot* filled with ornaments, and a light *stick* to give direction.

Rockets are denominated by the interior diameter of the case. The most common sizes are the .75 inch, 1 inch, and 1.5 inch.

To Make the Case.

Materials.—*No. 4 paper; paste; strong twine.*

Implements.—*Awl; ruler; knife; sandstone; rolling-bench; press* and *crank; choking-machine; gauge for the case; paste-brush.*

To Cut the Paper.—Lay off the paper into rectangles, their width equal to the length of the case, pricking with the awl the four corners on several sheets at once; cut them with the knife.

A sheet of No. 4 paper makes two rectangles for a .75 inch or for an inch rocket, by cutting it parallel to the short or the long side, respectively.

To Roll the Case.—Roll the rectangle smoothly on the former, pasting the paper after the first turn; put the case and former in one of the grooves of the press, and, by means of the crank slipped on the square end of the former, turn it; the top of the press bearing on it slightly at first. Paste the second rectangle, introduce one end under the last rectangle, and roll it as at first. Gauge the case, to see that it is the size of the mould.

If there be no rocket-press at hand, a long hand-rolling board may be used instead.

To Choke the Case.—Wrap a piece of strong paper around the end of the case to be choked, to prevent the cord from chafing it; take a turn around it with the choking-cord, and press on the treadle, turning the case at the same time, and drawing out the small part of the former as the paper contracts; make the choke fast by wrapping it several times with strong twine, drawing it firmly, and tie it in a hard knot; place the cases away to dry in the shade.

To Drive the Rocket.

Materials.—*Empty cases; composition; clay* or *plaster of Paris.*

The composition is composed of 26 parts of nitre, 5½ of sulphur, and 19 of charcoal, which are mixed by rubbing them in the hand, and passing them three times through the sieve No. 2; the charcoal is added, and mixed with the hands. If antimony or steel-filings be used, they should be added after the charcoal.

When beginning with a new composition or new materials, it is necessary to try the composition by firing two or three rockets made of it, and regulate the height of the *solid*. If the rockets do not ascend sufficiently high, increase the quantity of nitre, and diminish it if the rockets burst or blow out the head.

When rockets are well made, they ascend rapidly to a great height, and throw out their ornaments at the highest point of the curve, after all the composition has burned out.

UTENSILS.—1 *mould* and *spindle;* 1 *block of wood*, settled in the ground; 3 *hollow drifts*, bored to admit the spindle; 1 *solid drift; mallets; knives; sandstones;* 1 *charging-ladle* of such size that its contents, when driven in the case, shall be a diameter in height.

TO PUT THE CASE IN THE MOULD.—In the first place, cut off the choked end of the case square, and to such a length that when the case is settled down on the spindle the choke should fit closely over the nipple, and the end of the case rest on the base of the spindle.

Place the case on the spindle, the choked end down; settle it with two or three blows of the mallet; set the mould over the case and key it down.

DRIVING THE ROCKET.—Take a ladleful of composition, strike off the surplus and pour it into the case. Use first the longest hollow drift, and give each ladleful 25 or 30 blows with the mallet, keeping the drift down on the composition. As the case fills, use the shorter drifts until the composition reaches the top of the spindle; then drive 1 diameter in height with the solid drift, cover this with a patch of stiff paper cut to fit the case, and over this patch drive a wad $\frac{1}{3}$ diameter high, of clay, or of plaster of Paris slightly moistened with water.

Rockets are sometimes driven solid throughout, and afterward bored and reamed out with a reamer of the form of the spindle.

The *moulds* for driving are not indispensable. Rockets are often driven without them. For this purpose, screw the spindle vertically into the top of a block of wood firmly imbedded in the ground. To the opposite sides of this block attach two upright strips of plank, and fasten to them a cross-piece which has near its centre a hole to fit the rocket-case and keep it steady on the spindle in driving.

To guard against accidents, drive rockets in an empty room; particularly, let no powder be in the room, or composition, except that used at the time, and let no filled rocket-cases be lying about. In fair weather use a tent for a driving-room.

TO PRIME THE ROCKET.—Insert in the bore of the rocket one end of a piece of quick-match, 2 feet long, a small piece of paper attached, and push it in securely; coil the rest of the match in the bore and bottom of the case. To secure it from dampness, paste over the end of the case a circular cap of strong paper

To Make the Pots.

Materials.—*No.* 4 *paper, paste.*

Utensils.—*Knife, former, rolling-board, bowl for paste, brushes.*

Making the Pot.—Cut the rectangle and roll it on the former as described for portfire-cases.

To Attach the Pot.—Paste the pot on the inside the distance of one-half of a diameter, and also the outside of the case, at the end containing the clay, for the same length; slip the pot on the pasted end, leaving the length of the pot above the top of the case one and a half diameter.

To secure the pot in place and give a neat finish, cover the rocket-case and pot, when dry, with thin paper pasted on.

To Make the Cones.

Materials.—*No.* 4 *paper, paste, thin paper.*

Utensils.—*Compasses, knife, scissors, conical former, bowl for paste, brushes.*

Making Cones.—Mark out the No. 4 paper by describing with the compasses circles with a radius equal to the length of the cone required. Cut them out with the scissors, and cut each circle into semicircles. Paste each semicircle and roll it separately on the former; press it firmly, and put it away to dry. Cut the cones to such length that their bases shall be of the same diameter as the pot. Make in the same way a similar cone of thin paper one inch longer, and paste it on the first; cut the part of the cone formed of one thickness of paper into longitudinal slips ¼ inch wide.

To Load the Pot and Fix the Cone.—Put in the bursting-charge of 150 to 300 grains of powder in the bottom of the pot, and fill it with the decorations, placing the serpents and streamers on end, the primed ends down. Fill the cone with tow, and paste the strips of the cone; place the cone on the pot, and press the strips on the side of the pot; paste a narrow band of paper around the rocket close to the base of the cone.

The axes of the rocket-case, of the pot, and of the cone, should be in the same line.

To Attach the Stick.—Tie the stick to the rocket, with strong twine or annealed iron wire from .04 to .08 inch in diameter, at two places: first at the choke of the case and the second notch in the stick, crossing the ends of the twine under the stick to prevent its moving to the right or left; the second, in the notch at the end of the stick and near the pot; tie the twine in a hard knot, and cut the ends close.

If wire be used, twist the ends together with pliers, and flatten the ends into the notch.

After the stick is attached, the centre of gravity of the rocket should be from .8 inch to 2 inches from the end of the case, according to the kind of decorations used. For this purpose, if necessary, reduce the size of the stick at the end.

DECORATIONS FOR ROCKETS.

Stars.

Materials.—See table, page 327.

Utensils.—The necessary utensils for weighing and grinding the materials; a *cylindrical mould* with a pin in the axis, and a piston for pushing out the stars.

To Prepare the Composition.—Reduce the materials to the finest powder; mix them with the hands; pass them three times through the sieve, mixing them each time with the hand.

Moisten the composition with whiskey in which gum has been dissolved,* so that the composition shall retain its form when pressed in the hand.

To Mould the Stars.—Fill the mould by pressing it in the composition spread out in a wooden bowl; push out the star with the piston, letting it fall lightly on a sheet of paper dusted over with mealed powder.

Colored stars are made in the same manner as white ones, using the compositions indicated in the table, page 327.

Serpents.

Serpents are very small rocket-cases charged with composition.

Materials.—*No. 4 paper, thread, paste, clay.*

Utensils.—*Knife; former,* 0.4 inch in diameter; *bowl* for paste, *brushes, wooden mould, nipple, drift, mallet, charger, hand-rolling board.*

To Make the Case.—The case is made by rolling a rectangle of paper No. 4 with a hand-rolling board, and choking it at one end.

The cases are driven ⅔ their length, giving each ladleful of composition 3 blows with the mallet.

The case is choked over the composition, and the remainder of it is nearly filled with mealed powder, upon which a small paper wad is placed; a clay head is then driven on it, and the end of the case turned down, to secure it; the other end is primed with priming-paste, or a small strand of quick-match.

Streamers.

Streamers are small paper cases from .2 to .4 inch diameter and from 2 to 4 inches long, made of four turns of No. 7 paper. One end is closed, and the case is charged and primed like that of a lance.

A number of streamers produce the effect known as *rain of fire.*

Gold Rain.

Gold rain is made of small stars, all of the same size. The stars are cubes, the length of whose sides is .5 inch.

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* The use of the gum is to give consistency to the stars, so that the explosion of the pot may not break them to pieces and thereby destroy the effect.

Marrons.

Marrons are small cubic boxes, made of pasteboard, filled with powder, and wrapped with strong twine. They are used to give a loud report, or the effect of cannonading.

MATERIALS.—*Pasteboard, cartridge-paper, strong twine* or *marline, paste, quick-match, powder.*

UTENSILS.—*Knife, ruler, pencil, punch.*

TO MAKE THE MARRONS.—Cut the pasteboard into rectangles whose sides shall be 3 and 5 times, respectively, the length of the side of the marron required. Divide the rectangle into 15 equal squares; cut out the squares forming the four corners of the rectangle, and divide the three remaining squares on the long side from each other by a cut the length of their side and perpendicular to the long side of the rectangle.

Form a small cubic box with the pasteboard thus cut out; paste the squares together which cover each other, and paste a band of paper around the box, leaving the cover open. When dry, fill the box with powder, paste down the cover, and envelope it with two or three layers of strong twine. Cover the marron with glue or kit, and prime it with quick-match inserted in a hole punched into the powder at the middle of one of the faces.

Dimensions and Weights of Rockets and their Ornaments.

		Interior diam'r of Rockets.		
		.75 in.	1 in.	1.5 in.
Height of rectangle for cases	inches	10.	11.	13.0
Length of the finished case*	"	9.25	10.60	12.50
Interior diameter of the choke	"	.25	.42	.65
Exterior diameter of the case	"	1.35	1.60	2.0
SPINDLE. Height	"	6.25	6.75	8.0
SPINDLE. Diameter at base	"	.25	.42	.65
SPINDLE. " top	"	.13	.21	.33
NIPPLE... Diameter	"	.75	1.0	1.48
NIPPLE... Height	"	.65	.7	1.0
Diameter of cylinder and part of nipple	"	.75	1.0	1.48
DRIFTS... Length of cylindrical part. Diameter	"	.72	.97	1.47
DRIFTS... Length of cylindrical part. 1st drift	"	9.65	10.	12.75
DRIFTS... Length of cylindrical part. 2d "	"	7.25	9.	10.
DRIFTS... Length of cylindrical part. 3d "	"	4.5	5.25	7.60
DRIFTS... Length of cylindrical part. 4th "	"	2.5	3.0	4.0
DRIFTS... Conical cavity. Diameter at bottom or base. 1st drift	"	.27	.44	.67
DRIFTS... Conical cavity. Diameter at bottom or base. 2d "	"	.24	.36	.64
DRIFTS... Conical cavity. Diameter at bottom or base. 3d "	"	.21	.33	.60
DRIFTS... Conical cavity. Common diameter at top	"	.14	.23	.33
DRIFTS... Conical cavity. Length of... 1st drift	"	6.75	7.5	8.50
DRIFTS... Conical cavity. Length of... 2d "	"	4.25	5.0	6.0
DRIFTS... Conical cavity. Length of... 3d "	"	3.	3.	4.
DRIVING-MALLET. Weight	pounds	1.25	1.5	2.0
DRIVING-MALLET. Length of handle	inches	8.	8.	8.
CHARGER. Diameter†	"	2.25	2.75	3.5
CHARGER. Length of cylinder	"	2.5	2.20	2.85
CHARGER. Whole length	"	7.	7.75	8.30
Height of the solid	"	1.5	2.0	3.0
Composition for 100 rockets	pounds	30.	50.	125.
Clay in head	ounces	.75	1.	1.25
POT....... Rectangle.. Length	inches	12.5	7.25	15.0
POT....... Rectangle.. Height	"	3.10	3.25	5.
POT....... Former, diameter	"	1.35	1.60	2.25
POT....... Weight of pot. Stars	ounces	1.	1.5	2.
POT....... Weight of pot. Serpents	"	1.	1.5	3.
POT....... Weight of pot. Gold rain	"	1.	1.75	2.5
POT....... Bursting-charge	"	.5	1.	1.25
CONE...... Conical former.. Height	inches	3.25	3.75	4.
CONE...... Conical former.. Diameter at base	"	1.5	2.0	2.30
CONE...... Length of finished cone	"	1.75	4.	4.35
STICK..... Length	"	80.	84.	96.
STICK..... Thickness of large end	"	.6	.66	.8
STICK..... " small end	"	.35	.4	.5

* Without the pot.

† Its contents, when driven, should be half a diameter in height.

	.75-in. Rocket.		1-in. Rocket.		1.5-in. Rocket.	
	Number.	Weight.	Number.	Weight	Number.	Weight.
		Grains.		Grains.		Grains.
Stars	10	490	15	700	20	890
Gold rain	10	490	15	700	20	870
Streamers	8	685	12	1025	18	1575
Serpents	3	525	4	850	8	1350

WAR-ROCKETS.

The war-rocket used in the military service is made after Hale's patent. It consists, 1st. Of a sheet-iron case lined with paper and charged with rocket-composition. 2d. Of a cast-iron cylindro-conoidal head, with a small cavity communicating with the bore of the rocket, and pierced with three holes, oblique to the surface, for the escape of gas. 3d. Of a wrought-iron plug welded into the rear end of the case, and having a hole in its axis for the escape of gas.

The rocket is driven forward by the escape of gas through the hole in the rear end, and a motion of rotation around its axis is given to it by the escape of gas through the holes in the head, whereby its direction is preserved without the use of a directing-stick.

The composition is pressed solid in the case by means of a powerful press, and the bore of the rocket is drilled and reamed out to the proper size.

The sizes of rockets are indicated by the interior diameter of the cases. The two sizes used are the two-inch and three-inch.

To Make the 3-inch Case.—Select the best lap-welded sheet-iron tubing. Cut it into lengths of 14.4 inches, and weld into one end a ring made of bar iron 0.625 inch by .25 inch, leaving a hole in the centre of .75 inch diameter. Swage the ring into a conical shape, the small end 1.6 inch diameter; cut off the ends of the case square, and ream out the hole to .95 inch diameter.

Ream out the hole in the base of the head to .875 inch, turn and fit the head into the case, and bore three holes, equidistant from each other, .45 inch diameter, through the lap of the case and head into the cavity of the latter, the holes in a plane perpendicular to the axis, but the holes not passing through the axis. Bore nine holes .18 inch in diameter through the case into the head, for riveting on the head.

To Drive the Rocket.

Composition.—*Nitre*, 10 parts; *sulphur*, 2; *charcoal*, 3. Place the case in the mould, put in the case about 3½ oz. of composition, and press it with a pressure of about 20 tons: continue in the same way until the composition is about 1.2 inch from the top; put in a layer of potter's clay .25 inch thick when pressed: a space of .95 inch is left vacant for a pasteboard washer and the cast-iron head.

To Bore the Rocket.—Remove the rocket to the boring-room; drill a hole .75 inch diameter through its entire length; ream out the hole to .95 inch at the tail and .75 inch at the head; bore the hole in the clay .875 inch diameter.

To Fasten on the Head.—Put a washer of pasteboard on the clay, insert the head and rivet it on, cork up the holes, and cover the rocket with a coat of paint.

Dimensions.—	Whole length of the rocket..............	16.9	inches.
	Length of the finished case.............	14.2	"
	Exterior diameter of case..............	3.25	"
	Interior diameter of case...............	3.00	"
	Weight of rocket, complete............	14.00	pounds.

Rockets are carefully packed in tow, in boxes containing 8 rockets each. The contents of boxes to be marked on each end.

Dimensions of Packing-Boxes.—	Length, interior............	17.	inches.
	Width, interior..............	12.5	"
	Depth.........................	6.5	"
	Weight of box, empty......	20.	pounds.
	Weight of box, packed.....	136.5	"

These rockets are fired from open tubes formed of rods of iron bent spirally and mounted on a portable stand.

Petard.

The petard is a box of wood filled with powder, used to blow down doors, gates, barriers, etc.

The box should be made of dry wood, and have paper pasted over the joints to prevent the powder from sifting out. A fuze, by which the petard is fired, is screwed into the box, reaching to the powder.

The box should contain at least 20 lbs. of powder.

The effects of petards are nearly proportioned to the square of the charges of powder they contain, and their effects are considerably increased if loaded with sand-bags.

A 10 or 8 inch shell filled with powder, and provided with a long fuze, may be used for a petard.

STORAGE AND PRESERVATION OF AMMUNITION AND FIREWORKS.

Store-houses and magazines should be kept in the neatest possible order, the stores arranged as much as possible by classes, kinds, and calibres, and labelled. They should be ventilated from time to time, in the middle of the day, in fine weather,—particularly those which contain ammunition and fireworks which are injured by moisture.

Provide cloth blinds for all windows exposed to the sun.

Leaden Balls are generally kept in cellars, on account of their weight; the boxes should be kept as dry as possible, and so piled as to admit the circulation of air about them.

Cartridges for small arms are kept in magazines, the barrels or boxes being piled 3 or 4 tiers high at most.

Fixed Ammunition for Cannon.—If not in boxes, it should be placed in piles formed of two parallel rows of cartridges, with the sabots together,—in 4 tiers for 12-pdr., and 5 for 6-pdr.; chock the lower tier with strips of wood fastened with small nails; put a layer of tow 2 inches thick between the shot; let the piles rest on planks, if there be no floor, and cover them with tarpaulins; have the place swept, and the cartridge-bags brushed off. Leave a passage of 18 inches between the double rows, and keep them 2 feet from the walls.

Fixed ammunition should not be put into powder-magazines, if it can be avoided; it should be kept in a dry place, above the ground-floor if practicable; the store-rooms should be always aired in fine weather; the piles should be taken down and made up again every six months at most, the bags examined and repaired, and the damaged cartridges broken up. A ticket on each pile should show the number and kind of cartridges, the additions to the pile, and the issues.

Canisters.—Piled up like fixed ammunition, in 4 tiers for 24's and 18's; and 5 for 12's and 6's. Empty canisters in 10 or 12 tiers; the bottoms and covers separately.

Cartridge-Bags filled.—Like fixed ammunition; or packed in boxes or barrels.

Cartridge-Bags empty.—In bundles of 50, sealed up in paper cases, carefully closed with strips of thin paper pasted over the seams.

Paper Cartridge-Bags.—In bundles, packed in boxes or on shelves, in a dry place, with pounded camphor and black pepper, or tobacco: the flannel bottom dipped in a solution of the sulphate of copper.

Loaded Shells should never be put into magazines, except from absolute necessity; powder is not well preserved in them. They should be piled on the ground-floor of a secure building,—on planks, if the floor be not boarded; in 6 tiers at most; the fuzes of the lower tier in the vacant spaces between the shells; those of the other tiers turned downward, like the fuze-holes of empty shells; the pile should be covered with a tarpaulin.

Use the same precautions against moisture and accidents as in a powder-magazine.

Canister-Shot.—Keep them, the different kinds together, in bins or boxes.

Slow-Match.—In a dry place, such as a garret, in boxes or barrels, or piled on the floor.

Quick-Match.—If not in boxes, it may be hung up in bundles, on ropes or pins, and covered with paper.

Friction-Primers.—In tin boxes.

Portfires.—Bundles of 10 are placed in boxes or in barrels, on end, in safe and dry situations.

Fuzes.—Packed in boxes,—fuzes of the same kind, as much as possible, in the same box,—in very dry and well-ventilated stores.

Cylinders of Rock-Fire.—In boxes or barrels, like fuzes.

Fire-Balls.—In cool but dry and airy places, suspended by the handle, the bottom resting on a board or floor, that they may not become deformed. Each ball should be labelled, stating its calibre, weight, and year of fabrication.

Signal-Rockets.—Packed in boxes, the sticks tied together. Each box should contain rockets of but one calibre, and should be marked with the size and the kind of decoration. If the sticks be attached, they are tied in bundles of 5, according to the kind of decoration.

War-Rockets.—Preserved in dry places, with the same precautions as loaded shells.

Tarred Links.—Strung on a rope and hung up. For transportation they are packed in barrels, with straw between the tiers.

Fascines and Torches.—Packed like the preceding.

BREAKING UP UNSERVICEABLE STORES.

Cartridges for Small Arms.—1 *box;* 1 *rectangular screen,* of brass wire, which fits in the box; 1 *board,* with 4 *copper hooks,* placed across the middle of the screen; *boxes* for balls and caps; *barrels* for powder; 1 *paper-press;* 1 *sieve; stools.*

Put the bundles of cartridges on the screen, as they are required, and open them there near the wire gauze; put the pieces of twine on the hooks, the papers on the board, and the bundles of caps in the boxes; the powder, passing through the screen, falls in the box, and the balls, remaining on the screen, are washed, if necessary, and boxed. The unserviceable papers are thrown into water, or burned; the others are put under the press for 12 hours, and then placed in barrels or boxes. The bundles of caps are put in boxes without being broken up, unless the caps are damaged; the caps are then put in bags by themselves. The powder is dried and sifted, to separate the dust and the caked powder, which are laid by to be reworked, or to be melted for the saltpetre.

Fixed Ammunition for Cannon.—1 *tarpaulin;* 1 *box;* 2 *barrels;* 1 *knife;* 2 *brushes;* 1 *punch;* 1 *hammer;* 1 *scraper,* (piece of *sword-blade;*) *tow;* a *tub* half-full of water, to clean the balls; *stools.*

One man holds the cartridge over the box, whilst another cuts the twine near the knot, takes off the strapped shot, brushes it, and stands it on the tarpaulin, on its sabot; the first man pours the good powder into a barrel, the caked powder into another, turns the bag wrong side out, and cleans it. The strapped shot are taken to the door of the laboratory, where the shot which still require cleaning are separated from their sabots and immersed in the tub of water; after standing some time, they are washed and cleaned. The others remain strapped. The serviceable, reparable, and unserviceable cartridge-bags are separated from each other; the last are immersed in water, and used for rags. The pieces of twine are tied up in bundles. The shells are put aside to be unloaded and cleaned in like manner.

The breaking up of fixed ammunition requires many precautions, and should never be done in the magazine, but as much as possible in the open air. Never have but little powder and a few cartridges in the shop at one time.

CANISTERS.—Turn up the slit ends of the canisters, by means of a small chisel; take off the cover, and pull out the balls and sawdust into a box by means of a hook; take out the bottom plate, and straighten the cylinder with a mallet on an anvil.

PORTFIRES.—Split the paper; take out the composition, and pulverize it by rolling for two hours. It may be made to burn more or less quickly by adding mealed powder or sulphur.

Unloading Shells.

This is necessary in order to save room in the store-houses, and to prevent accidents and the deterioration of the powder. It should be performed with great care, and at a distance from the magazines, store-houses, or dwelling-houses, employing no more men than are absolutely necessary.

Separate the workmen from each other; place them near a ditch or deep hole, into which they may throw a shell, should it take fire, and thus shelter the men from the fragments.

Remove the powder frequently as it is taken from the projectiles.

WORKMEN.—1 artificer; 1 helper.

IMPLEMENTS.—1 *fuze-wrench; awls; a coil of rope*, or a *block*, to place the shell on; 1 *brace*, with *bits* of the size of the bore of the fuzes; 1 *copper chisel;* 1 *wooden drift;* 1 *mallet;* 1 *copper hook*, and *rags*, to get out the powder and clean the interior of the shell; 1 *knife;* a *tub* and a *basket* for the powder and fuzes; a *tarpaulin;* a *bucket of water.*

For large shells, in addition to the above: 1 *fuze-extractor*, for mortar-shells; a *pair of shell-hooks* and a *handspike;* 2 *trestles* and a *frame*, to rest the shells on after extracting the fuze, for the purpose of emptying the shells over the tub.

The helper places the shell on the coil of rope, and holds it firmly in both hands: the artificer unscrews the fuze with the fuze-wrench. If the shell have a paper fuze, the artificer thrusts the sharp point of the awl between the fuze and the plugs, and pries the fuze out; a second awl may be used opposite the first; or cut out the composition .3 or .4 inch with a knife, and screw into the paper case a screw fitting it closely; draw out the fuze by means of the screw.

If it be a mortar-shell, bore out the composition with a brace and bit, keeping the composition constantly wet with water; drive in the bore of the fuze a plug of hard wood; screw in the fuze-extractor and draw the fuze.

ORNAMENTAL FIREWORKS.

Lances.

Lances are small paper cases, .2 to .4 inch diameter, filled with one or more compositions, each burning with a flame of a particular color. They are used to mark the outlines of figures, and are attached to light frames of wood, or sticks of bamboo.

To Make the Cases.—Cut the paper into rectangles, of a length equal to the required length of the case, and of such width as to make the case three thicknesses of No. 7 paper. The length of the case is generally about ten times its exterior diameter, depending on the composition with which it is to be filled, and the time it is required to burn.

Paste the rectangle, and roll it on an iron former with the hand. When the cases are dry, cut them to their proper length.

To Drive the Lance.—Place the cases in holes bored in a block of hard wood, the holes .02 inch larger than the case, and their depth .25 inch less than the length of the case.

Drive in the bottom of each case a ladleful of clay. Insert in the top of the case a small funnel; pass the drift through the funnel into the case: fill the funnel with composition; raise the drift 1 inch above the top of the case; press it to the bottom, and give it three light blows with a rocket-drift; continue in the same way, raising the drift above the top of the case between each volley, until the case is filled to .25 inch of the top.

Prime the lance with mealed powder moistened with gummed water, and dip the end while moist in rifle-powder.

When the case is to be filled with two different compositions, drive the case with the first composition till it is about .2 inch above the required height; remove the surplus to the exact height with a gauge, and proceed with the second composition as with the first.

To Fasten the Lances to the Frame.—Bore holes .02 inch larger than the lances, and .5 inch deep, from 2 to 4 inches apart, according to the size of lance. The holes should be bored so that the lance shall be horizontal when the frame is in position. Dip the end of the lance in glue, and press it firmly in the hole, arranging the lances parallel to each other. Or they may be fastened to the frame by means of sharp nails or tacks driven into the frame and projecting about .4 inch. The end of the lance is pierced with an awl, dipped in glue and thrust on the point of the nail, arranging them perpendicular to the frame.

Sun-Cases.

Sun-cases are strong cases made like those for rockets, and filled with a composition which burns more slowly than rocket-composition. They are attached to wooden frames, to give long rays of sparkling light. The choke is sometimes made by driving clay in the end of the case, and boring a hole through it for the escape of the flame; or the clay is driven on a short nipple, forming the choke.

Sun-cases are generally made from .75 inch to 1.5 inch interior diameter; their exterior diameter about double that of the interior. The length of the case may vary according to the time they are required to burn.

The diameter of the choke is about $\frac{1}{4}$ the interior diameter.

To Make the Cases.—The cases are made like rocket-cases.

To Drive the Case.—Set the case on the nipple and place it in a wooden mould; pour in a ladleful of composition, and give it ten blows with the mallet; continue in the same way till the case is filled to the required height: put in a charge of rifle-powder, and over it drive a ladleful of clay.

When the cases are filled, prime them by inserting in the choke a strand of quick-match, doubled in the middle and secured by driving a little composition on it with a lance-drift.

Paste on each end of the case a strip of paper 5 inches wide, projecting 3 inches over the end of the case and forming an envelope to enclose the leaders.

Sun-cases are fastened to the frames in the plane of the frame, by means of iron wire, or with strong twine.

Lights.

Lights are made by pressing lance or similar composition in shallow vessels, or in cases of large diameter. The burning-surface being large, the light attains a great intensity.

Shallow, earthen, wooden, or metal vases, or paper cases, are used. The vase or case is filled with dry composition, slightly pressed in; or composition moistened with gummed water may be used and pressed in the case more compactly. It is primed by powdering the surface first with a mixture of equal parts of the composition and mealed powder, and then with powder alone. Cover the top over with paper, pasted on the sides of the case. Through the centre of the cover pass several strands of quick-match, spreading them over the surface and uniting them on the exterior in a single strand.

When the light is made with dry composition, the case must be placed in a vertical position. It may be placed horizontally if moistened composition be used and firmly packed.

Torch-lights for funeral ceremonies are made by impregnating large strands of cotton with a thin alcoholic pap, the whole arranged in vases like an oil-lamp, the pap replacing the oil.

Petards.

Petards are small paper cases filled with powder. One end is entirely closed, and the other has only a small hole left for a piece of quick-match, to communicate fire to the powder. Petards are placed at the bottom of lances; they are also used to imitate the fire of musketry.

Rockets.

Rockets are made and driven as described for signal-rockets, (see page 308,)—except that different compositions are used, giving a more brilliant train of fire.

Rockets may be made of all sizes: their general dimensions may be deduced from those given.

Generally, in proportion as the size of the rocket is increased, the thickness of the case must be increased, and the bore of the rocket diminished, or the quickness of the composition, or both of them.

The stick should be from eight to nine times the length of the case, and of such thickness as to throw the centre of gravity about 1.25 inch from the end of the case.

Tourbillon.

The tourbillon is a paper case filled with composition, with the holes for the escape of the gas so disposed as to cause the case to rise vertically in the air at the same time that it revolves horizontally around its middle point. It has light wings attached to it, to direct its motion.

Shells.

Shells are made of light wood or paper, and filled with ornaments of different kinds. They are thrown nearly vertically from a mortar, and, when at their highest point, explode and throw out their ornaments, set on fire by the bursting-charge.

To Make the Shell.—Turn in a lathe, from well-seasoned poplar or pine, two hemispheres of the size and thickness required, leaving a rabet to unite the two. Cover the shell thus formed with lens-shaped pieces of No. 2 paper, pasted on smoothly, two or three thicknesses; or form the shell on a ball the size of the cavity of the shell, by pasting on it strips of paper of lens-shape until it is .2 inch thick. Cut the shell into two equal parts and take out the core; place the two halves together, and continue to paste on pieces of paper, permitting them to dry perfectly, until the shell is of the required thickness. This mode requires much time, as the shells dry slowly, and each successive layer must be thoroughly dry before other pieces are pasted on.

To Charge the Shell.—Introduce the stars, serpents, etc. through the fuze-hole, and then the bursting-charge; cover the fuze where it comes in contact with the shell with glue, and drive it in place.

To insure the fuze taking fire, tie around the shell two pieces of quick-match, crossing over the fuze.

Cover the fuze with several strips of paper pasted to the shell at their ends. These are removed before the shell is fired.

Stars.

The stars for shells are made as described page 311. Those made of composition which burn with difficulty must have a hole in their axes, like those used for Roman candles.

Wheel-Cases.

Wheel-cases are made and driven like sun-cases. They are used to give a rotary motion to pieces mounted on an axis, and to produce at the same time a brilliant fire. They are attached to the end of the spoke of the wheel which they are to turn by means of iron wire, or strong twine, and they are inclined to the spoke from 20° to 30° to give a larger circle of fire.

Roman Candles.

The Roman candle is a long and strong tube charged with stars which are thrown out successively by a charge of powder placed under each star.

The ends of gun-barrels, 20 inches long, are used for cases. When paper cases are used, make them about .65 to .7 interior diameter and 1 inch exterior diameter; roll them like portfire-cases.

Three *drifts*, of different lengths, are used; they are made of hickory or other hard wood, with brass tips on the lower ends.

To Charge the Case.—Put in the case a ladleful of clay and drive it with ten blows of the mallet; then a ladleful of composition, which is driven in the same way; next a charger of powder and a star, which is gently pressed down; then another ladleful of composition, a second charger of powder, and another star,—driving the composition and pressing down the star gently; continue until the ten stars are in, and add a half-ladleful of composition.

Prime the candle with a strand of quick-match 6 inches long, held in place against the side of the case by a little composition driven in on its ends. Cover the end of the candle with a strip of paper pasted on.

Roman candles are inserted in holes bored in frames, or tied with wire or twine in the direction in which they are to throw their stars. The stars used for Roman candles have a hole through their axes, communicating the fire to the charge below, which throws it out.

Leaders.

Leaders are long paper tubes of small diameter, enclosing a strand of quick-match. They are used to communicate fire rapidly from one point to another.

The velocity of combustion is from 1 to 2 yards per second, depending upon the size of the tube, being more rapid as the tube is smaller.

Leaders are made by rolling a strip of thin paper, 2.5 inches wide, as obliquely as possible, on a ramrod; or cut the paper into trapezoids, 4 inches wide at one base and $2\frac{1}{4}$ at the other; paste the edges of the strips .25 inch, and roll them on a ramrod so that one end shall be enlarged, funnel-shape. When dry, pass a strand of quick-match through, and let it project about an inch at each end.

To unite them into a long line, insert the end of one into another a distance of .75 inch, and tie them with a thread.

If the line be long, first stretch a piece of twine, and attach the leader to it every few feet.

Preparation of Colored Fires.

The materials for colored fires should be as pure as can be obtained: those which crystallize should be procured in the crystalline state. They should be generally first dried, ground fine, weighed out, and mixed. The composition is then moistened and pressed into shape. Some of the materials, such as the flowers of sulphur and lampblack, ought to be first well washed in warm water. Antimony, glass, and copper-filings ought, as well as other materials, to be passed through sieve No. 1.

Drying.—All materials should be perfectly dry. Those which contain water of crystallization, as the nitrate of baryta, nitrate of strontia, and sulphate of copper, should have it driven off. For this purpose, place the salt in a broad, shallow vessel in a water-bath or on a moderate fire and stir it till it be perfectly dry, taking it off the fire some minutes before.

As the sulphate of copper is easily decomposed in this operation, and as the sulphuric acid set free might occasion a spontaneous explosion when the sulphate of copper was brought in contact with the chlorates, two parts of liquid ammonia are poured by degrees on the sulphate of copper powdered and yet hot. (The ammonia neutralizes the acid, and, instead of injuring the color, it heightens it. The same process should be adopted with other decomposable metallic salts.) A thick liquid of an indigo-blue color is obtained: place it on the fire, and warm it gently until it become a thick paste: then, leaving only a few coals under it, stir it with a spatula and crush it into a powder.

GRINDING.—The materials are ground in a mortar with a pestle, or on a sieve with copper balls 0.4 inch in diameter of equal weight with the composition to be ground. All the utensils should be kept perfectly clean.

To pulverize antimony, melt it and pour it into a cast-iron mortar previously warmed: when the metal is on the point of congealing, stir it briskly with the pestle: it is thus reduced to fine grains, which are then pulverized with a pestle. Zinc and other similar metals are treated in the same way.

To obtain shellac in the state of a fine powder, it is first broken into pieces and melted with its weight of saltpetre. The mass is then ground as usual, and the powder thus obtained is washed in pure water till all the saltpetre is removed.

The resins and other substances insoluble in water and difficult to pulverize in their pure state are treated in the same manner.

All materials when pulverized should be passed through hair sieve No. 1. They ought, if possible, to be sifted when warm, and placed away immediately in well-stopped bottles to preserve them from moisture.

The chlorates should be pulverized in a marble mortar with a hard-wood pestle. The mortar, pestle, and sieve should be used only for a single chlorate, and the whole operation be performed in a place apart, to avoid accidents. The chlorate can be ground and manipulated by itself without danger; but when it is mixed with sulphur, charcoal, etc., it explodes very readily.

WEIGHING.—Each material should be weighed accurately by itself, according to the proportions laid down in the table.

MIXING.—The materials after being weighed out are poured on a sheet of pasteboard and mixed as well as possible with the hand: they are then passed three times through sieve No. 2, keeping the sieve stationary, and stirring the materials with the hand.

If a chlorate enter into the composition, begin by mixing all the materials, on a pasteboard, except the sulphur, charcoal, lampblack, sugar, tallow, and shellac. When they are well mixed, add the combustible materials separately, mix them thoroughly, and then add the chlorate.

Pass the composition three times through sieve No. 2, using a feather for the purpose.

All these manipulations with compositions into which a chlorate enters should be performed in a place aside, and with a small quantity at a time.

Compositions thus prepared should be preserved in well-stopped bottles carefully labelled. Those containing chlorates should be placed away from the rest and apart from each other.

Dampening.—Compositions are dampened by pouring the pure or gummed liquid on them, a little at a time, and mixing it well with the hand or a wooden knife. Compositions should not be dampened until just before they are to be moulded.

Moulding.—All compositions may be firmly compressed, provided care be taken to avoid friction and blows with those containing chlorates.

However great the care taken in the choice of materials, their proportions and manipulations, it is difficult always to get uniform results. It is necessary, therefore, to try the mixtures and modify the proportions as may be required.

In every composition there are certain substances which are used to furnish oxygen for the consumption of the rest: the nitrates and chlorates are such. There are other substances, as sulphur, charcoal, and vegetable matters, which are burned; and others which are only used to give color to the flame, as antimony, lead, copper, strontia, etc.

The same substance may furnish oxygen and color the flame at the same time. Certain materials are used only to heighten the color,—as the protochloride of mercury and the hydrochlorate of ammonia: the action of the latter is weaker than that of the former.

When a composition burns too slowly, there is an excess of coloring-matter or of that which is to be burned, or some other substance, (as water, for example,)—very rarely of that which furnishes oxygen. When the composition burns too fast, it is necessary to add coloring-matter, or such substances as sugar, rosin, or tallow, which operate by separating the substances supplying the oxygen from those which are burned, and at the same time keeping up the combustion.

Generally, the quicker the combustion the more will the flame approach to whiteness, whatever may be the coloring-principle, and the slower the combustion the more certainty there will be of obtaining the desired color.

Sieves.

Sieves are made of brass wire, hair, or silk, and may be square or round in shape.

Hair sieves for mixing compositions.	No. 1.	50 meshes in 1 inch, or 2,500 in a square inch, a single hair in one direction, 2 in the other.
	No. 2.	25 meshes in 1 inch, or 625 in a square inch, 2 hairs side by side in each direction.
	No. 3.	12.5 meshes in 1 inch, or 156 in 1 square inch, 3 hairs side by side in each direction.
	No. 4.	180 meshes in a square inch, brass wire.

The silk sieve is made like No. 1, and often replaces it. Brass sieves ought to be used only for dry materials.

Dimensions and Weights of Paper or Poplar Shells.

	Thickness of		Weight of		Weight of Charge.				Ornaments.							
									Weight of				Number of			
Calibre.	Sides.	Bottom.	Empty.	Loaded.	In Mortar.	In Shell.	Drain of Fuze-Hole.	Time of Fuze.	Stars.	Gold Rain.	Rain of Fire.	Serpents.	Stars.	Gold Rain.	Streamers.	Serpents.
In.	In.	In.	lbs. oz.	lbs. oz.	Oz.	Oz.	In.	Sec.	Oz.	Gr.		Gr.				
5.8	.5	.62	.10 5	2.10	3.5	.5	1.4	3.	.5	40	......	210	50	170	32	14
8.	.5	.52	1.10	7.8	5.	.5	1.4	3.	.5	40	......	210	140	600	40	60
10.	.75	.1	3.25	11.14	5.	1.	1.4	3.	.5	40	......	210	270	950	230	130
15.	1.25	1.5	14.14	35.	12.	2.	1.4	3.	.5	40	......	210	900	3400	760	460

Dimensions for Sun and Wheel Cases.

			Sun-Cases.			Wheel-Cases.		
Interior diameter		....................in.	0.75	1.0	1.5	0.75	1.0	1.5
Case......	Exterior diameter	.....in.	1.2	1.6	2.0	1.20	1.6	2.0
	Length	..................in.	11.	10.60	12.5	8.75	8.75	8.75
Spindle..	Diameter	at bottom.in.	.28	.55	.65	.28	.55	.65
		at top......in.	.18	.38	.40	.18	.38	.40
	Length	..................in.	.35	.75	.80	.35	.75	.80

Rate of Burning of Compositions.

Dimensions.	Wheel-Fires.			Standing Fires.		
	Common.	White.	Chinese.	Sun.	Star.	Roman Candles.
Length of case...............in.	8.75	8.75	8.75	11.	8.	19.
Interior diameter............in.	.75	.75	.75	.75	.75	.75
Weight of composition....oz.	3.5	3.5	4.	5.	4.	5.
Time of burning, per in..sec.	17.	17.	21.	22.	20.	45.

Rate of Burning of Compositions.—Continued.

	Lances.					Pot-Fires.						Changeable Wheels.
	Red.	White.	Blue.	Yellow.	Green.	Red.	White.	Blue.	Yellow.	Green.	Lilac.	
Length of case..................in.	4.	4.	5.	4.	4.	3.	3.	3.	3.	3.	3.	3.
Interior diameter................io.	.32	.32	.32	.32	.32	1.	1.	1.	1.	1.	1.	.7[illegible]
Weight of composition...... gr.	141	140	150	150	160	547	560	546	545	560	550	250
Time of burning..............sec.	90	90	90	90	90	60	65	45	65	65	45	60

Compositions for Fireworks.

The parts are, by weight:

Stars...
- *White.*—16 nitre; 8 sulphur; 4 mealed powder.
- *Yellow.*—1 charcoal; 1 sulphur; 6 nitrate of soda.
- *Red.*—5 chlor. of potassa; 20 nit. of strontia; 4 gum dammar
- *Blue.*—8 chlor. of potassa; 4 sulph. of copper; 4 gum dammar.
- *Green.*—96 chlorate of potassa; 192 nitrate of baryta; 64 sulphur; 8 lampblack.
- *Five-pointed.*—7 sulphur; 10 mealed powder.

Lances.
- *White.*—26 nitre; 9 sulphur; 5 mealed powder.
- *Yellow.*—16 nit. of soda; 4 sulph.; 4 mealed powder; 2 lampblack.
- *Red.*—30 nit. of strontia; 16 nitre; 10 sulph.; 7½ mealed powder.
- *Blue.*—8 nitre; 2 sulphur; 4 sulphate of copper.
- *Green.*—96 nitre; 64 sulp.; 8 lampblack; 192 nitrate of baryta.

Lights.
- *White.*—16 nitre; 8 sulphur; 4 mealed powder.
- *Yellow.*—2 nitre; 4 sulphur; 20 nitrate of soda; 1 lampblack.
- *Red.*—5 nitre; 6 sulphur; 20 nitrate of strontia; 1 lampblack.
- *Blue.*—8 nitre; 2 sulphur; 4 sulphate of copper.
- *Green.*—24 nitre; 16 sulph.; 48 nitrate of baryta; 1 lampblack.
- *Bengal.*—2 antimony; 4 sulph.; 4 mealed powder; 16 nit. of soda.

Wheel-Fires.
- *Common.*—6 nitre; 1 sulphur; 16 mealed powder; 6 charcoal.
- *Brilliant.*—1 nitre; 1 sulphur; 16 mealed powder; 7 steel-filings
- *Chinese.*—1 nitre; 1 sulph.; 16 mealed powder; 7 cast-iron filings.
- *White.*—6 nitre; 7 sulphur; 16 mealed powder.

Sun-Fires—*Chinese.*—1 nitre; 1 sulphur; 16 mealed powder; 7 cast-iron filings.

Streamers.—2 nitre; 1 sulphur; 16 mealed powder; 4 charcoal.

Serpents.—2 charcoal; 16 mealed powder.

Roman Candles.—6 nitre; 2 sulphur; 16 mealed powder; 6 charcoal.

Gold Rain.—16 nitre; 10 sulphur; 4 mealed powder; 3 lampblack; 1 flowers of zinc; 1 gum arabic.

The nitrate of soda may be replaced by the bicarbonate of soda or the oxalate of soda. The sulphate of copper is ammoniated.

Tools and Implements.

The following list of laboratory tools and implements shows the kinds and proportions which may be required for a large laboratory and for a park of artillery:

Kind.		Quantity.	
		Laboratory.	Park.
Awls, brad		3	1
Adze, copper, weighing 5 lbs		1	1
Bench, for drawing the loads of shells		1	
Bench-stake		1	
Bick-iron		1	
Bill-hooks		....	2
Blocks	for driving fuzes of different calibres	20	
	for driving signal-rockets and portfires	4	
	for punches	2	
	for cutting on	1	
Bottles, with ground-glass stoppers		4	
Boxes, for 12 workmen making cartridges—3 to each		36	
Bowls	wooden, various sizes	12	4
	earthen, glazed, large	6	
Braces and bits		2	1
Brushes, of various kinds		18	4
Buckets		6	
Callipers, various sizes		3	1
Chargers, copper	for fuzes	10	5
	for portfires	2	1
	for signal-rockets	6	2
	for cartridges for small arms (revolving)	4	1
Chisels	brass, for unloading shells	6	3
	cold	3	2
	joiner's	3	2
Compasses	common	3	1
	spring	2	1
Cooper's drivers, copper and wood		2	2
Crowbar		1	1
Cutting-boards		6	
Cylinders for gauging balls		3	2
Dippers		6	
Dredging-boxes		6	2
Drifts	of iron, pointed with copper or brass, for driving portfires	2	
	for driving fuzes for 13-inch and 10-inch shells; long and short	24	8
	for driving fuzes for 8-inch shells and howitzers; long and short	24	8
	for driving signal-rockets, sets for 1-inch	1	
	" " " .75-inch	2	1
	for driving serpents, iron	6	2

Tools and Implements.—Continued.

Kind.		Quantity. Laboratory.	Quantity. Park.
Drills, assorted		6	3
Files	half-round	6	4
	saw	4	2
	rat-tail	3	2
	large	4	2
Formers	of iron or wood, for portfire-cases	2	.
	for rocket-cases—sets for each calibre	2	1
	for serpents	6	2
	for leaders	2	
	for small-arm cartridges, of each calibre, 1 to each workman	20	20
	for cylinders and caps, for each calibre	2	1
	for pot for rockets, " "	1	1
	for cutting pots on, " "	1	1
	for cones for rockets, " "	1	1
	for wads, " "	1	
Fork, iron, for dipping pitched fascines		1	
Funnels, of copper and tin, various kinds		20	5
Fuze-cutters		......	2
Fuze-setters		......	5
Fuze-extractors		2	1
Gauges	steel, for shot and shells; for each calibre	2	2
	double, for grape and canister; " "	1	1
	" for cartridge-formers; " "	1	1
	of sheet iron, for sabots; " "	1	1
	" for canister-bottoms; " "	1	
	" for canisters; " "	1	
	of copper or wood, for cannon-cartridges	1	1
Gimlets		2	2
Gimlets, for priming rockets		6	3
Glue-pot and brush		1	
Gunner's callipers		......	1
Gunner's pincers		3	3
Hammers	iron, hand, for strapping shot, &c	13	4
	copper	2	1
Hand-barrows, with rope bottoms, for powder-barrels		2	
Hatchet		1	1
Hooks for unpacking ammunition-boxes		6	3
Implements for making paper fuzes—sets		4	1
Kettles	iron, for melting lead	2	1
	iron, for rock-fire, &c	2	
	iron, for pitch	1	1
	copper, for paste	2	1
Knives	for cutting paper, large and small	12	6
	block	1	

Tools and Implements.—Continued.

Kind.		Quantity. Labora-tory.	Quantity. Park.
Ladles	iron, for lead, pitch, &c	5	1
	copper, for saltpetre, &c	1	
Lanterns		5	5
Letter-punches (stencils)—set		1	1
Mallets	for driving fuzes and portfires	20	5
	for driving rockets	6	4
	carpenter's	2	
Measures	for powder, from 8 pounds to 4 ounces	22	12
	gallon, quart, pint, half-pint, and gill	5	5
Mortar and pestle, bronze		1	1
Mortar, marble, with pestle of hard wood		1	
Moulds	for balls and buckshot—sets	......	2
	for incendiary-balls, different calibres	4	
	brass, for portfires	2	
	for rockets, of each calibre	2	1
Mullers, wooden		4	2
Needles, of various kinds		150	50
Nippers	for cutting wire	2	1
	for trimming balls	......	1
Palms, for sewing canvas		4	2
Paste-brushes		12	12
Patterns	for cartridge-papers for small arms	4	2
	tin, of each kind and calibre, for paper cartridges	1	1
	" " " for flannel cartridges	1	1
	" " " for canisters	1	
Pans, copper, various sizes		18	6
Pitchers, stone		6	
Planes		1	
Pliers, flat, for twisting wire		4	2
Plugs, pointed, for loading spherical case		2	
Press, for paper and pasteboard		1	
Profiles, of sheet iron, for sabots—for each calibre		1	
Punches		6	
Punches	for piercing shot-straps	12	2
	centre	4	
	for fuze-caps, for 13, 10, and 8-inch—2 each	8	
Rasps, for wood		6	6
Reels, or frames, for quick-match		2	
Rocket-stand		1	
Rolling-boards, for portfire-cases, &c		2	
Rules	carpenter's	2	1
	iron, for cutting by	8	2
Sandstones, for sharpening knives		6	2
Saws		2	1
Scale, of 1 foot, (diagonal,) divided into inches and 100ths		1	1

Tools and Implements.—Continued.

Kind.	Quantity. Laboratory.	Quantity. Park.
Scales, copper, large, small, and medium	5	2
Scissors and shears, of different sizes	12	12
Scoops, copper, for taking up materials	6	4
Screw-drivers	4	2
Scribers	4	2
Shell-hooks	1	
Shell-plug screws	4	2
Sieves { hair, Nos. 1, 2, 3, and 4, with frames	4	4
Sieves { bolting-cloth	2	2
Screens, for demolition of cartridges for small arms	2	
Shovels	2	
Skimmer, copper, for saltpetre	1	
Soldering furnaces and irons	2	1
Socks—pairs	60	
Spatulas { steel, for saltpetre, &c.	3	1
Spatulas { for rock-fire	6	
Spatulas { for packing ammunition-boxes	24	2
Spoke-shave	1	
Sponges	2	
Spools, for twine	40	
Squares { wooden	6	2
Squares { iron	2	1
Stamps for flannel cartridges—for each calibre	1	
Tarpaulins	4	2
Thimbles	6	6
Tinner's creaser	1	
Tinner's shears	2	1
Trestles—pairs	2	
Trivets, iron	2	
Tubs { for the demolition of cartridges for small arms	1	
Tubs { common	6	
Tubs { for making slow-match, &c. (casks sawed in two)	6	
Twisting-machine, for slow-match, &c.	1	
Watering-pots	2	1
Weights—sets for each balance or pair of scales	1	1
Whetstones	......	1
Wrenches { screw	1	1
Wrenches { fuze	1	1
Yard-stick	1	1

CHAPTER ELEVENTH.

EQUIPMENT OF BATTERIES FOR FIELD, SIEGE, AND GARRISON SERVICE.

EQUIPMENT OF FIELD-BATTERIES.

Interior Arrangement of Ammunition-Chests for Field Guns and Howitzers. (Plate 18.)

THE principal divisions of a chest are designated as the *right half* and the *left half*, to a person facing the front of the chest.

The smaller divisions in each half, perpendicular to the sides, are designated as *first*, *second*, *third*, &c., from the principal partition, each way; the divisions parallel to the sides are designated as the *front*, *middle*, and *rear divisions*.

The kind of ammunition contained in the small divisions is marked on the inside of the cover, over each division.

Ammunition-Chest for the 6-pounder Gun.

Eight partitions, (poplar,) four in each half, perpendicular to the sides of the chest. The partitions are supported by *two strips* of wood at each end, forming a groove in which the partition slides; each strip is fastened to the side of the chest with *four copper nails*, 3-penny, 1.13-inch.

In the first four divisions of the right half are *two bolsters*, to each division, for spherical case shot,—one fastened to the principal partition by 3 *screws* No. 14, the others fastened to the movable partitions each by 3 *screws*.

One tray, for holding equipments, rests on the partitions in the left half of the chest. The tray has *two sides*, *two ends*, and *one bottom*, (poplar or white pine.) The sides and ends are dovetailed together and fastened by 12 *nails*; the bottom is fastened to the ends and sides by 14 *brass screws* No. 12. Three finger-holes are bored in the inside of the ends, to lift the tray by; and a hole is bored through the middle of the bottom, to let the air enter when the tray is lifted out.

Ammunition-Chest for the 12-pounder Gun.

Six partitions, three in each half, perpendicular to the sides of the chest, supported as in the 6-pounder chest.

Four bolsters, for spherical case shot,—one of them fastened to the principal partition with 3 *screws* No. 14, two fastened to the first partition in the right half with 3 *screws* No. 14, and one to the left side of the second partition, right half, with 3 *screws* No. 14.

The second and third partitions in the right half are made higher than the others, to suit the height of the canisters fixed.

One tray, for equipments, in the left half; made like that for the 6-pdr. chest.

For the gun of model 1857, there are 8 *bolsters* for shells and spherical case shot, fastened as above.

Ammunition-Chest for the 12-*pounder Howitzer.*

Six partitions, three in each half, supported like those of the 6-pdr. chests.

Twenty-one bolsters, for the lower tier of shells and spherical case shot. They are cupped out to receive the balls, and have holes bored through the bottom for the fuzes to lie in. They are placed in the bottom of the chest, three in each division, except the first division in the right half; they are fastened to the bottom each by 4 *sprigs*.

Twenty-eight props, for the upper tier of shells and spherical case. Four of the props are placed in each division, except the first one in the right half. Two of them are fastened to each end of the chest, two to the left side of the principal partition, and two to the right side of the first partition in the right half, each by 6 *copper nails*, 3-penny.

The rest of the props are fastened in pairs to the movable partitions each by 6 *copper nails*, 3-penny.

Six props for canisters, (oak,) in the first division of the right half; three fastened to the principal partition, three to the movable partition, each with 3 *screws* No. 14.

Ammunition-Chest for the 24-*pounder Howitzer.*

Eight linings, two in each of the front and rear divisions, fastened to the ends of the chest and to the principal partition each by 6 *copper nails*, 3-penny.

Four long partitions, two in each half, parallel to the sides of the chest; they are supported by the end linings and by *two upright strips*, fastened to the ends and principal partition each by 4 *copper nails*, 3-penny.

Two short partitions for canisters, in the rear division of the right half; each of them is supported by 4 *strips*, fastened to the back of the chest and to the long partition each by 3 *copper nails*, 3-penny.

Seven short partitions, for shells and spherical case shot; two in each of the front divisions, two in the rear division of the left half, and one in the middle division of the left half. These partitions slide into grooves made each by *two upright strips*, which are fastened to the sides and to the long partitions each by 4 *copper nails*, 3-penny; each partition is formed of two pieces, which slip into the grooves, one over the other.

Thirty-three bolsters for shells and spherical case. Seven of them are fastened, at the bottom of the chest, to the end linings of the two front divisions and the left rear division, and to the principal partition in the right middle division, each by 2 *screws* No. 14. Twenty-four of the bolsters are fastened in pairs on each side of the short partitions of the two frout divisions and the left rear divisions; twelve to the lower half and twelve to the upper half of the partitions; each pair fastened by 3 *screws* No. 14, which pass through the bolsters and the partition. Two bolsters are fastened to the left side of the middle partition in the right half, one to the lower and one to the upper part of the partition, each by 2 *screws* No. 14.

Ammunition-Chest for the 32-pounder Howitzer.

Six long partitions, three in each half,—one parallel to the ends and two parallel to the sides of the chest; each partition is supported by 4 *strips* fastened to the sides and ends of the chest, or to the other partitions, each by 5 *copper nails*, 3-penny.

Four short partitions, one in the front and rear division of each half, made in two pieces, and fastened in the same manner as those of the 24-pounder howitzer chest.

Twenty-one bolsters for shells and spherical case. Seven of them are fastened, at the bottom of the chest, to the ends and cross partitions each by 2 *screws* No. 14. Twelve bolsters are fastened in pairs, as in the 24-pounder howitzer chest, to the short partitions in the left half, and in the rear division of the right half. Two bolsters are fastened, in like manner, on the right side of the short partition in the right front division.

Ammunition-Chest for the Mountain-Howitzer.

Eight long cleats, for supporting the ammunition: they are glued to the sides, opposite to each other, and fastened by 32 *copper nails*, 3-penny. *Eight short cleats*, fastened to the sides by 8 *screws* No. 14, and 16 *copper nails*, 3-penny.

Ammunition-Chest for the Prairie-Carriage.

The same as for the mountain-howitzer.

Ammunition carried in each Chest.

KIND.	No.	Weight.	PLACE.
FOR 6-POUNDER GUN.		Lbs.	
Shot, fixed	25	190.	In the left half.
Spherical case, fixed	20	140.	In the 1st four divisions of right half.
Canisters, fixed	5	42.	In 5th division, right half.
Spare cartridges, $1\frac{1}{4}$ lb	2	2.6	On the spherical case.
Friction-primers	75	.97	In a tin box, in the tray.
Slow-match ... yard	2	.38	On the ammunition in right half.
Portfires	2	.57	
Total number of rounds	50	376.52	
FOR 12-POUNDER GUN.			
Shot, fixed	20	308.	In left half, and in 4th division of right half.
Spherical case, fixed	8	117.6	In 1st and 2d divisions, right half.
Canisters, fixed	4	67.64	In 3d division, right half.
Spare cartridges, $2\frac{1}{2}$ lbs	2	5.12	On the spherical case.
Friction-primers	48	.62	In a tin box, in the tray.
Slow-match ... yard	1.5	.28	On the ammunition in right half.
Portfires	2	.57	
Total number of rounds	32	499.83	
FOR 12-PDR. GUN, (1857.)			
Shot, fixed	12	184.8	In 1st, 2d, and 3d divisions, left half.
Spherical case	12	176.4	In 1st, 2d, and 3d divisions, right half.
Shells	4	48.68	In 4th division, right half.
Canisters	4	67.64	In 4th division, left half.
Spare cartridges, 2.5 lbs	2	5.12	On the shells.
Friction-primers	48	.62	In a tin box, in the tray.
Slow-match ... yard	1.5	.28	On the ammunition in right half.
Portfires	3	.57	
Total number of rounds	32	484.11	
FOR 12-PDR. HOWITZER.			
Shells, fixed	15	157.5	In 2d, 3d, and 4th divisions, right half.
Spherical case, fixed	20	273.	In left half.
Canisters, fixed	4	47.4	In 1st division, right half.
Friction-primers	58	.75	In a tin box on the canisters.
Slow-match ... yards	2	.38	On the canisters.
Portfires	2	.57	
Total number of rounds	39	479.6	

Ammunition carried in each Chest.—Continued.

KIND.	No.	Weight.	PLACE.
FOR 24-PDR. HOWITZER.		Lbs.	
Shells, strapped............	12	225.60	In left half.
Spherical case, strapped..	8	214.92	In front and middle divisions of right half.
Canisters....................	3	63.75	In rear divisions of right half.
Cartridges { Small charge	23	53.82	12 in middle division, left half; 9 in middle division, right half; 2 on the canisters.
Cartridges { Large charge	2	5.40	On canisters.
Friction-primers............	34	.44	In a tin box on the canisters.
Slow-match ....yard	1	.19	} On the canisters.
Portfires......................	2	.57	} On the canisters.
Total number of rounds...	23		
		564.69	
FOR 32-PDR. HOWITZER.			
Shells, strapped............	8	196.80	Front and rear divisions of left half.
Spherical case, strapped...	6	216.00	Rear divisions and right front division of right half.
Canister......................	1	28.50	Left front division, right half.
Cartridges { Small charge.	15	46.50	} 1st division in each half.
Cartridges { Large charge.	1	3.88	} 1st division in each half.
Friction-primers............	22	.28	In a tin box in the middle division.
Slow-match............yard	.5	.09	} In the middle division.
Portfires	1	.28	} In the middle division.
Total number of rounds...	15		
		492.33	
FOR MOUNTAIN-HOWITZER.			
Shells, fixed	1	9.9	In left end.
Spherical case, fixed.......	6	75.6	In middle.
Canisters, fixed..............	1	11.8	In right end.
Friction-primers............	12	.15	In water-proof paper.
Slow-match............yard	$\frac{1}{2}$	.09	
Portfires......................	1	.28	
Total number of rounds...	8		
		97.82	

FOR PRAIRIE-HOWITZER.—The same as for the mountain-howitzer.

Implements and Equipments for Field-Carriages.

Kind.	No.	Weight.	Place.
FOR A GUN OR HOWITZER CARRIAGE.		Lbs.	
Sponges and rammers......	2	....	On the gun-carriage.
Sponge-covers.	2	0.24	On the gun-carriage.
Worm and staff..............	½	3.6	On the gun-carriage.
Handspikes	2	14.5	On the gun-carriage.
Sponge-bucket	1	10.	On the gun-carriage.
Prolonge......................	1	12.5	On the gun-carriage.
Vent-cover....................	1	0.2	On the gun.
Tar-bucket....................	1	7.	On the limber.
Water-bucket (leather).....	2	16.	On the limber.
Gunner's haversacks	2	3.72	In the implement-trays, or in other vacant spaces in the ammunition-chest.
Tube-pouch....................	2	1.80	In the implement-trays, or in other vacant spaces in the ammunition-chest.
Vent-punch....................	1	0.08	In the implement-trays, or in other vacant spaces in the ammunition-chest.
Gunner's pincers	1	0.85	In the implement-trays, or in other vacant spaces in the ammunition-chest.
Tow-hook......................	1	0.60	In the implement-trays, or in other vacant spaces in the ammunition-chest.
Hausse.........................	1	0.65	In the implement-trays, or in other vacant spaces in the ammunition-chest.
Thumb-stalls..................	2	0.01	In the tube-pouch.
Priming-wire	1	0.08	In the tube-pouch.
Lanyard for friction-primers.........................	2	0.20	In the tube-pouch.
Gunner's gimlet	1	0.08	In the tube-pouch.
Fuze-cutter	1	0.2	In the tube-pouch.
Tarpaulin, large.............	1	37.75	Strapped on the ammunition-chest.
FOR A CAISSON.			
Felling-axe	1	6.	In the places provided for them on the caisson-body.
Shovel, long handle.........	1	4.75	In the places provided for them on the caisson-body.
Pick-axe......................	1	6.5	In the places provided for them on the caisson-body.
Spare handspike............	1	7.25	In the places provided for them on the caisson-body.
Spare pole....................	1	25.30	In the places provided for them on the caisson-body.
Spare wheel	1	180.	In the places provided for them on the caisson-body.
Tow-hooks.....................	2	1.2	One in the limber-chest, and one in a caisson-chest.
Tar-bucket....................	1	7.	On the limber.
Watering-bucket (leather).	2	16.	On the limber.
Tarpaulin, large............	1	37.75	Strapped on the limber-chest.

Implements and Equipments for Prairie-Carriages.

KIND.	No.	Weight.	PLACE.
		Lbs.	
Sponges and rammers	2	3.	On the carriage.
Sponge-covers	2	2.3	
Handspike	1	5.	
Vent-cover	1	.18	On the gun.
Haversack	1	1.86	In ammunition-chests.
Tube-pouch	2	1.80	
Priming-wire	1	0.08	In the tube-pouch.
Thumb-stalls	2	.01	
Gunner's gimlet	1	0.08	
Lanyard for friction-primers	2	0.2	
Fuze-cutter	1	0.2	
Gunner's pincers	1	0.85	In tool-chest A.
Tarpaulin, 6 × 10 ft	1	12.25	On the ammunition-chest.
Water-bucket	1	8.	On the limber.
Prolonge	1	....	On the gun-carriage.
Tar-bucket	1	7.	On the limber.

Implements and Equipments for the Mountain-Howitzer Carriage.

KIND.	No.	Weight.	PLACE.
		Lbs.	
Handspike	1	5.0	On the carriage.
Sponge and rammer	1	3.0	
Sponge-cover	1	.11	On the sponge.
Vent-cover	1	0.18	On the gun.
Haversack	1	1.86	On the pack with the ammunition-chests.
Tube-pouch	2	1.80	
Priming-wire	1	0.08	In the tube-pouch.
Gunner's gimlet	1	0.08	
Lanyard for friction-primers	2	0.2	
Fuze-cutter	1	0.2	In ammunition-chest.
Gunner's pincers	1	0.85	In tool-chest A.
Tarpaulin, 5 × 5 ft	1	5.25	On the pack with the ammunition-chest.

EQUIPMENT OF TRAVELLING-FORGES AND BATTERY-WAGONS.

One forge and one battery-wagon accompany each field-battery. They are furnished with the tools and materials required for shoeing horses and for ordinary repairs and preservation of carriages and harness.

Other forges and battery-wagons, equipped for the general service of the army, accompany the field-park which contains the general supplies of ordnance stores.

The forge for the field-battery is designated by the letter A.
The forge for the field-park " " " B.
The battery-wagon for the field-battery " " " C.
The battery-wagon for the field-park " " " D.

EQUIPMENT OF A FORGE FOR A FIELD-BATTERY.

Limber-Chest.

The chest is marked FORGE A. The stores and tools are carried in 6 *boxes* and 1-*oil-can.*

INTERIOR ARRANGEMENT.—2 *copper clamps* for iron square, fastened on the inside of the cover by 11 *screws.*

BOXES FOR TOOLS AND STORES, (white pine, .75 inch thick.) The sides and ends are dovetailed together and fastened by 8-penny *nails*: the covers are made with *clamps* on the ends, and are loose: they have three $\frac{3}{4}$-in. holes bored in each end, to lift them by. Two handles of leather, doubled, are nailed on the inside of the ends of the boxes, so as not to interfere with the covers.

The boxes are marked, respectively, A Nos. 1, 2, 3, 4, 5.

Exterior Dimensions of the Boxes.

Dimensions.	A Nos. 1, 3, 6.	A No. 2.	A No. 4.	A No. 5.	Shoeing-Box.
Length......... in.	17.8	17.8	23.5	39.8	16.5
Width.......... in.	13.25	13.25	8.	9.8	8.
Depth.......... in.	7.5	7.5	6.5	6.5	6.5
Weight........ lbs.	8.25	9.75	8.	14.5	4.7

Nos. 2 and 4 have each a partition; No. 2 at 4.5 inches from one end, and No. 4 at 5.25 inches.

One oil-can, made of tin, to hold one quart: it has a neck for a cork near one corner. It is marked A, SPERM-OIL.

Dimensions of can.—Length, 5 inches; width, 5 inches; height, 4 inches: diameter of neck, 1 inch; height of neck, 0.5 inch; weight of can, 0.9 lb.

Contents of the Limber-Chest of Forge A.

Smith's Tools and Stores.	No.	Weight.
		Lbs.
Box A 1, containing:	...	8.25
Horseshoes Nos. 2 and 3..	90	100.
Box A 2, containing:	...	9.75
Horseshoe-nails Nos. 2 and 3	...	50.
Washers and nuts No. 2.	30	5.25
Washers and nuts No. 3.	10	3.20
Washers and nuts No. 4.	4	2.15
Nails No. 1 C	...	1.00
Nails No. 2 C	...	1.00
Tire-bolts	20	5.00
Keys for ammunition-chests	5	1.80
Linch-washers	8	7.30
Linch-pins	12	8.37
Chains Nos. 1 and 2...ft.	2	1.54
Coldshut *S*-links, No. 3..	50	2.50
Coldshut *S*-links, No. 5..	12	2.00
Total contained in Box A 2	...	91.11
Box A 3, containing:	...	8.25
Horseshoes Nos. 2 and 3..	90	100.
Box A 4, containing:	...	8.0
Hand cold-chisels	2	2.00
Hardie	1	0.75
Files, assorted, with handles	12	10.00
Buttress	1	1.50
Hand-punches, round and square	2	2.00
Screw-wrench	1	2.42
Hand screw-driver	1	0.32
Hand-vise	1	1.00
Smith's callipers....pair.	1	0.40
Taps } Nos. 1, 2, 3, and 4	4	1.50
Dies, pairs } Nos. 1, 2, 3, and 4	4	1.83
Wood-screws, 1 in. No. 14 ...groce.	1	2.10
Quart can of sperm-oil	1	2.70
Total contained in Box A 4	....	28.52

Smith's Tools and Stores.	No.	Weight.
		Lbs.
Box A 5, containing:	...	14.5
Fire-shovel	1	3.05
Poker	1	1.90
Split broom	1	1.25
Hand-hammer	1	3.50
Riveting-hammer	1	1.05
Nailing-hammer	1	1.80
Sledge-hammer	1	10.50
Chisels for hot iron	2	3.00
Chisels for cold iron	2	3.00
Smith's tongs	3	15.00
Fore-punch	1	1.00
Creaser	1	1.00
Fuller	1	2.40
Nail-claw	1	5.00
Round-punch	1	2.10
Tap-wrench	1	3.75
Die-stock	1	6.25
Nave-bands, developed	4	11.75
Tire-bands, developed	2	2.75
Total contained in Box A 5	...	80.05
Shoeing-box, containing:	...	4.7
Shoeing-hammer	1	0.82
Pincers ... pair.	1	2.00
Rasps (12 inches)	2	2.15
Shoeing-knife	1	0.33
Toe-knife	1	0.30
Pritchel	1	0.85
Nail-punch	1	0.80
Clinching-iron	1	1.00
Oil-stone	1	1.50
Leather aprons	2	3.00
Total contained in shoeing-box	...	12.75
Iron square, in clamps on the inside of cover..	1	2.00
Padlock, on chest	1	0.50
Tow, used in packing	...	5.00
Tar-bucket, on its hook.	1	7.00
Total	...	480.38

Boxes Nos. 1, 2, and 3 are placed in the bottom of the chest: No. 1 against the left hand; No. 2 in the middle.

No. 4 is placed on top of Nos. 1 and 2, against the left end and the back of the chest; the division for the oil-can on the left hand.

No. 5 is placed on top of Nos. 1, 2, and 3, against the front of the chest.

The shoeing-box is placed on No. 3, against the right end and the back of the chest.

The tools and stores in all the boxes, and in the forges and battery-wagons, are securely packed with tow.

Contents of Forge-Body A.

Tools and Stores.	No.	Weight.	Place.
		Lbs.	
Square iron, $\frac{1}{2}$ in. and $\frac{5}{8}$ in.	...	100.00	In the iron-room. The bars not more than 3 feet long; the square iron in 2 bundles.
Flat iron, $1\frac{1}{4}$ in. $\times$ $\frac{5}{8}$ in., 1 in. $\times$ $\frac{1}{2}$ in., and $1\frac{1}{2}$ in. $\times$ $\frac{1}{4}$ in.	...	50.00	
Round iron, $\frac{3}{8}$ in.	...	50.00	
Cast steel, $\frac{5}{8}$ in. square	...	5.00	
English blister-steel	...	5.00	
Box A 6, containing:	...	8.25	
Horseshoes	100	108.25	In the iron-room.
Water-bucket, wood	1	10.00	On its hook.
Anvil	1	100.00	On the fireplace.
Vise	1	29.00	Fixed on the stock of the carriage.
Watering-bucket, leather	1	8.00	On the vise.
Bituminous coal		250.00	In the coal-box.
Coal-shovel	1	4.75	
Padlock	1	0.50	On coal-box.
Tow	...	2.00	
Total, exclusive of vise	...	693.50	

To put the box in the iron-room or take it out, loosen the thumb-nuts and raise the rear of the bellows an inch.

EQUIPMENT OF A BATTERY-WAGON FOR A FIELD-BATTERY.

The battery-wagon for a field-battery is designated by the letter C.

Limber-Chest.

The chest is marked on the front side BATTERY-WAGON C.

The tools and stores are carried in 4 *boxes* and 1 *oil-can.*

INTERIOR ARRANGEMENT.—4 *brackets,* fastened to the inside of the cover by 10 *screws.*

BOXES FOR TOOLS AND STORES, (white pine, 0.75 inch thick.)—The sides and ends are dovetailed together and fastened by 8-penny *nails;* the covers are loose, like those of the limber-chest of Forge A, as are also the handles.

The boxes are marked, respectively, C, Nos. 1, 2, 3, and 4.

Exterior Dimensions of the Boxes.

DIMENSIONS.	C No. 1.	C No. 2.	C No. 3.	C No. 4.	Remarks.
Length........in.	17.8	26.5	39.8	39.8	The covers of Nos. 1 and 2 are .75 inch thick, and those of 3 and 4 are .5 inch thick.
Width.........in.	13.25	17.8	9.8	8.0	
Depth.........in.	7.5	7.5	6.25	6.25	
Weight.......lbs.	8.25	17.5	12.5	11.0	

No. 3 has a partition, at 5.25 inches from one end, for the oil-can.

No. 4 has two partitions perpendicular to the sides, making three divisions, respectively 15.8 inches, 10 inches, and 11 inches long.

The *oil-can* is like that for the limber-chest of Forge A, and is marked C, SPERM-OIL.

Contents of Limber-Chest for Battery-Wagon C.

Tools and Stores.	No.	Weight.	Tools and Stores.	No.	Weight.
CARRIAGE-MAKER'S TOOLS.		Lbs.	CARRIAGE-MAKER'S TOOLS. Box C 2—*continued.*		Lbs.
Hand-saws, on inside of cover.	2	4.00	Broad-axe..................	1	6.00
Tenon-saw (14-in.) on inside of cover.	1	1.50	Hand-axe..................	1	5.00
Box C 1, containing :..	...	8.25	Claw-hatchet..............	1	2.00
Jack-plane..................	1	4.15	Claw-hammer.............	1	1.50
Smoothing-plane..........	1	1.80	Pincers (small)......pair	1	1.06
Brace, with 24 bits.......	1	4.35	Table-vise.................	1	3.80
Spoke-shave...............	1	0.30	Framing-chisels (1-in. and 2-in.)................	2	3.00
Gauge.......................	1	0.30	Firmer-chisels ($\frac{3}{4}$-in. and $1\frac{1}{2}$-in.)..............	2	1.00
Plane-irons.................	2	1.05	Framing-gouges (1-in. and $1\frac{1}{2}$-in.).............	2	2.60
Saw-set......................	1	0.25	Augers and handles ($\frac{1}{2}$-in., $\frac{5}{8}$-in., and $\frac{3}{4}$-in.)..	3	2.35
Rule (2 feet)...............	1	0.14	Screw-wrench............	1	2.42
Gimlets......................	12	0.95			32.23
Compasses............pair	1	0.18	Box C 3, containing :..	...	12.5
Chalk-line..................	1	0.10	Felling-axe with handles.....	1	6.00
Brad-awls..................	2	0.17	Adze......... with handles.....	1	3.30
Scriber......................	1	0.15	Frame-saw................	1	4.50
Saw-files ($4\frac{1}{2}$-in.)..........	12	0.87	Quart can of sperm-oil..	1	2.70
Wood-files (10-in.).......	2	1.12	SADDLER'S TOOLS AND STORES.		
Wood-rasp (10-in.).......	1	0.40	Mallet........................	1	1.75
Trying-square (8-in.)....	1	0.60	Clamp.........................	1	5.00
Hand screw-driver.......	1	0.32			23.25
		17.20			
Box C 2, containing :..	...	17.5			
Oil-stone....................	1	1.50			

Contents of Limber-Chest for Battery-Wagon C.—Continued.

Tools and Stores.	No.	Weight.	Tools and Stores.	No.	Weight
		Lbs.			Lbs.
Box C 4, containing:..	...	11.00	Black wax............lbs.	3	3.00
Hammer....................	1	0.65	Bristles.................oz.	8	0.50
Shoe-knife..................	1	0.09	Shoe-thread..........lbs.	5	5.00
Half-round knife..........	1	0.28	Patent thread........lbs.	2	2.00
Shears.................pair	1	0.47	Buckles (assorted, .75-in. to 1.5-in.)......doz.	3	1.00
Sandstone..................	1	1.54	Tacks....................M.	3	0.75
Rule (2 feet)..............	1	0.14	Gunner's callipers.......	1	0.50
Needles......................	100	0.08	Shoe-knives..............	2	0.18
Awls and handles.........	12	0.75	Scissors..............pairs	2	0.20
Punches.....................	2	0.22			20.66
Pincers.................pair	1	0.75	Padlock, on the chest..	1	0.50
Pliers...................pair	1	0.22	Tar-bucket, on its hook	1	7.00
Claw-tool....................	1	0.12	Tow, for packing.........	...	7.00
Creaser......................	1	0.15			
Thimbles.....................	4	0.06			
Strap-awl....................	1	0.01			
Beeswax...............lbs.	2	2.00	Total..................	...	162.59

Boxes Nos. 1 and 2 occupy the bottom of the chest; No. 1 against the left end.

Nos. 3 and 4 are placed on top of Nos. 1 and 2; No. 3 against the rear of the chest.

Wagon-Body C.

The large stores are piled loosely in the body and in the till; the small stores and tools are packed in *five boxes.*

INTERIOR ARRANGEMENT.—A *till,* 9 inches wide and 9.5 inches deep, as described page 51.

An axe-rack extends along the whole length of the body, on the left side, 11 inches from the bottom; it is 2 inches deep and 1.5 inch wide, and is fastened to the side by the middle rivets of the side studs, and by 5 *wood-screws.* The rack has notches, to hold 3 *axes,* 3 *hatchets,* and 3 *bill-hooks.*

Exterior Dimensions of the Boxes.

DIMENSIONS.	C Nos. 5 & 6.	C No. 7.	C No. 8.	Candle-Box.
Length ....in.	23.	23.5	13.	11.
Width ....in.	18.5	20.25	13.	6.5
Depth ....in.	11.25	14.	5.	5.5
Weight................................lbs.	17.5	28.	6.	2.85

Nos. 1 and 6 have no cover; No. 7 has a loose cover; No. 8 is divided into 4 equal parts; No. 8 and candle-box are of white pine, 0.625 inch thick, with cover-hinges and locks; Nos. 5 and 6 are of hard wood, 0.75 inch thick.

The boxes are marked, respectively, C, Nos. 5, 6, 7, 8, and candle-box C.

Dimensions of Cans and Kegs.

Dimensions.	Neat's-foot Oil.	Turpentine & Linseed-Oil.	Olive Paint.	Black Paint.	2 Kegs.
Capacity	2 gal.	1 gal.	25 lbs.	5 lbs.	50 lbs.
Diameter ... in.	8.	6.	9.75	7.	9.75
Diameter of the bilge .. in.	......	......	....	....	10.5
Height ... in.	11.5	10.	10.25	8.5	12.5
Weight ... lbs.	2.2	1.37	3.	1.5	5.

The first two cans have rounded tops and necks for corks; the other two have flat tops, and the opening covered by a piece of tin soldered on.

There are *seven* cans,—*two* marked C, NEAT'S-FOOT OIL; *one* marked C, LINSEED-OIL; *one* marked C, TURPENTINE; *two* marked C, OLIVE PAINT; *one* marked C, BLACK PAINT.

Contents of Wagon-Body C.

Tools and Stores.	No.	Weight.	Tools and Stores.	No.	Weight.
		Lbs.			Lbs.
Box C 5, containing in 5 cans:	...	17.5	Claw-hatchet, in axe-rack	1	2.
Linseed-oil ... gal.	1	9.17	Hand-bills, in axe-rack	2	4.
Spirits turpentine ... gal.	1	8.77			
Olive paint ... lbs.	50	56.			
Black paint ... lbs.	5	6.5	Box C 6, containing:	...	17.5
			Paint-brushes	12	3.00
Total in Box C 5	...	80.44	Sperm or wax candles, lbs	5	7.85
			Rammer-heads	4	2.90
Box C 7, containing in 2 cans and 2 kegs	...	28.	Sponge-heads	4	3.20
			Sponges	12	3.00
Neat's-foot oil ... gals.	4	32.80	Priming-wires	3	0.24
Grease ... lbs.	50	60.	Gunner's gimlets	3	0.24
		92.80	Lanyards for friction-primers	4	0.40
			Cannon-spikes	6	0.30
Box C 8, containing:	...	6.	Dark lanterns	3	3.00
Nails (4, 6, 8, and 10 penny) ... lbs.	20	20.	Common lanterns	4	4.60
Felling-axes, in axe-rack	2	12.	Total in Box C 6	...	28.73

Contents of Wagon-Body C.—Continued.

Tools and Stores.	No.	Weight.	Remarks.
		Lbs.	
Caisson-stock	1	35.	Under the till, against the side and rear of the wagon.
Splinter-bar	1	15.	
Rammers and sponges	3	13.5	On the caisson-stock, against rear end.
Spokes	40	72.	On the bottom; piled lengthwise against the front end.
Fellies	24	160.	On the spokes, crosswise.
Grindstone, 14 in. × 4 in.	1	50.	On the fellies, against the left side of the wagon.
Arbor and crank for do.	1	6.5	
Screw-jacks	3	75.	On the fellies, against the front and the till.
Wheel-traces	10	47.5	In a pile occupying 30 inches at the rear end of the wagon, between the left side and the caisson-stock, and up to the top of the till; the collars piled on each other, from the bottom.
Leading-traces	10	57.5	
Collars	6	27.5	
Girths	16	11.	
Whips	16	8.	
Bridles	6	18.	
Halters	6	21.	
Halter-chains	12	15.5	
Hame-straps	25	4.5	
Spare nose-bags	12	13.5	On the harness.
Sash-cord ... pieces	6	10.	
Slow-match ... yards	2	0.25	On Box No. 7, to the left of No. 8.
Elevating-screw	1	15.75	On the pile of harness.
Pole-yoke	1	12.25	
Harness-leather ... side	1	25.	Under the till, in front of the pile of harness, against the caisson-stock.
Bridle-leather ... sides	2	22.	
Prolonge	1	12.5	On Box No. 7, in front of No. 8.
Scythes	4	9.	In the till, against the front end.
Scythe-stones	4	6.	In the curve of the scythes.
Spades	6	30.	In the till; the bits against rear end.
Pick-axes and handles	2	13.	Between the spade-handles.
Corn-sacks	24	20.	On the scythes.
Tarpaulins, 5 feet square	2	18.	On the corn-sacks, against front end.
Reaping-hooks	4	3.85	Fastened to the ridge-pole with a wooden clamp and a leather strap.
Scythe-snaths	4	12.	Fastened to the ridge-pole with two leather straps and buckles.
Spare stock for battery-wagon	1	90.	In the spare stock-stirrup.
Padlock	1	0.5	
Watering-bucket	1	8.	Tied to the forage-rack.
Forage	...	......	In the forage-rack.
Boxes	4	69.	
Tow	...	24.5	
Total	...	1292.57	Exclusive of forage.

Box C No. 5 is placed on the bottom of the wagon, next to the pile of harness which occupies the rear part of the body. Box No. 6 is on top of No. 5; No. 7 on the bottom of the wagon, in front of No. 5; No. 8 on top of No. 7. The candle-box in No. 6.

EQUIPMENT OF A FORGE FOR THE FIELD-PARK.

Limber-Chest.

The chest is marked Forge B.

The stores and tools are packed in 5 *boxes* and 1 *oil-can.*

Interior Arrangement.—3 *copper clamps* for iron square, fastened on the inside of the cover by 11 *screws.*

Boxes for Tools and Stores.—Made like those for Forge A.

Exterior Dimensions.

DIMENSIONS.	Box B Nos. 1, 5, 6.	Box B No. 2.	Box B No. 3.	Box B No. 4.	Shoeing-Box B.
Length..........in.	17.8	26.5	23.5	39.8	16.5
Width...........in.	13.25	17.8	8.	9.8	8.
Depth...........in.	7.5	7.5	6.5	6.5	6.5
Weight ....lbs.	8.25	17.5	8.	14.5	4.7

No. 3 has a partition for oil-can, 5.25 inches from one end.

The boxes are marked, respectively, B, Nos. 1, 2, 3, and 4.

The oil-can is like that for Forge A.

Contents of Limber-Chest of Forge B.

Tools and Stores.	No.	Weight.	Tools and Stores.	No.	Weight.
		Lbs.			Lbs.
Box B 1, containing: ..	...	8.25	Box B 1—*continued.*		
Nuts and washers No. 5..	4	5.00	Linch-pins	12	8.00
Nuts and washers No. 4..	6	3.22	Chain No. 2 ....feet	2	0.75
Nuts and washers No. 3..	10	3.20	Pintle-hook	1	20.00
Nuts and washers No. 2..	45	7.88	Cap-square.................	1	5.00
Nails, Nos. 1 and 2, C.lbs.	2	2.00	Tire-bands (clips) devel.	2	2.75
Tire-bolts	20	5.00			
Rivets for amm. chests..lb	1	1.00	Total in Box B 1....	...	83.40
Washers Nos. 3 and 4.....	20	2.50			
Keys for ammun. chests..	5	1.80	Box B 2, containing :..	...	17.5
Pole-prop socket & ferrule	1	1.30	Heading-tools, for bolts..	2	12.00
Linch-washers............	8	7.00	Heading-tool, for nails...	1	4.00
Shoulder-washers.........	4	7.00	Tire-punches, w. handles	2	3.00

Contents of Limber-Chest of Forge B.—Continued.

Tools and Stores.	No.	Weight.	Tools and Stores.	No.	Weight
		Lbs.			Lbs.
Box B 2—*continued.*			Box B 4, containing:..	...	14.5
Round punch, w. handles	1	2.10	Nave-bands, developed...	4	11.75
Square punch, "	1	2.10	Hand-hammer.............	1	3.50
Square hand-punch	1	1.00	Riveting-hammer	1	1.05
Round hand-punch.......	1	1.00	Nailing-hammer	1	1.80
Centre-punch..............	1	0.50	Sledge......................	1	10.50
Key-punch..................	1	1.00	Fore-punch.................	1	1.00
Set-hammer, flat	1	2.85	Creaser......................	1	1.00
Set-hammer, half-round.	1	3.00	Screw-wrench	1	2.42
Chisels for hot iron	3	4.50	Smith's shovel	1	3.05
Chisels for cold iron......	2	3.00	Smith's poker	1	1.90
Hand cold-chisels.........	2	2.00	Split broom	1	1.25
Smith's tongs..............	3	15.00	Tap-wrench, with 4 holes	1	3.75
Nail-claw	1	5.00	Die-stock	1	6.25
Tire-circle	1	1.35	Tracing-point..............	1	0.15
Bevel-vise..................	1	1.75	Augers, $\frac{3}{4}$-in. and 1-in....	2	2.50
Hardie	1	0.75	Framing-chisel............	1	1.50
Fuller	1	2.40	Felling-axe.................	1	6.00
Hand-axe....................	1	5.00			
			Total in Box B 4....	...	59.37
Total in Box B 2....	...	73.30			
			Shoeing-box, cont'g:..	...	4.7
Box B 3, containing:..	...	8.	Shoeing-hammer	1	0.82
Screws, 1-in., No. 14. groce	1	2.10	Shoeing-pincers...........	1	2.00
Small hand-vise...........	1	1.00	Shoeing-rasps	2	2.15
Hand screw-driver	1	0.32	Pritchel.....................	1	0.85
Taps, } $\frac{1}{4}$, $\frac{3}{8}$, $\frac{1}{2}$, $\frac{5}{8}$, $\frac{3}{4}$, & 1 in.	6	2.85	Nail-punch	1	0.80
Dies, }	6	2.75	Toe-knife...................	1	0.30
Gimlets, assorted	12	0.95	Clinching-iron.............	1	1.00
Small punches	3	0.75	Shoeing-knife	1	0.33
Spring compasses....pair	1	0.15	Leather aprons	2	3.00
Files, assort., w. handles	12	10.00	Oil-stone....................	1	1.50
Iron wire-gauge	1	0.25			
Scribing-awl	1	0.15	Total in Shoeing-Box.	...	12.75
Callipers..............pair	1	0.40			
Bevel........................	1	0.35	Iron square, on inside		
Trying-square..............	1	0.60	cover	1	2.00
Scriber	1	0.15	Padlock, on chest.........	1	0.5
Buttress	1	1.50	Tar-bucket, on its hook..	1	7.00
Quart can of sperm-oil...	1	2.70	Tow..........................	...	14.00
Total in Box B 3....	...	26.97	Total.............	...	332.24

Boxes Nos. 1 and 2 occupy the bottom of the limber-chest; No. 1 against the left end.

No. 3 is placed on top of Nos. 1 and 2, against the left end and the back of the chest.

No. 4 on top of Nos. 1 and 2, against the front of the chest.

The shoeing-box, on No. 2, against the right end and the back of the chest.

Contents of Forge-Body B.

Tools and Stores.	No.	Weight.	Place.
		Lbs.	
Square iron ($\frac{1}{2}$ to 1 in.)............	.....	100.	In the iron-room. Bars not more than 3 feet long. Square iron in two bundles.
Flat iron ($1\frac{1}{4}\times\frac{5}{8}$, $1\times\frac{1}{2}$, $1\frac{1}{4}\times\frac{2}{10}$, $1\frac{1}{2}\times\frac{1}{4}$ in.)............	.....	50.	
Round iron ($\frac{3}{8}$-in.)............	.....	50.	
Cast steel............	.....	10.	
English blistered steel............	.....	5.	
Boxes B 5 and B 6, containing:..	.....	16.5	In the iron-room.
Horseshoes Nos. 2 & 3............	.....	200.	
Horseshoe-nails Nos. 2 & 3.........	.....	20.	
Water-bucket............	1	10.	On its hook.
Watering-bucket (leather)........	1	8.	On the vise.
Anvil............	1	100.	On the fireplace.
Vise............	1	....	On the stock of the forge.
Bituminous coal............	.....	250.	In the coal-box.
Coal-shovel............	1	4.75	
Padlock............	1	0.50	On coal-box.
Tow............	.....	3.	
Total............	.....	827.75	Exclusive of vise.

To put the boxes 5 and 6 in place, loosen the thumb-nuts and raise the rear of the bellows one inch.

EQUIPMENT OF A BATTERY-WAGON FOR THE FIELD-PARK.

Limber-Chest.

The chest is marked Battery-Wagon D.

The stores are packed with tow in the bottom of the chest, and in 2 *boxes* and 1 *oil-can.*

Interior Arrangement.—2 *cleats* of oak for the boxes, .175 inch wide and 0.75 inch thick, are fastened to the ends of the chest by 8 *screws* No. 14, 1.5 inch; the upper edges of the cleats 7.5 inches from the bottom of the chest.

5 *wooden clamps* for saws, fastened to the inside of the chest-cover by 12 *screws.*

2 *brass clamps* for webs of frame-saw, fastened to the inside of the cover by 12 nails.

Exterior Dimensions of Boxes.

	D No. 1.	D No. 2.	Remarks.
Length ....in.	39.8	39.8	No. 1 has 2 partitions, 5.25 inches from one end and 7.5 inches from the other.
Width ....in.	8.0	9.8	No. 2 has 2 partitions, 14 inches from one end and 11.8 inches from the other.
Depth................in.	6.25	6.25	Made like the boxes for Forge A.
Weight ....lbs.	11.0	13.0	

The boxes are marked, respectively, D, Nos. 1 and 2.

One *oil-can*, like that for the limber-chest of Forge A, marked D, SPERM-OIL.

Contents of Limber-Chest for Battery-Wagon D.

Tools and Stores.	No.	Weight.	Tools and Stores.	No.	Weight
CARRIAGE-MAKER'S TOOLS.			Box D 1—*continued.*		Lbs.
			Spoke-shaves...............	2	0.60
			Gauges........................	2	0.60
(Packed in the bottom of the chest with tow.)			Plane-irons..................	6	3.15
		Lbs.	Saw-set........................	1	0.25
Bench-planes...............	4	16.00	Trying-square..............	1	0.60
Wood-clamps...............	2	12.	Bevel..........................	1	0.35
Oil-stones....................	2	3.	Rule (2 feet)...............	1	0.14
Broad-axe....................	1	6.	Gimlets........................	12	0.95
Hand-axe.....................	1	5.35	Compasses............pair	1	0.18
Felling-axe..................	1	6.	Chalk-line....................	1	0.10
Hand-hammer	1	1.50	Brad-awls....................	2	0.17
Claw-hatchet	1	2.	Scriber........................	1	0.15
Adze...........................	1	3.30	Taper-files (4½-in.)........	12	0.87
Table-vise...................	1	3.80	Wood-files....................	6	3.36
Holdfast......................	1	10.5	Wood-rasps..................	2	0.80
Framing-chisels...........	4	6.	Compass-saw...............	1	0.30
Firmer-chisels.............	4	2.	Harness-buckles... groce	1	4.
Gouges........................	4	5.	Tacks......................M.	10	2.50
Frame-saw	1	4.50	Quart can sperm-oil......	1	2.70
Screw-wrenches	2	4.84			
Augers and handles......	6	4.70	Total in Box D 1..	...	27.52
Claw-hammers.............	2	3.00			
Saddler's mallet	1	1.75	SADDLER'S TOOLS AND STORES.		
Saddler's clam.............	1	5.00			
		106.24	Box D 2, containing: ..	...	13.
			Hammer......................	1	0.65
Box D 1, containing:..	...	11.09	Shoe-knives.................	6	0.54
Brace and 24 bits.........	1	4.35	Half-round knife..........	1	0.28
Pincers, small.........pair	1	1.	Shears..................pair	1	0.47
Callipers...............pair	1	0.40	Sandstones..................	3	4.62

Contents of Limber-Chest for Battery-Wagon D.—Continued.

Tools and Stores.	No.	Weight.	Tools and Stores.	No.	Weight.
Box D 2—*continued.*		Lbs.	Box D 2—*continued.*		Lbs.
Rule (2 feet)................	1	0.14	Beeswax		3.
Needles, assorted..........	600	0.50	Black wax		5.
Collar-needles	5	0.05	Patent thread		5.
Awls	36	2.25			
Awl-handles	6	0.60	Total in Box D 2..	...	30.24
Punches, assorted.........	6	0.66			
Pincers..................pairs	3	2.25	Hand-saws, } in wooden clamp	2	4.
Pliers ....pairs	6	1.32	Tenon-saws, } in wooden clamp	2	3.
Claw-tools....................	3	0.36	Webs or blades for frame-saw, in brass clamps..	2	0.75
Creasers	3	0.45	Padlock, on chest.........	1	0.50
Strap-awls	3	0.03	Tar-bucket, on its hook..	1	7.
Gauge-knife..................	1	0.80	Tow..........................		5.25
Compasses..............pair	1	0.18			
Thimbles......................	6	0.09			
Bristles........................		1.	Total	...	208.50

Boxes Nos. 1 and 2 rest on the cleats; No. 1 against the back of the chest.

Wagon-Body D.

The large stores are packed loosely in the body and in the till: the small stores and tools are packed in 9 *boxes*, 8 *tin cans*, and 2 *kegs*.

Interior Arrangement.—A *till* and *axe-rack* as in Battery-Wagon C.

2 *wooden buttons* for rammer-staves, fastened to the ridge-pole by 2 *screws*.

1 *wooden clamp* for reaping-hook, fastened to the ridge-pole.

2 *wooden clamps* for saws.

1 *iron staple* and *leather strap* for reaping-hooks, passing through the ridge-pole.

Exterior Dimensions of the Boxes.

Dimensions.	D Nos. 3 and 5.	D No. 4.	D No. 6.	D No. 7.	D No. 8.	D No. 9.	D No. 10.	Shoeing-Box.
Length........in.	23.5	27.5	19.5	31.5	12.5	13.	14.5	16.5
Width..........in.	20.25	23.5	19.5	19.5	8.5	13.	6.	8.
Depth.........in.	14.	14.	10.5	8.	7.5	5.	5.5	6.5
Weight......lbs.	28.	34.	21.	26.	4.	6.	3.5	4.7

Nos. 3, 4, 5, 6, and 7 are of hard wood, .075 inch thick, with hinged covers and hooks.

Nos. 8, 9, and 10 are of white pine, .625 inch thick, with hinges and hooks. No. 9 is divided into 4 parts.

The boxes are marked, respectively, D, Nos. 3, 4, 5, 6, 7, 8, 9, 10.

The *shoeing-box* is marked D.

Eight tin cans: two, of the capacity of *two gallons*, for NEAT'S-FOOT OIL and LINSEED-OIL; three, of *one gallon*, for the same oils and for TURPENTINE; two, for *twenty-five pounds* each of OLIVE PAINT; and one, for *five pounds* of BLACK PAINT. They are made like those of the same capacity for Battery-Wagon C.

Two kegs, for grease; like those in Battery-Wagon C.

Contents of Wagon-Body D.

Tools and Stores.	No.	Weight.	Place.
		Lbs.	
Gun-carriage stock (ironed)....	1	165.00	On the bottom of the wagon, against the right side, resting on two blocks, to clear the rammer-stop; the lunette to the rear.
Caisson-stocks (not ironed).....	2	70.00	Against the left side and rear of the wagon; one on the other, the lunette-ends in front.
Splinter-bars........................	2	30.00	On the bottom, lying on each other against the caisson-stocks and the rear of the wagon.
Tire-bolts, nuts, and washers..	28	11.75	On the bottom, against the front and right side.
Axle-trees, 6-pdrs................	2	234.00	On the bottom, against the gun-carriage stock and the front end.
Half-tires..............................	4	140.00	Between the axle-trees and the splinter-bars.
Bar-iron..............................		200.00	In 5 bundles, not more than 3 feet long; on the half-tires, against the front of the wagon.
Steel		50.00	
Pole-yokes..............................	3	37.00	On the bar-iron, toward the front.
Wheel-traces........................	10	47.5	Piled on the bottom of the wagon, against the gun-carriage stock and the till, and on the caisson-stocks and splinter-bars; occupying about 31 inches in length of the rear part of the wagon.
Leading-traces	10	57.5	
Trace-chains, staples, and rivets	20	26.00	
Collars..................................	6	27.50	
Girths..................................	16	11.00	
Whips....................................	16	8.00	
Hame-straps	25	4.50	
Bridles	6	18.00	
Halters..................................	6	21.00	
Halter-chains	12	15.50	

Contents of Wagon-Body D.—Continued.

Tools and Stores.	No.	Weight.	Place.
		Lbs.	
Harness-leather ....sides	3	75.00	Trimmed and rolled up tight; on the axle-trees and tires, in front of the pile of harness.
Bridle-leather.................. "	2	22.00	
Rope, 2¾-in.........................	.....	30.00	Between the front ends of the caisson-stocks and the bar-iron.
Nose-bags	12	13.50	On the pile of harness.
Slow-match ....yards	5	0.60	
Screw-jacks.........................	3	75.00	On the slow-match.
Elevating-screws	2	31.50	
Drag-ropes.......	2	33.00	Coiled on the screw-jacks.
Grindstone and arbor.............	1	56.50	On the drag-ropes.
Felling-axes.........................	3	18.00	In the axe-rack.
Hand-bills	3	6.00	
Tarpaulins, 5 feet square........	2	18.	On the gun-carriage stock.
" " "	2	18.	Between the till and boxes Nos. 3, 4, and 5.
Marline	.....	10.	On box No. 3.
Sheep-skins.........................	6	12.	On boxes Nos. 4 and 5.
Spades	6	30.	In the till, on each other; the bits against the back of the wagon.
Pick-axes, without handles.....	3	14.50	In the till, between the spade-handles.
Handles for do......................	3	5.	
Sash-cord ....pieces	24	40.	
Drill-bow............................	1	0.45	In the till, lying on the bottom.
Barrel-wiper and scraper........	1	2.5	
Shoe-thread.........................	.....	10.	In the till, in front of box No. 10.
Dark lanterns.......................	3	3.	In the left side of the till, between the shoe-thread and the front end.
Common lanterns..................	4	4.60	
Rammer-heads	6	4.40	In the till, between the lanterns and the side of the wagon.
Sponges	12	3.	
Paint-brushes.......................	12	3.	On box No. 10, and by the side of it.
Rammer-staves, 12-pdr..........	6	13.5	In the wagon-cover; three on each side of the ridge-pole, secured by two wooden buttons.
Reaping-hooks......................	6	5.75	Fastened to the ridge-pole by a wooden clamp and leather strap.

Contents of Wagon-Body D.—Continued.

Tools and Stores.		No.	Weight.	Place.
			Lbs.	
Cross-cut saw.........	without handles	1	9.	In the wagon-cover, laid on each other, and fastened by two wooden clamps; the teeth of the cross-cut saw against the right cover-rail; the handle end of the pit-saw against the rear board of the cover.
Pit-saw.................	without handles	1	15.	
Handles for do....................		4	3.	On the spade-handles.
Spare stock for battery-wagon.		1	90.	On its hook.
Padlock..............................		1	0.5	
Watering-bucket..................		1	8.	
Tow..................................		.....	26.50	

Contents of Wagon-Body D.—Continued.

Tools and Stores.	No.	Weight.	Tools and Stores.	No.	Weight.
		Lbs.			Lbs.
Box D 3, containing 3 cans and 2 kegs......	.....	28.	Box D 4—*continued.* Lead-ladle	1	2.00
Neat's-foot oil.........gals.	3	25.00	Stencil-cutters, for letters and figures...........set	1	18.00
Grease	.....	60.00	Box for do..................	1	5.00
Spirits turpentine...gals.	1	8.77	Mallets......................	4	4.00
Box D 4, containing:..	.....	34.	Powder-measures, 4 oz.. 8 oz., 1 lb., and 2 lbs.	4	2.00
LABORATORY TOOLS.			Brass mortar and pestle.	1	6.00
Copper adze, with handle	1	3.00	Moulds for musket and rifle balls and buck-shot....................set	1	23.00
Wooden bowls..............	4	6.00	Wooden mullers...........	2	4.00
Bench-brushes.............	2	0.90	Needles.....................	50	0.04
Callipers...............pair	1	0.40	Paste-brushes.............	3	1.25
Dredging-box..............	1	1.00	Copper pans, 10 or 12 in.	3	5.00
Rocket-mould, for 1-inch rockets	1	25.00	Rule, (2 feet,) not folded	1	0.15
Set of formers, for 1-inch rockets	1	1.60	Sandstones.................	2	3.00
Set of drifts, for 1-inch rockets	1	1.75	Spring balance, 30 lbs...	1	5.00
Formers for cylinders and caps, each calibre...set	1	7.50	Scissors.....................	12	1.50
Copper funnels..............	4	4.00	Copper scoop, large......	1	2.00
Shot and shell gauges, set	1	15.00	" small......	3	1.50
Gimlets......................	3	0.25	Hair sieve..................	1	0.80
Copper hammer...........	1	1.80	Hand screw-drivers, l'ge	2	2.00
Paste-kettle.................	1	9.00	Spatula......................	1	0.30

Contents of Wagon-Body D.—Continued.

Tools and Stores.	No.	Weight.
		Lbs.
Box D 4—*continued.*		
Thimbles	6	0.09
Gunner's callipers	1	0.50
Priming-wires	6	0.50
Gunner's gimlets	6	0.50
Gunner's pincers	3	2.55
Tinner's furnace	1	9.00
Total in box D 4	.....	176.83
Box D 7, containing:	.....	26.0
Haversacks	12	22.32
Tube-pouches	8	7.60
Thumb-stalls	8	0.04
Linen canvas.........yards	15	7.50
Box D 8, containing:	.....	4.
Sperm or wax candles	.....	10.
Box D 9, containing:	.....	6.
Nails, 4d. to 10d	.....	20.
Shoeing-box, cont'g:	.....	4.7
Shoeing-tools...........set	1	12.75
Box D 5, with 5 cans:	.....	25.
Linseed-oil............gals.	3	26.5
Olive paint	.....	50.
Black paint	.....	5.
Box D 6, containing:	.....	21.
ARMORER'S TOOLS.		
Wire awls	3	0.25
Band-set	1	0.50
Drill-brace	1	2.60
Hand-brace	1	2.50
Centre-bits	6	0.40
Hand-brushes	2	0.60
Bench-brush	1	0.50
Callipers...............pair	1	0.30
Centre-punch	1	0.50
Cold-chisels	6	6.75
Stocker's chisels	6	2.00
Stocker's gouges	6	1.60
Compasses...............pair	1	0.18

Tools and Stores.	No.	Weight.
		Lbs.
Box D 6—*continued.*		
Spring-clamps	2	3.00
Wood-clamps	2	3.00
Drill-stock	1	0.45
Drills, assorted	6	0.25
Die-stock	1	0.75
Dies.......................set	1	0.25
Files, assorted	72	21.50
File-handles	12	1.5
Glue-pot	1	2.15
Spring-hooks	3	0.63
Bench-hammers	3	5.25
Drawing-knife	1	1.25
Nippers...............pairs	3	0.90
Pliers.................. "	3	0.90
Reamers, assorted	12	1.40
Spring-compasses ...pair	1	0.21
Rifler	1	0.25
Bench-stake	1	6.50
Hack-saw frame	1	1.
Hack-saw blades	6	1.
Armorer's punches	4	0.38
Screw-drivers, brace	6	0.75
Rule, 2 feet	1	0.15
Armorer's tongs	2	2.50
Screw-taps..............set	1	0.50
Breeching-vise	1	7.
Hand-vises	3	3.
Bevel-vise	1	1.75
Breeching-wrench	1	1.80
Tap-wrench	1	1.20
Straight-edge	1	0.57
Bayonet-mandrel	1	2.50
Soldering-irons	2	3.50
Screw-wrench	1	2.42
Oil-cans, small	2	0.22
Tinner's shears......pair	1	1.60
Brass scale, 1 foot	1	0.20
		100.92
Box D 10, containing:	.....	3.5
Quick-match	.....	2.0
Total weight	.....	25.83

Boxes D 3 and 4 are placed on the caisson-stocks and the rolls of leather. No. 3 against the front of the pile of harness.

Box D 5 is placed on the pole-yokes and rope, between No. 4 and the front of the wagon.

Box D 6 is placed on top of No. 5, against the front of the wagon.

Box D 7 is placed on top of No. 4, and against No. 6.

Box D 8 on top of No. 3; box D 9 on No. 3 and on the till; the shoeing-box on No. 3; box D 10 in the left side of the till, in front of the spade-handles.

The boxes are put in after the grindstone and tarpaulins.

FORGE FOR THE MOUNTAIN-HOWITZER..

Two chests, designated the *forge-chest* and the *smith's tool-chest,* contain the forge and the necessary tools for shoeing horses and making repairs.

The chests are carried on the sides of the pack-saddles, fastened by means of the lashing-chain.

The coal-sack, containing the charcoal, is fastened to the arc by the handles.

Forge-Chest.

The different articles are packed in this chest in racks, or held fast by cleats. The legs of the frame are first folded up close to the frame, and the back of the fireplace is turned down on the hearth and fastened by its catch. The handle is detached from the bellows, which is closed and fastened by the connecting-rod.

INTERIOR ARRANGEMENT.—WOOD.—1 *corner-piece,* fastened to the left end, at the back, by 4 *copper tacks;* 1 *cleat* for bellows, fastened to the bottom by 2 screws No. 14, 1½ inch; it has a hole in its top surface to receive the journal; 1 *support for nozzle of bellows,* framed and fastened to the bottom of the chest by 2 *screws* No. 14, 1½ inch; 1 *cleat for bellows-handle,* fastened to the front side, toward the right, by 2 *screws* No. 14, 1½ inch; 1 *clamp for bellows* has a hole for upper journal of bellows, goes over and across the bellows, and is held by the staple-plates; 1 *clamp* for frame.

IRON.—1 *strap-staple,* driven through the nozzle-support for the right side and clenched; 1 *bracket* for wrench, fastened to the right end by 2 *screws* No. 9, .62 inch; 2 *staple-plates,* fastened opposite each other, one on the front side and the other on the back, by 4 *screws* No. 9, .625 inch; 1 *staple-plate,* fastened to the back by 2 *screws* No. 9, .625 inch; 2 *clamp-plates,* fastened to the clamps by 4 *screws* No. 9, .625 inch.

LEATHER.—1 *nozzle-strap* 16 inches long; 1 *buckle* No. 6; 2 *straps* 40 inches long; 2 *buckles* No. 8.

Contents of Forge-Chest.

Tools and Stores.	No.	Weight.	Where placed.
		Lbs.	
Fireplace and frame, folded up	1	31.5	On its side, the bottom against the back of the chest.
Bellows, closed..................	1	18.25	The right journal in the hole in the cleat on the bottom, the left in that in the clamp; the nozzle fastened to its support by the strap.
Bellows-handle	1	1.875	On its cleat.
Wrench for nuts Nos. 1 and 4.	1	1.0	In its bracket.
1 hand-hammer with handle..	1	2.375	Placed upright near the wrench
1 riveting " " " ..	1	1.5625	" " " " "
1 fore-punch and creaser on same handle................	1	1.844	" " " " "
Bags of horseshoe-nails........	2	10.0	Packed with tow in the space to the right of the bellows.

Weight of forge-chest with cleats and clamps. 45. lbs.
" " tools and stores .... 68.4 "
" " forge-chest packed .... 113.40 "

Smith's Tool-Chest.

The stores are secured by cleats or brackets.

Interior Arrangement.—Wood.—1 *anvil-rest,* with a mortise for the head of the anvil, fastened to the bottom of the chest by 2 *screws* No. 14, 1.75 inch; 1 *triangular cleat,* fastened in the left front corner by 2 *screws* No. 14, 1.25 inch; 1 *vise-cleat,* fastened to the front side by 2 *screws* No. 14, 1.75 inch; 2 *racks* for *poker and shovel,* 1 button on upper cleat, fastened to the back by 4 *screws* No 14, 1.5 inch; 2 *racks* for rasp, fastened to the back by 4 *screws* No. 14, 1.25 inch; 2 *cleats* for toe-knife, fastened to the back by 4 *screws* No. 9, .625 inch; 1 *cleat* for tongs, fastened to the left end by 2 *screws* No. 14, 1.25 inch; 2 *cleats* for files, and 1 *button* on right cleat, fastened on the inside of cover by 4 *screws* No. 14, 1 inch; 1 *movable cleat,* hollowed out to fit the anvil-block and bucket; 1 *stud.*

Iron.—1 *strap-staple,* fastened to the bottom by 2 *rivets,* .25 inch; 3 *brackets,* fastened to the front side by 6 *screws* No. 8, .5 inch; 2 *hooks* driven into the upper cleat for poker.

Leather.—1 *strap* 28 inches long; 1 *buckle* No. 5.

Contents of Smith's Tool-Chest.

Tools and Stores.	No.	Weight.	Where placed.
		Lbs.	
Anvil and block..............	1	38.5	The head in the mortise of the rest, the block secured by the strap and buckle.
Water-bucket (iron)........	1	4.6875	On the movable cleat resting on the anvil-block.
Pair shoeing-pincers	1	1.875	In its cleat on the front with the vise.
Vise	1	2.656	In its cleat.
Nailing-hammer	1	1.5	In brackets on front.
Shoeing "	1	.875	" " " "
Splitting-chisel..............	1	.8125	" " " "
Tongs......................pair	1	1.6875	In triangular cleat in the corner.
Pritchel	1	.718	" " " " " "
Hardie	1	.406	In rack on the left end.
Clenching-iron	1	.9375	" " " " "
Shoeing-knife.................	1	.406	In rack on the left end.
Poker	1	.5	In two wooden racks on the back of the chest.
Shovel	1	.6875	
Rake	1	.531	
Nail-punch	1	.064	
Buttress.......................	1	1.469	On two hooks in the poker-rack, held by a button.
Toe-knife	1	.50	In its cleats on the back of the chest.
Rasp	1	1.5	In two racks on the back of chest, near the left end.
Square file....................	1	.719	
Flat file	1	1.031	In two cleats on the inside of cover, held by a button.
Half-round	1	.8125	
Bags horseshoe-nails.......	2	10.	One on the bottom at the left end, the other in the bucket.

Weight of the chest with cleats and racks	44.	lbs.
" " " tools and stores................	72.875	"
" " " chest packed.....................	116.875	"

Carriage-Maker's Tools and Stores.

The tools and stores for the use of carriage-makers, in repairing the carriages and equipments, are packed in two chests, which are like those for the ammunition, but without the interior divisions.

The hasp and *hasp-staples* are like those of the forge-chest.

The two chests are designated by the letters A and B.

Contents of Carriage-Maker's Tool-Chests.

Chest A.	No.	Weight.	Chest A.	No.	Weight.
		Lbs.			Lbs.
Claw-hatchet............	1	2.125	Wood-files, 12-inch....	2	1.125
Nailing-hatchet..........	1	1.75	Sickles..................	2	2.125
Firmer-chisels, $\frac{1}{2}$ & $\frac{3}{4}$ in.	2	.594	Gunner's gimlet........	1	0.083
Trying-square	1	.422	Priming-wire...........	1	0.08
Bevel......................	1	.375	Gunner's pincers.......	1	1.25
Augers, $\frac{1}{2}$ and $\frac{5}{8}$ inch, and one handle	2	1.375	Fuze-cutter	1	....
Riveting-hammer	1	1.5	Papers of sprigs, 1 in. and $1\frac{1}{2}$ inch...........	2	1.0
Hand-saw	1	2.0	Papers of tacks, 8 oz. and 12 oz.............	2	1.25
Jack-plane	1	4.25	Wood-screws, $\frac{3}{4}$ in. No. 9	60	0.31
Screw-driver	1	.375	Lbs. sash-cord	2	2.0
Rule (two feet)	1	.156	Lbs. twine...............	$\frac{1}{2}$	.5
Gimlets....................	3	.1875			
Hand-saw files..........	2	.125			

Weight of chest.............. 21 lbs.
" " tools and stores, 24.96 "
" " chest packed .... 46.96 "

Chest B.	No.	Weight.	Chest B.	No.	Weight.
		Lbs.			Lbs.
Hand-axe..................	1	3.25	Brad-awls	6	.5
Claw-hatchet	1	2.125	Sickles....................	2	2.125
Nailing-hatchet..........	1	1.75	Gunner's gimlet........	1	0.083
Firmer-chisels	2	0.594	Priming-wire............	1	0.08
Firmer-gouge	1	0.25	Papers tacks, 8 & 12 oz.	2	1.125
Pair compasses..........	1	0.25	Lb. twine................	$\frac{1}{2}$	0.5
Trying-square, 6 inches	1	0.422	Leather thongs	25	0.344
Scriber....................	1	0.125	Wood-screws, $1\frac{1}{2}$ and 1 inch, No. 14..........	36	0.562
Riveting-hammer	1	1.5	Wood-screws, $1\frac{1}{2}$ and 2 inch, No. 16.........	12	0.312
Mallet......................	1	2.25	Nuts No. 1; 2, No. 2; 6, No. 4...............	12	0.625
Gimlets....................	3	0.1875	Washers No. 1..........	12	0.437
Screw-driver	1	0.375			
Wood-rasp	1	0.5			
Oil-stone	1	1.812			

Weight of chest.............. 21 lbs.
" " tools .... 22.083 "
" " chest packed .... 45. "

The sickles are fastened to the front and back of the chests (inside) by small cleats at the necks and points. The other articles are securely packed in tow, the edges of the cutting-tools being carefully wrapped up, to prevent injury.

WEIGHTS OF GUN-CARRIAGES AND CAISSONS, EQUIPPED FOR FIELD-SERVICE.

Designation.	For guns.		For howitzers.		
	6-pdr.	12-pdr.	12-pdr.	24-pdr.	32-pdr.
GUN-CARRIAGE.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
Gun	884	1,757	788	1,318	1,890
Gun-carriage, without wheels	540	783	540	736	783
Two wheels	360	392	360	392	392
Limber-body, without wheels	335	335	335	335	335
Two wheels	360	360	360	360	360
Ammunition-chest, with interior divisions	185	182	206	198	192
Ammunition, packed	395	497	465	541	470
Large tarpaulin	36	36	36	36	36
Other implements and equipments	83	86	83	86	86
Total weight	3,178	4,428	3,173	4,002	4,544
Number of rounds of ammunition on each limber	50	32	39	23	15
CAISSON.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
Body, without wheels	432	432	432	432	432
Two wheels	360	360	360	360	360
Two ammunition-chests	370	364	412	396	384
Ammunition, packed in do.	790	994	930	1,082	940
Limber-body, without wheels	335	335	335	335	335
Two wheels	360	360	360	360	360
Ammunition-chest	185	182	206	198	192
Ammunition, packed in do.	395	497	465	541	470
Large tarpaulin	36	36	36	36	36
Other implements and spare parts	246	246	246	246	246
Total weight	3,509	3,806	3,782	3,986	3,755
Number of rounds of ammunition on each caisson and its limber	150	96	117	69	45

Weights of Forges and Battery-Wagons equipped for Field-Service.

Designation.	For the Battery.	For the Park.
FORGE.	Lbs.	Lbs.
Body complete, without wheels	997	997
Two wheels	360	360
Anvil and water-buckets	118	118
Stores in iron-room	320	455
Stores in coal-box	255	255
Limber-body, without wheels	335	335
Two wheels	360	360
Limber-chest, empty	158	158
Stores and tools on the limber	480	332
Total weight	3,383	3,370
BATTERY-WAGON.	Lbs.	Lbs.
Body complete, without wheels	910	910
Two wheels	360	360
Stores in wagon-body	1,289	2,583
Limber-body, without wheels	335	335
Two wheels	360	360
Limber-chest, empty	158	158
Stores and tools on the limber	162	200
Total weight (exclusive of forage)	3,574	4,915

Bill of Boards for Interior of Ammunition-Chests.

	Designation.	No. of pieces.	Dimensions, (rough.) Length.	Width.	Thickness.	Quantity.	Kind.
			In.	In.	In.	Feet.	
6-PDR. GUN.	Partitions	1	168	11.	0.625	8.02	Poplar.
	Tray. bottom	1	22	20.	0.75	2.29	Poplar, or white pine.
	Tray. sides	1	22	10.	0.75	1.15	
	Tray. ends	1	20	11.	1.	1.53	
12-PDR. GUN.	Partitions	1	84	12.	0.75	5.25	Poplar.
		1	42	14.	0.75	3.06	"
	Tray. bottom	1	22	20.	0.75	2.29	Poplar, or white pine.
	Tray. sides	1	22	7.5	0.75	0.86	
	Tray. ends	1	20	9.	1.	1.25	
12-PDR. HOW'R.	Partitions	1	120	15.5	0.75	9.69	Poplar.
	Bolsters for lower tier	1	54	10.	2.	7.50	"
	Props for upper tier	1	90	12.	1.	7.5	"
	Bolsters for canisters	1	8	10.	1.5	1.87	Oak.
24-PDR. HOW'R.	Partitions	1	96	15.5	0.75	7.75	Poplar.
		1	13	10.5	1.	0.94	"
		1	96	8.25	1.	5.5	"
	Linings	1	54	15.5	1.	5.81	"
32-PDR. HOW'R.	Partitions	1	108	16.	1.	12.	Poplar.
		1	60	8.5	1.	3.54	"

FIELD-TRAIN.

Ordnance.

The proportion of artillery to other troops varies generally between the limits of 1 and 3 pieces to 1,000 men, according to the force of the army, the character of the troops of which it is composed, the force and character of the enemy, the nature of the country which is to be the theatre of war, and the character and objects of the war.

Similar considerations must regulate the selection of the kinds of ordnance and the proportions of the different kinds in the train.

The following principles may be observed in ordinary cases:—

$$\text{2 pieces to 1,000 men.} \begin{cases} \frac{2}{3} \text{ guns, of which} & \begin{cases} \frac{1}{4} \text{ are 12-pdrs.} \\ \frac{3}{4} \text{ `` 6-pdrs.} \end{cases} \\ \frac{1}{3} \text{ howitzers, of which} & \begin{cases} \frac{1}{4} \text{ `` 24-pdrs. or 32-pdrs.} \\ \frac{3}{4} \text{ `` 12-pdrs.} \end{cases} \end{cases}$$

Distributed as follows:—

For the Infantry.—1 piece to 1,000 men; 6-pdr. guns and 12-pdr. howitzers, in batteries of foot artillery.

For the Cavalry.—2 pieces to 1,000 men; 6-pdr. guns and 12-pdr. howitzers, in batteries of horse artillery.

For the special and general parks of reserve:—

$$\text{1 piece to 1,000 men.} \begin{cases} \left. \begin{array}{l} \frac{1}{2} \text{ in 12-pdr. batteries} \\ \frac{1}{3} \text{ `` 6-pdr. ``} \end{array} \right\} \text{of foot artillery.} \\ \frac{1}{6} \text{ `` 6-pdr. batteries of horse artillery.} \end{cases}$$

Ammunition for Cannon.

200 rounds to each piece, both of the reserves and of the active batteries.

The ammunition which cannot be carried in the caissons attached to the pieces will be kept in boxes with the reserves.

Additional supplies of ordnance and ordnance stores are placed in convenient depots, according to circumstances.

Ammunition for Small Arms.

100 rounds to each man; of which, for the musket, 40 rounds are in the cartridge-box, 60 in the parks of reserve. In the same proportion for other small arms.

Percussion-caps in the proportion of 12 caps to 10 cartridges.

Composition of a Battery on the War Establishment.

Kind of Battery.			12-pdr.	6-pdr.
Guns	12-pounders, mounted		4	
	6-pounders, "		......	4
Howitzers	24-pounders, "		2	
	12-pounders, "		......	2
Total number of pieces			6	6
Caissons	for guns		8	4
	for howitzers		4	2
			12	6
Travelling-Forge			1	1
Battery-Wagon			1	1
Whole number of carriages with a battery			20	14
Ammunition	For 4 guns	Shot	448	400
		Spherical case	358	320
		Canisters	90	80
			896	800
	For 2 howitzers	Shells	168	120
		Spherical case	112	160
		Canisters	42	32
			322	312
Total number of rounds with a battery			1,218	1,112
Draught-Horses	6 to each carriage		120	84
	Spare horses, one-twelfth		10	7
Total			130	91

Note.—For two 32-pdr. howitzer-carriages and 4 caissons, the number of rounds of ammunition is

Shells	112
Spherical case	84
Canisters	14
Total	210

Harness, corresponding to the number of horses to the carriages.

Battery of Mountain-Howitzers.

Howitzers	6	
Gun-carriages	7	
Ammunition-chests	36	(48 rounds for each howitzer.)
Forge and tools, in 2 chests	1	
Set of carriage-maker's tools, in 2 chests	1	
Pack saddles and harness	33	
Horses or mules	33	

Such additional supplies of the above kinds as may be thought necessary will be carried with the park of reserve, together with the necessary ammunition for infantry, in packs.

A mountain-howitzer ammunition-chest will carry about 700 musket ball-cartridges.

Rocket-Battery.

No regular organization of a rocket-battery has been arranged.

The nature and number of rockets, and of carriages or conductors, will be determined by the character of the service for which they may be required.

The Field-Park.

The spare carriages, reserved supplies of ammunition, tools and materials for extensive repairs, and for making up ammunition, for the service of an army in the field, form the *Field-Park*, to which should be attached also the batteries of reserve.

The quantities of these supplies must depend in a great measure on the particular circumstances of the campaign.

The ammunition required for artillery and small arms, (according to the proportions above stated,) in addition to what can be carried by the batteries and the troops, will be carried with the park, in caissons, or in store-wagons.

The following carriages and stores, in due proportion, according to circumstances, will also form parts of the field-park, viz. :—

Spare gun-carriages, 1 to each field-battery.

Travelling-Forges, B. } One or more of each.
Battery-Wagons, D. }

Spare spokes, 50 to each battery. } In store-wagons.
Spare fellies, 20 to each battery. }
Spare harness } In boxes. }
Horseshoes and nails } In boxes. }

Gunpowder.	Friction-primers for cannon.
Saltpetre.	Stuff for cartridge-bags.
Sulphur.	Woollen yarn.
Charcoal.	Cotton yarn.
Laboratory-paper.	Glue.
Percussion-caps for small arms.	

SIEGE-TRAIN.

The number and kind of cannon for a siege-train must be determined by the circumstances of each case; but the following general principles may be observed in assigning the proportion of different kinds and calibres, and the relative quantity of other supplies, for a train of 100 pieces of ordnance.

Cannon.

GUNS..	24-pdr.	about one-half of the whole number	50
	18-pdr. or 12-pdr.	" one-tenth "	10
HOWITZERS, 8-in. siege		" one-fourth "	25
MORTARS...	10-in. siege	" one-eighth "	12
	8-in. siege	"	3
COEHORN MORTARS, in addition to the 100 pieces			6
WALL PIECES			40

Gun-Carriages.

For 24-pdr. guns and 8-in. howitzers,	one-fifth spare	90
For 18-pdr. and 12-pdr. guns	one-fifth spare	12
For 10-in. mortars	one-sixth spare	21
For 8-in. mortars		4

Other Carriages.

Mortar-Wagons.—1 for each 10-in. mortar and bed, and for three 8-in. mortars and beds	13
Wagons, for transporting implements, intrenching and miner's tools, laboratory tools and utensils, and other stores,—each loaded with about 2,700 lbs., say	140
Carts (carrying balls, &c. on the march)	50
Park Battery-Wagons, fully equipped	28
Park-Forges, fully equipped	8
Sling-Carts, large	5
Sling-Carts, hand	4

Draught-Horses.

For each Gun and howitzer, with its carriage	8
" Spare gun-carriage	6
" Mortar-wagon	8
" Battery-wagon	6
" Forge	6
" Cart	2

For each Sling-cart, large.. 2
Spare horses 1-10th

Total, about.......................... 1,900 horses.

Projectiles and Ammunition.

FOR GUNS.....	Round shot. 800 to each 24-pdr	40,000
	Round shot. 1,000 to each 18 and 12 pdr..................	10,000
	Grape and canisters strapped, 20 rounds to each piece	1,200
	Spherical case strapped, 20 rounds to each piece...	1,200
FOR HOWITZERS....	Shells, 800 to each 8-inch howitzer....................	20,000
	Canisters strapped, 5 to each............................	125
	Spherical case strapped, 20 to each....................	500
FOR MORTARS.	600 shells to each 10-inch................................	7,200
	800 " " 8-inch................................	2,400
	200 " " Coehorn................................	1,200

Gunpowder, in barrels..lbs. 500,000

Computing for each 24-pounder round shot, one-third the weight of shot.
" " 18 & 12 pdr. " one-fourth " "
" " grape, canister, and spherical case, one-sixth the weight of shot.
" " round of howitzer ammunition 5 lbs. } including charge of shell.
" " " 10-inch mortar........ 7 "
" " " 8-inch mortar........ 3 "
" " " Coehorn................ ½ "

Cartridge-bags, 1 for each round.
Cartridge-paper, bundles 200
Wads,—hay wads, made in the field.
Slow-match..lbs. 500
Portfires 200
Fuzes, ⅛ more than the number of shells.................................... 35,000
Wooden bottoms and tubs, for firing small shells.......................... 1,200
Friction-primers, for guns and howitzers, 1¼ to each round.
Cartridges for wall pieces, 500 rounds to each.
Cartridges, powder, percussion-caps, and lead, for small arms, according to the force of the army.
Most of the ammunition is transported by hired wagons.

Implements and Equipments.

FOR EACH GUN.

2 Sponges—1 spare.
2 Rammers—1 do.
1 Worm to 4 pieces.
1 Ladle "
8 Handspikes—2 spare.
1 Pass-box.
2 Tube-pouches.
1 Gunner's perpendicular to 16 pieces.
1 Vent-punch to 3 pieces.
2 Thumb-stalls.
2 Priming-wires—1 spare.
1 Gunner's gimlet.
1 Breech-sight.
1 Vent-cover.
1 Water-bucket.
1 Broom.
1 Tompion.
2 Chocks.
2 Lanyards for friction-primers.
1 Piece of chalk.
1 Wrench to 6 pieces.
1 Short roller.
1 Trace-rope.

FOR EACH HOWITZER AND MORTAR.

Implements.	Howitzer.	Mortar.
Sponges and rammers	2—1 spare	2—1 spare
Handspikes (2 shod, for mortar)	7—2 spare	6—2 spare
Haversacks	1	1
Tube-pouches	2	2
Thumb-stall	1	
Priming-wires	2—1 spare	2—1 spare
Vent-punch—to 3 pieces	1	1
Gunner's gimlet	1	1
Gunner's perpendicular—to 6 pieces	1	1
Quadrants	1	1
Fuze-setters	2—1 spare	2—1 spare
Fuze-mallets	2—1 spare	2—1 spare
Baskets	1	1
Chocks for wheels	2	
Maul	....	1
Loading-tongs	1	
Tompions	1	1
Vent-cover	1	1
Water-bucket	1	1
Broom	1	1
Breech-sight	1	
Lanyards for friction-primers	2	2
Plummets	....	1
Pointing-stakes	....	2
Pointing-cord	....	1
Quoins	....	2
Shell-hooks	....	2—1 spare
Scrapers	....	1
Spatulas	....	1
Gunner's sleeves (pair)	....	1
Grommet wad	1	
Wipers of tow linen	....	1
Chalk	1	
Hammer-wrench—to 6 pieces	1	

Scales and weights, or a spring balance, funnel, set of powder-measures of 3 sizes, and fuze-extractor, to each battery-magazine.

The number of implements must be proportioned to the whole number of gun-carriages, including the spare carriages.

One tar-bucket to each travelling carriage.

Platforms.

For guns and howitzers	1-10th spare.
For mortars	1-8th do.

Embrasure-Shutters.

For half the number of guns and howitzers.

Spare Parts of Carriages.

Proportion to the number of parts in the carriages:—

Pintles for siege-carriages		1-30th.
Nuts and washers, assorted		1-10th.
Linch-pins		1-5th.
Axle-trees		1-20th.
Wheels		1-15th.
Axle-washers	Shoulder	1-20th.
	Linch	1-10th.
Cap-squares		1-15th.
Poles, one-half ironed		1-4th.
Elevating-screws		1-8th.
Leading-bars, one-half ironed		1-8th.

Spare parts of field-carriages, as for field-batteries.

Timber and other Materials for Repairs.

Proportion to the number of parts that enter into the construction of the carriages:—

Axle-bodies for siege-carriages, 1-50th; Breech-bolsters, 1-20th; Cheeks, 1-30th; Fellies, 1-50th; Spokes, 1-30th; Fork-saddles, 1-30th; Poles, 1-20th; Hounds, 1-20th; Splinter-bars, 1-20th; Leading-bars, 1-10th, Square timber of various scantling—Plank—Wooden parts of mortar-wagons; of each 1-20th.

Bar-iron, assorted, 80 lbs. to a piece, 8,000 lbs.; Steel, 5 lbs. to a piece, 500 lbs.; Sheet iron, 50 sheets; Iron wire, 400 lbs.; Tin, 225 sheets; Nails, assorted, 300 lbs.; Screws, assorted, 5 groce.

Machines and Ropes.

7 Gins, with tackle, complete; 10 Lever-Jacks; 14 Screw-Jacks; 5 Lifting-Jacks; 20 Wheelbarrows, 1-5th for shells; 7 Hand-barrows; Balances,

for weighing; 10 Spare gin-falls; 75 Double prolonges; 75 Single prolonges; Drag-ropes, 200; $2\frac{3}{4}$-inch rope, 500 fathoms; Men's harness, 50; Small ropes, 200 lbs.; Twine, of various sizes, 50 lbs.

Tools.

Sets of carriage-maker's and blacksmith's tools:—Pioneer's tools, for the artillery alone, 40 to a piece, say 4,000; of which 1,600 spades, 270 shovels, 2,000 mattocks, 130 picks—Spare tool-handles, one-half.

Axes, 5 to a piece, 500; Bill-hooks, 2 to a piece, 200; Saws, various kinds, 100; 10-foot rods, 2-foot rules, mason's levels, 50 of each; Mauls, 200; Scythes, 8; Miner's tools; Baskets.

Laboratory Tools and Materials.

2 Sets of Laboratory tools. (See page 335.)

Nitre, pulverized..........	1,500 lbs.	Twine	50 lbs.
Sulphur, pulverized	100 "	Tarred rope-yarn	200 "
Charcoal, pulverized......	100 "	Copper wire...............	10 "
Sulphur, roll	100 "	Brass wire	10 "
Pitch	150 "	Cotton yarn................	25 "
Rosin..........................	150 "	Glue..........................	10 "
Beeswax	50 "	Wrapping-paper	10 reams.
Camphor.....................	20 "	Tar............................	2 barrels.
Spirits turpentine	10 gals.	Mealed powder	300 lbs.
Sperm-oil.....................	30 "	Quick-match..............	150 "
Linseed-oil	2 "	Torches......................	100 "
Tow—Tarred links—Rock-fire, etc.		Coal-tar.....................	1 barrel.

Implements for firing Hot Shot.

4 Sets. (See Chapter XIII.)

Instruments and Books.

2 Theodolites, or other instruments for measuring angles; 2 Levels and staves; 2 Compasses; 4 Surveying-chains; Diagonal scales; Cases of mathematical instruments; Spy-glasses; Thermometer; Barometer.

Books.—Ordnance Manual; Artillery for the land service; Tables of firing; Logarithmic tables; Drawing-paper.

Miscellaneous Supplies.

Smith's coal, 20 tons; Grease, 2,000 lbs., in 50-lb. kegs; Sand-bags, 500 to each piece of ordnance; Chevaux-de-frise; Scaling-ladders; Rampart-grates, 50; Tarpaulins, various sizes, 100; 2 Grindstones; Lanterns, 100; Sperm candles, 150 lbs.; Lamplighter's torches; Canvas; Friction-matches, in small tin cases.

ARMAMENT OF FORTIFICATIONS.

The kind and number of pieces of ordnance required for the armament of each of the fortifications are prescribed by the War Department, according to the character and extent of each work.

The carriages, ammunition, implements, equipments, and other supplies, for a fort placed on the war establishment, may be proportioned to the number of pieces on the following general principles, the application of which must, however, be regulated by the importance of the position and by the peculiar circumstances of each case.

Carriages.	For a front of attack.	For other land fronts and for sea-coast batteries.	
Gun-carriages. Casemate.....	......1-6th	1-10th.....	more than the number of pieces.
Gun-carriages. Barbette	......1-3d	1-20th.....	more than the number of pieces.
Gun-carriages. Siege	......1-3d.	1-10th.....	more than the number of pieces.
Gun-carriages. Field	......1-3d	....	more than the number of pieces.
Gun-carriages. Mortar-beds	......1-4th	1-10th.....	more than the number of pieces.
Trench-carts, for advanced works	1 to 20 pieces.		
Sling-carts	1 to 25 pieces.	1 to 25 pieces.	
Tumbrils or hand-carts..	1 to 20 pieces.	1 to 20 pieces.	
Caissons	1 to each field-piece.		
Forges, travelling (besides permanent forges)	1 to 30 pieces of all kinds.		
AMMUNITION.			
For each 10-in. columb.	400 rounds.		
For each gun and sea-coast howitzer and 8-in. columbiad.................	800 "	250 rounds.	1-20th Grape and canister.
For each 24-pdr. howitzer	100 "	100 "	1-2d Grape and canister.
For each siege-howitzer	600 "	200 "	1-20th Grape and canister.
For each 10-in. mortar...	400 "		
For each mortar	....	200 "	
For each 8-in. mortar, and Coehorn	600 "		

Rampart grenades, 300 to a front of attack.

For each piece of artillery of a field-battery for sorties, 200 rounds.

Gunpowder.—The quantity of cannon-powder may be calculated on the following principles:

For each charge of a gun—$\frac{1}{4}$ of the weight of the shot.

" " 10-inch columbiad, 15 lbs.

For each charge of an		8-inch columbiad,	10 lbs.		
"	"	24-pdr. howitzer,	2 "		
"	"	8-inch siege-howitzer,	4 "		
"	"	10-inch sea-coast "	12 "		
"	"	8-inch " "	8 "		
"	"	10-inch mortar, light,	7 "	including the charge of the shell.	
"	"	10-inch " heavy,	15 "		
"	"	8-inch "	3 "		
"	"	13-inch "	30 "		
"	"	Coehorn "	$\frac{1}{2}$ "		

To spare: for mining, fireworks, and waste, $\frac{1}{10}$ of the whole, including a proportion of mealed powder and its components, pulverized.

Fuzes, $\frac{1}{6}$ more than the number of shells.

Slow-match, 4 lbs. to a piece.

Cannon cartridge-paper, 1 sheet to a round.

Sabots.

Wooden bottoms for mortars firing grenades.

Portfires, 1 to 200 rounds.

Friction-primers, $1\frac{1}{4}$ the number of rounds.

Small Arms.

Muskets	$\frac{1}{3}$	more than the number of troops of the several kinds supposed to be fully armed and equipped.
Pistols	$\frac{1}{8}$	
Artillery and infantry swords	$\frac{1}{25}$	
Cavalry sabres	$\frac{1}{5}$	

Wall pieces—50 to a front of attack, or a front exposed to escalade.

Ammunition.—Musket cartridges, for each man 400

Musketoon, pistol, and rifle cartridges 100

Cartridges for each wall piece 400

Spare powder for small arms, $\frac{1}{25}$ of the whole quantity required for the cartridges. Cartridge-paper in proportion.

Percussion-caps, in addition to those packed with the cartridges, $\frac{1}{4}$ the number of rounds.

Implements and Equipments.

FOR EACH GUN.

2 Rammers—1 spare.
2 Sponges— 1 "
1 Worm, } to 6 pieces.
1 Ladle, }
1 Gunner's perpendicular, to 6 pcs.
1 Pass-box.
1 Budge-barrel.
2 Tube-pouches.
2 Thumb-stalls—1 spare.
2 Priming-wires—1 "
1 Gunner's gimlet.
1 Vent-pouch, to 3 pieces.
1 Breech-sight.
1 Vent-cover.
2 Lanyards for friction-primers.
1 Water-bucket.
1 Tompion.
1 Chalk-line and chalk
1 Broom.
1 Wrench to 6 pieces

FOR EACH HOWITZER.

The same as for a gun, omitting *pass-box*, and adding:
1 Haversack.
1 Fuze-setter.
1 Fuze-mallet.
1 Fuze-extractor, to 6 pieces.
1 Quadrant.

FOR EACH COLUMBIAD.

The same as for a howitzer, adding, for those of model 1844,
1 Woollen sponge, of the diameter of the bore, to 3 guns.

FOR EACH MORTAR.

1 Sponge and rammer.
6 Handspikes—4 shod.
1 Haversack.
1 Tube-pouch.
2 Priming-wires.
1 Vent-punch, to 3 pieces.
1 Gunner's gimlet.
1 Quadrant.
1 Plummet.
2 Pointing-stakes.
2 Quoins.
1 Tompion.
2 Lanyards for friction-primers.
1 Pair shell-hooks.
1 Scraper.
1 Spatula.
1 Pair gunner's sleeves.
1 Wiper.
1 Fuze-setter.
1 Mallet.
1 Fuze-saw.
1 Fuze-extractor, to 6 mortars.
1 Basket.
1 Broom.
1 Tarpaulin.

FOR EACH 24-PDR. HOWITZER FOR FLANK DEFENCE.

2 Rammers and sponges—1 spare.
2 Sponge-covers— 1 "
1 Roller-bar.
2 Manœuvring-handspikes.
1 Gunner's haversack.
1 Budge-barrel.
2 Tube-pouches.
2 Thumb-stalls—1 spare.
2 Priming-wires—1 spare.
1 Gunner's gimlet.
1 Breech-sight.
2 Lanyards for friction-primers.
1 Water-bucket.
1 Fuze-cutter.
1 Vent-punch.
1 Vent-cover.
1 Tompion and strap.
1 Broom.

FOR EACH CASEMATE-CARRIAGE, (wooden, including the spare carriages,) 2 truck-bars; 2 chocks; 1 broom.

FOR EACH BARBETTE-CARRIAGE, (wooden,) 2 manœuvring-handspikes; 1 tarpaulin, or other cover; 1 platform and 1 maul; if the platform be not permanent.

FOR EACH IRON CARRIAGE, 2 manœuvring-bars; 2 pinch-bars; 1 manœuvring-handspike; 2 wrenches; 1 elevating-bar for columbiads.

FOR EACH SIEGE-CARRIAGE, 4 handspikes; 1 maul; 1 platform.

FOR EACH COLUMBIAD BARBETTE-CARRIAGE, (wooden,) 4 truck-bars; 2 manœuvring-bars; 1 elevating-bar.

Spare Parts for Repair of Carriages.

Proportion of the number of spare parts to that of similar parts which belong to the carriages:—

Forks for traversing wheels of barbette-carriages		1-20th.
Pintles for siege-carriage limbers		1-30th.
Pintles for casemate-carriages		1-20th.
Linch-pins		1-5th.
Axle-trees	for siege-carriages	1-20th.
	for barbette-carriages	1-40th
	for casemate-carriages	1-40th.
Rollers for casemate-carriages		1-40th.
Bolster-plates, for pintles not permanently fixed		1-40th.
Wheels	for siege-carriages	1-15th.
	for barbette upper carriages (including rollers)	1-20th.
	for casemate "	1-40th.
	for barbette-chassis	1-40th.
	for casemate-chassis	1-40th.
Axle-washers,	shoulder	1-20th.
	linch	1-10th.
Poles, for siege-carriage limbers, one-half ironed		1-4th.
Elevating-screws		1-8th.
Tongues (iron) for casemate-carriages		1-10th.
Nuts, assorted		1-10th.

Timber and other Materials for Repairs.

Cheeks, stocks, naves, spokes, fellies, for siege-carriages, of each 1-20th; cheeks of mortar-beds, 1-12th. Handspikes, 4 to a piece; tool-handles, ½; sets of timber for barbette-carriages, 1-20th; ditto, casemate, 1-40th; iron, assorted, 50 lbs. to each piece; nails and screws, assorted, 100 to each piece; steel, 1 lb. to each piece; sheet iron, 6 square feet to each piece; tin, 5 sheets to each piece; spare parts for small arms, see Chapter VIII.

Machines, Ropes, etc.

Gins, casemate and rampart, as may be required, according to the extent of the fort; screw-jacks, capstans, lever-jacks, wheelbarrows, 1 to each piece; hand-barrow, for shells, 1 to each mortar; sling hand-barrow, or frame hand-barrow with legs, 1 to 6 guns and howitzers; platform balance, or scales and weights; gin-falls, 1-5th spare; double prolonges, 2 to each gin; drag-ropes, 2¼-inch rope, small rope, 5 lbs. to a piece; handspikes, 7 feet long; skids, blocks, rollers.

Tools.

Sets of carriage-maker's, smith's, and armorer's tools; intrenching and miner's tools, saws, levels, pavior's rammers; 10-foot rods; 2-foot rules; the number of each kind to be regulated by the particular circumstances of each case.

Tools and Materials for Fireworks.

(See Chapter X.)

Laboratory tools and materials, according to the extent and resources of the fort. See the proportion of those for a siege-train.

For each night of a siege, or for each night on which the guns will probably be served, have 6 tarred links to each piece mounted on the ramparts of a front of attack, or of a sea-coast battery, and 5 fire-balls for a front of attack.

Signal-rockets, torches, rock-fire, &c., according to circumstances.

Instruments, Books, and Stationery.

According to the character and extent of the fort.—See *Siege-Train.*

Miscellaneous Supplies.

Timber, plank, and boards; wood for sabots, fascines, gabions, etc. Pickets; coal, 5 tons to a forge; grease, grindstones, rampart-grates, 2 to each piece on the ramparts; sand-bags, for the batteries of the front of attack; lantern, 1 to each piece; candles, oil, fire-engine and buckets.

Field-pieces forming a part of the armament of a fortification should be provided with their caissons, ammunition, etc., as for service in the field.

CHAPTER TWELFTH.

MECHANICAL MANŒUVRES.

The introduction here of a few of the most common mechanical manœuvres with heavy guns, for mounting and dismounting, etc., it is believed, will prove convenient. For full directions for the manœuvres of heavy ordnance, see "Heavy Artillery."

Knots, and the Manner of Tying them. (Plate 33.)

Loop.—Bend the rope so as to bring the branches near to each other, without crossing them.

Half-hitch.—Bend the rope, crossing one branch over the other.

Simple Knot.—Form a half-hitch; turn one end around the other, passing it through the half-hitch; close it by drawing the two ends.

Simple Draw-knot, or Bow-knot.—Form a half-hitch; make a loop with one end; turn this loop around the other part, so as to pass it in the half-hitch; close it.

Galley Knot.—Form a simple draw-knot; pass a lever in the loop, and close it.

Square Knot.—1*st Method:* Cross the ends of the rope, say, the right end over the left; turn the left end around the right branch from above downward, and from within outward; bend the left end, forming a loop with it; turn the right end around the left, and pass it in the loop from below upward; close it.

2d Method: Make a loop with one end; pass the other end through the loop, and take a turn around the two branches that form the loop, beginning with the long one; pass it again through the loop, and close it.

That the knot may not slip, the two ends of the rope should separate, one to the right, the other to the left, but both in front or both behind.

Draw Square-knot.—Make an ordinary square-knot, but with the end passed in the loop to complete the knot; form a second loop, and pass it through the first; close it.

Weaver's Knot.—Form a loop with one end; pass the other end through the loop, and take a turn around the two branches forming the loop,—first around the long one,—and pass it between the loop and that part already passed through the loop; close it.

German Knot.—Form a half-hitch; turn the free end around the standing part; cross the free end on itself, and pass it through the half-hitch.

Artificer's Knot, or two Half-hitches.—*1st Method:* Make two half-hitches near to each other, but in contrary directions; that is, if the free end of one half-hitch cross *above* that part of the rope which is between the half-hitches, the free part of the other half-hitch must cross *under*; place these two half-hitches one on the other, so that the ends shall be on the inside; put the half-hitches over the end of the object to which the rope is to be fastened, and close it.

2d Method: To fasten a rope to a picket, keeping it stretched, take a turn around the picket with the free end, and bring it back under the standing part; take a second turn above the first with the same end, passing the free end between the last turn and the fixed part; close it by drawing on the free end.

3d Method: Form a half-hitch, with the free end beneath; place it over the head of the picket; form a second half-hitch, the free end beneath; place it over the picket, above the first; close it.

Magnus Hitch.—Take a turn around the picket with the free end, and bring it back above the standing part; take a second turn with the same end, and bring it back under the standing part; make with this end a half-hitch, the free end being underneath; place this half-hitch over the picket; close it by drawing on the free end.

This knot differs from the artificer's knot, by having *three* turns around the picket, instead of *two*.

Mooring Knot, with Half-hitches.—To fasten a rope to a picket by half-hitches, take two turns around the picket, and bring the free end back along the standing part; take a turn with the free end around tne standing part, and pass it through the half-hitch thus formed; make a second half-hitch by crossing the free end again over the standing part, and passing the free end through the half-hitch; tie the end to the standing part with lashing-cord, if necessary.

Rolling Hitch.—To tie a rope to another which is stretched, cross the end of the free rope on the stretched one, and take a turn around it from above downward, and bring back this end in the acute angle formed by the two ropes; take a second turn in the same manner; make a half-hitch with the free end around the stretched rope, and then a second half-hitch above the turns already formed; tie the end to the rope with lashing-cord.

Anchor Knot.—To fasten a rope to a ring, pass the rope through the ring twice; make a half-hitch around the standing part and the part forming the second turn; make a second half-hitch below the first; tie the short end to the standing part, if necessary.

Capstan Knot.—To fasten the gin-fall, for instance, to the handles of a gun, make a half-hitch by crossing the free end on the part coming from the head of the gin; pass the free end through the handles and through the half-hitch from beneath upward; pass the end around the standing part, turning it between the standing part and the part leading to the handle; pass it in the loop from above downward; draw it close.

CROWN.—Take the rope and form a coil of the size required, and with the free end wrap the several strands forming the coil, and fasten the two ends by a square knot.

SHORT SPLICE.—Unlay about one foot of the ends of the two ropes, A and B, that are to be spliced; bring the ends together, so that the strands of one rope shall be between those of the other. Holding the rope A in the left hand, for instance, cross each strand of this rope over the strand of the other that is to its left, and pass each strand of the rope A, by means of a marline-spike, under the strand B to the left of that which it crossed; draw hard on each strand thus *served;* do the same thing with the strands of the rope B. To give greater strength to the splice, pass again each strand over that to its left and under the one to the left of this last: cut off the projecting ends. This splice will not pass through the throat of the pulley.

LONG SPLICE.—Unlay about 20 inches of each rope; bring them together as in the short splice; unlay one of the strands of A, and replace it by the corresponding strand of B; cross the end of this last strand over the replaced strand, and pass them, each on its own side, under the adjoining strands; replace, in the same way, each strand of one rope by one of the other, and secure them two and two, as has just been explained, at different places in the splice; cut off the projecting ends. The long splice will pass through the throat of the pulley.

To Slew a Gun.

Chock the gun on the side to which it is to be turned; pass a trunnion-loop over one of the trunnions, run a handspike through it, and turn the gun in its place.

To Move a Gun by Rolling it.

Place a skid under the middle of the reinforce, and another under the middle of the chase, and roll the gun over.

By inclining the skids and cutting the muzzle, it may be moved in different directions.

In rolling heavy guns, it is most convenient to use two collars of wood or cast iron, of equal diameters, (one on the breech, the other on the muzzle,) large enough to allow the trunnions to turn without striking the ground.

To Transport a Field-Piece by means of a Limber.

Detach the prolonge; place the limber over the piece, so that the pintle-hook shall be over the handles, (or over the rear of the trunnions,) with the breech toward the pole: run a handspike into the bore and raise the chase; lash the piece to the pintle-hook with the prolonge, by passing the ring of the prolonge twice through the handles (or around the piece in rear of the trunnions) and over the pintle-hook.

With the loose end of the prolonge, lash the cascable to the fork of the limber.

The gun may be placed on blocks at the proper height, and then lashed to the limber as before.

To Shift a Gun from the Trunnion-Holes to its Travelling-Bed.

Limber up; remove the cap-squares and chock the wheels front and rear; place the short roller under the reinforce; attach the trace-rope at its middle to the cascable by two half-hitches; cross two handspikes under the one in the bore; lift and push at the muzzle and haul on the rope until the trunnions are over their travelling-position; raise the chase, bring forward the roller to the head of the stock, and lower the chase upon it; raise the chase again; remove the roller, and lower the chase upon the stock; take off the rope; replace the cap-squares; insert the elevating-screw from below, and lash it.

With the Lifting-Jack.—Place the jack under the swell of the muzzle; raise the chase; place a half-block on the head of the stock; take a second lift, and place two rollers on the stock, one just in rear of the trunnion, the other under the reinforce; chock the latter toward the muzzle, and remove the half-blocks; haul on the rope attached to the cascable, and bring the breech over the bolster; chock the rear roller; place the jack under the muzzle, and remove the rollers.

To Shift a Gun from its Travelling-Bed to the Trunnion-Holes.

Chock the wheels front and rear; remove the cap-squares; raise the chase and insert the short roller under the trunnions; attach the rope by its middle to the cascable; bear down the muzzle, and, as the piece rolls forward, guide the trunnions into their holes by means of the rope; remove the short roller.

A howitzer is shifted to and from its travelling-bed by the same means, except that the handspike in the bore is chocked above and below for raising the chase, the lower chock being placed about 18 inches in the bore. The vertical diameter of the short roller should be just forward of the rimbases.

MANŒUVRES WITH GINS.

IMPLEMENTS.—2 *gin-handspikes*; 1 *gin-fall for siege-gin*, 4-inch rope, 90 feet long; 1 *gin-fall for casemate or garrison gin*, 5-inch rope, 120 feet long; 1 *trace-rope*, 2.25 inches round, 30 feet long; 2 *lashing-ropes*, 12 feet long; 1 *hammer*.

To Put the Field or Siege Gin together.

Lay the legs on the ground, outer sides down, in position to receive the sheaves, braces, windlass, and pry-pole. Put these in place, and key the braces.

To Reeve the Fall.

Raise the pry-pole; run one end of the fall through the left sheave from below; pass it through the pulley which is hooked to the middle brace, and thence through the right sheave, securing it to the pulley or to the middle brace.

To Raise the Field-Gin.

One man places his foot on the lower brace, holds the feet of the gin in place, and steadies the pry-pole. Six men seize the legs and raise the gin.

To Move the Field-Gin when Raised.

Place four men at the ends of two handspikes run under the windlass, and two men at the handles of the pry-pole, and move the gin. The gin is lowered in a manner similar to that prescribed for raising it.

To Put a Casemate or Garrison Gin together.

The legs or pry-pole are laid on the ground or across the gun-carriage, inner sides down and upper ends together, to receive the clevis and bolt. The windlass, braces, and clevis and holt are then put in their proper places and secured. The gin is then raised by moving up the legs and pry-pole toward each other.

To Reeve the Fall of a Casemate or Garrison Gin.

Fasten one end of the trace-rope to the upper block, pass the other end through the clevis, and thence round the windlass. Heave upon the windlass, raise the block, and hook it in the clevis. Reeve the fall as described for the field-gin.

To Lower the Casemate or Garrison Gin.

Draw out gradually the legs and pry-pole until the men can get near enough to the head to support it. Lower it upon the piece or upon the ground.

To Move the Casemate or Garrison Gin.

Lash the pry-pole to the upper brace to keep the gin from spreading Four men lay hold of each leg aud move them; then move the pry-pole.

To Mount a Piece by Means of a Gin.

Place the gin with its pulleys directly over the trunnions, and the foot of the pry-pole about thirteen feet from the lower brace. Remove the cap-squares, run a handspike into the bore, fasten the sling to it and over the cascable, and hook the pulley to it, just in rear of the trunnions. Steady the gun with the handspike in the bore, pass the running end of the fall from the outside under the windlass, and take three turns with it from the right to the left around the left of the windlass, and hold fast to the end of the rope. Work the windlass and raise the gun to the required height. Bring up the carriage until the trunnion-holes are directly under the trunnions. Slack off the fall slowly, and let the trunnions descend into their holes. Put on the cap-squares.

REMARK.—The piece may be slung with a short piece of rope passed around each trunnion, and the ends fastened together on the top of the piece; or the trunnion-rings may be put on. Hook the pulley to this sling, or to the trunnion-rings, bear down with one or two men on the handspikes in the bore to balance the piece, and raise it to the proper height. Place a handspike in the trunnion-holes, and a block on the stock to receive the breech. Lower the gun, the trunnions directly over the trunnion-holes, until it rests upon the handspike. Remove the sling from the trunnions, and run the carriage, with the gun on it, back until the heads of the cheeks are in rear of a perpendicular let fall from the head of the gin. Pass the sling around the chase, hook the pulley to it, and work the gin to relieve the weight on the handspike. Remove it, and lower the trunnions into their places. Bear down the muzzle, and remove the block from under the breech.

To Dismount a Piece by Means of a Gin.

Place the gin as for mounting the gun, remove the cap-squares, put on the sling, raise the gun out of the trunnion-holes, run out the carriage, and slack off gradually to lower the gun to the ground.

To Shift the Fall.

Overhaul the loose end of the fall, and make a double hitch with it around the leg of the gin below the lower cross-bar, passing the end inside of the windlass and braces to a man mounted on the windlass, who makes with it a rolling hitch on the standing part of the fall near the upper brace. Slack off until the weight bears on the end of the fall, and slip the rope to the other end of the windlass; or the standing part of the fall may be lashed to the leg above the windlass with a small rope.

To Mount a Gun on a Casemate-Carriage.

Traverse the carriage to one side; place the gun on blocks, or on the truck, near the middle of the casemate, the muzzle toward the embrasure, and the gin over the gun and carriage; the latter on the side of the pry-pole. Sling the gun, and work the gin until the gun is raised sufficiently high to traverse the chassis under it; place the carriage so that the trunnion-holes come exactly under the trunnions; lower the gun into its place; remove the sling, and take away the gin.

To prevent the pavement from being injured by the points, a truck-wheel, or a piece of 3-inch plank, with a hole to receive the point, is placed under each foot.

To dismount a piece, proceed in the inverse manner.

To Lower a Barbette-Carriage from its Chassis, the Piece being Mounted.

Place the piece in battery, the limber accurately in the prolongation of its axis, about six yards to the rear. Chock the rollers; place wheel-chocks upon the rails, near the manœuvring-staples, to serve as fulcrums; embar under the staples. Insert a handspike in the bore to bear down with. Raise the trail and put blocks on the tongue under and perpendicular to the transom and axle-tie. Raise the rear of the chassis; remove the traverse-wheels, and lower the chassis upon the traverse-circle. Form scaffolds one block and a half high on each side of the carriage, under and perpendicular to the chassis, about four inches in rear of the middle transom, and place the planks on them, their inner edges against the rails of the chassis, and their front ends about eight inches in front of the scaffolds, bevelled sides up. Back the limber upon the planks; raise the pole to engage the pintle in the lunette, and then bear down the pole; remove the blocks from under the trail, and key the pintle. Unchock the wheels, and run the piece carefully down the planks to the terre-plein.

To Mount the Barbette-Carriage upon its Chassis.

Lower the rear of the chassis upon the traverse-circle, and place the piece, limbered, accurately in the prolongation of the tongue, about six yards to the rear. Place the planks in position. Embar with two handspikes through the wheels near the tire under the front manœuvring-bolts; embar with two handspikes, in a similar way, over the rear manœuvring-bolts, and with two more under the wheels; guide the pole; heave upon the handspikes and at the limber-wheels, and back the carriage up the planks into battery; chock the wheels; raise the trail and place a block under and perpendicular to the transom and axle-tie; raise the pole to disengage the pintle from the lunette; remove the limber and planks;

raise the rear of the chassis; replace the traverse-wheels and prop, and remove the block from under the transom and axle-tie.

To Grease the Rollers of a Barbette-Carriage, the Piece being Mounted.

Run the piece from battery; place a half-block lengthwise on the chassis-rail in front, and another in rear of the roller to be greased, with a wheel-chock upon each to serve as a fulcrum. Embar on them and under the front and rear manœuvring-bolts; raise the roller from the rail; move it about six inches; grease the spindle, and return the roller to its place. Unbar, and put on the wheel.

To Grease the Forks of the Traverse-Wheels.

Raise the rear of the chassis; remove the nuts of the fork-bolts with a wrench; take out the bolts and grease them.

REMARK.—The iron gun-carriages have holes for oiling the truck-wheel, traverse-wheels, and axle-boxes.

To Sling a Gun, Howitzer, or Mortar on the Cart.

Back the cart over the piece, the pole toward the breech, and the axle-tree directly over the trunnions; chock the wheels. Fasten the middle of the prolonge to the end of the pole, and carry one end of it to the rear of the cart; raise the pole by hand and by means of the prolonge until it is nearly vertical, and steady it. Lay the middle of the sling-chain over the piece; carry each end around the trunnions, from the rear to the front, and hook them to the axle-hooks, being careful to take up all the slack. Haul upon the prolonge until the end of the pole can be reached by hand; seize and bear it to the ground; hook the cascable-chain around the cascable in such a manner that the piece will swing level when the pole is horizontal. Raise the pole until it rests on the pole-prop. By putting blocks under the piece, and repeating the operation, the piece may be raised higher.

To Lower the Piece.

Bear the end of the pole to the ground; unhook the cascable-chain, and allow the pole to rise gently until it is nearly vertical. If the piece do not rest upon the ground, it must be blocked up and unslung. The operation is repeated and the piece is lowered to the ground. Ease the pole down carefully.

To Sling a Mortar mounted on its Bed.

Back the sling-cart over the mortar, the pole toward the breech, and the axle-tree directly over the trunnions; raise the pole vertically; pass the sling-chain around the front manœuvring-bolts; hook it over the axle-hooks, and haul down the pole. Block up the front of the bed; take off the sling-chain, and pass it under the bed just in front of the cap-square bolts; bear the pole down to the ground; remove the blocks; pass another sling-chain around the rear manœuvring-bolts and over the pole, and hook it in such a manner that the bed will be level when the pole rests on the pole-prop.

Sea-coast mortars and their beds must be slung separately. The sling-chain is passed through the clevis of the mortar and over the axle-tree, and hooked around the pole at its junction with the axle, the pole having been raised vertically.

To Sling a Piece on Two Limbers so that it may be transported with Horses.

Place blocks under the chase and reinforce; remove the pole of one of the limbers, and run it over the piece until the pintle is over the knob of the cascable; raise the muzzle and slip the front block under the trunnions; bear down the muzzle, and fasten the pintle to the cascable with the chain or lashing-rope; bear down the fork to the piece and lash it around the reinforce. Back the other limber over the neck of the piece; raise the pole, and attach the neck to the limber by taking two turns with the prolonge around the pintle, and two turns over the fork in front of the axle-tree. Raise the piece by bearing on the pole.

To Mount a Gun on an Iron Carriage.

A simple and expeditious method of mounting a gun upon an iron casemate-carriage consists in raising the gun upon two scaffolds, and assembling the chassis and top carriage in position under the gun.

To do this, place the gun with its muzzle toward the embrasure and its axis perpendicular to the middle of the face of the wall; raise the muzzle and the breech alternately by means of the lifting-jack, supporting the gun on two scaffolds of blocks, placed in front and in rear of the trunnions; assemble the chassis in position; place one cheek of the top-carriage on the chassis-rail, with the trunnion-hole directly under the trunnion, and bolt the transoms to it; place the other cheek in position and bolt it to the transoms. Lower the trunnions into their holes, and remove the blocks.

The blocks for the scaffolds should be about three inches shorter than the distance between the rimbases of the gun, and not less than fifteen inches wide. They should be two inches, four inches, and eight inches thick. Neither the muzzle nor the breech should be raised more than four inches by a single lift. As soon as the gun has been raised high enough to allow it, the chassis should be put in place and assembled. Care must be taken to build the scaffolds so as not to let them interfere with the transoms in assembling the carriage.

To Dismount the Gun.

Raise the breech and build a scaffold under it, as in mounting the gun; raise the muzzle with a jack, and build a scaffold under the chase; take the cheeks apart and remove them; lower the gun until its under-surface is nearly down to the chassis; take the chassis apart, remove it, and lower the gun upon two blocks.

To Mount or Dismount a 15-*inch Gun.*

Place the chassis on the platform, and roll the gun on skids upon it, placing the axis of the gun in the vertical plane of the axis of the chassis. Place a gin over the muzzle and another over the cascable, and, by means of them and the lifting-jack, raise the muzzle and the breech, alternately, supporting them upon scaffolds. When the gun has been raised to the proper height, place the cheeks of the top-carriage upon the chassis-rails, and proceed as in mounting a smaller gun.

To dismount a gun, proceed in the inverse manner.

CHAPTER THIRTEENTH.

ARTILLERY PRACTICE.

The plan of this work does not include the details relative to the servioe of artillery; but, in the absence of more full and accurate tables of firing, it is thought useful to give here the mean results of such trials of the ranges of our ordnance as have been made from time to time by the Ordnance Department, together with some other practical information derived from authentic sources.

Ranges.

The range of a shot or shell is the first graze of the ball on horizontal ground, the piece being mounted on its appropriate carriage.

The range of a spherical case shot is the distance at which the shot bursts near the ground, in the time given; thus showing the elevation and the length of fuze required for certain distances.

KIND OF ORDNANCE.	Powder.	Ball.	Elevation.	Range.	Remarks.
	Lbs.		° ′	Yards.	
6-PDR. FIELD-GUN.	1.25	Shot.	0	318	
		"	1	674	
		"	2	867	
		"	3	1138	
		"	4	1256	
		"	5	1523	
	1.25	Sph. case shot.	1 0	600	Time 2 seconds.
			1 45	700	" 2¾ "
		"	2 0	800	" 3 "
		"	2 45	900	" 3¼ "
		"	3 0	1000	" 3¾ "
		"	3 15	1100	" 4 "
		"	4	1200	" 5 "
12-PDR. FIELD-GUN, Model 1841.	2.5	Shot.	0	347	
		"	1	662	
		"	1 30	785	

Ranges.—Continued.

KIND OF ORDNANCE.	Powder.	Ball.	Elevation.	Range.	Remarks.
	Lbs.		° ′	Yards.	
12-PDR. FIELD-GUN, Model 1841.—Continued.	2.5	Shot.	2	909	
		"	3	1269	
		"	4	1455	
		"	5	1663	
	2.5	Sph. case.	1	600	Time, 1¾ seconds.
		"	1 45	700	" 2½ "
		"	2	800	" 2¾ "
		"	2 15	900	" 3 "
		"	2 30	1000	" 3¼ "
		"	3	1100	" 4 "
		"	3 30	1200	" 4½ "
12-PDR. FIELD-GUN, Model 1857.	2.5	Shot.	0	325	
		"	1	620	
		"	2	875	
		"	3	1200	
		"	4	1320	
		"	5	1680	
	2.5	Sph. case shot.	0 30	300	Time, 1 second.
			1 0	575	" 1¾ seconds.
		"	1 30	633	" 2½ "
		"	2 0	730	" 3 "
		"	3 0	960	" 4 "
		"	3 30	1080	" 4¾ "
		"	3 45	1135	" 5 "
	2.0	Shell.	0	300	" 0¾ "
		"	0 30	425	" 1¼ "
		"	1	616	" 1¾ "
		"	1 30	700	" 2¼ "
		"	2 0	787	" 2¾ "
		"	2 30	925	" 3½ "
		"	3 0	1080	" 4 "
		"	3 45	1300	" 5 "
12-PDR. FIELD-HOWITZER.	1.	Shell.	0	195	
		"	1	539	
		"	2	640	
		"	3	847	
		"	4	975	
		"	5	1072	
	0.75	Sph. case.	2 15	485	Time, 2 seconds.

Ranges.—Continued.

KIND OF ORDNANCE.	Powder.	Ball.	Elevation.	Range.	Remarks.
	Lbs.		° ′	Yards.	
12-PDR. FIELD-HOWITZER.—Continued.	0.75	Sph. case.	3 15	715	Time, 3 seconds.
		"	3 45	1050	" 4 "
12-PDR. MOUNTAIN-HOWITZER.	0.5	Shell.	0	170	
		"	1	300	
		"	2	392	
		"	2 30	500	Time, 2 seconds.
		"	3	637	
		"	4	785	" 3 "
		"	5	1005	
	0.5	Sph. case.	0	150	
		"	2 30	450	Time, 2 seconds.
		"	3	500	
		"	4	700	" 2¾ seconds.
		"	4 30	800	" 3 "
24-PDR. FIELD-HOWITZER.	2.	Shell.	0	295	
		"	1	516	
		"	2	793	
		"	3	976	
		"	4	1272	
		"	5	1322	
	2.5	Sph. case.	1 30	600	Time, 2 seconds.
		"	2 0	700	" 2½ "
		"	2 30	800	" 3¼ "
		"	2 45	900	" 3½ "
		"	3 15	1000	" 4 "
		"	3 45	1100	" 4½ "
		"	3 50	1200	" 4¾ "
32-PDR. FIELD-HOWITZER.	2.5	Shell.	0	290	
		"	1	531	
		"	2	779	
		"	3	1029	
		"	4	1203	
		"	5	1504	
	3.25	Sph. case.	1 30	600	Time, 2 seconds.
		"	2 0	700	" 2½ "
		"	2 15	800	" 3 "
		"	2 45	900	" 3½ "
		"	3 0	1000	" 3¾ "
		"	3 35	1100	" 4¼ "
		"	3 45	1200	" 4¾ "

Ranges.—Continued.

Kind of Ordnance.	Powder.	Ball.	Elevation.	Range.	Remarks.
	Lbs.		° ′	Yards.	
18-PDR. SIEGE AND GARRISON GUN. On barbette-carriage.	4.5	Shot.	1	641	
		"	2	950	
		"	3	1256	
		"	4	1450	
		"	5	1592	
24-PDR. SIEGE AND GARRISON GUN. On siege-carriage.	6.	Shot.	0	412	
		"	1	842	
		"	1 30	953	
		"	2	1147	
		"	3	1417	
		"	4	1666	
		"	5	1901	
32-PDR. SEA-COAST GUN. On barbette-carriage.	6.	Shot.	1 45	900	
	8.	"	1	713	
		"	1 30	800	
		"	1 35	900	
		"	2	1100	
		"	3	1433	
		"	4	1684	
		"	5	1922	
42-PDR. SEA-COAST GUN. On barbette-carriage.	10.5	Shot.	1	775	
		"	2	1010	
		"	3	1300	
		"	4	1600	
		"	5	1955	
8-INCH SIEGE-HOWITZER. On siege-carriage.	4.	Shell, 45 lbs.	0	251	
			1	435	
		"	2	618	
		"	3	720	
		"	4	992	
		"	5	1241	
		"	12 30	2280	
8-INCH SEA-COAST HOWITZER. On barbette-carriage.	4.	Shell, 45 lbs.	1	405	
			2	652	
		"	3	875	
		"	4	1110	
		"	5	1300	
	6.	"	1	572	
		"	2	828	

Ranges.—Continued.

KIND OF ORDNANCE.	Powder.	Ball.	Elevation.	Range.	Remarks.
	Lbs.		° '	Yards.	
8-INCH SEA-COAST HOWITZER. On barbette-carriage—Cont'd.	6.	Shell, 45 lbs.	3	947	
		"	4	1168	
		"	5	1463	
	8.	"	1	646	
		"	2	909	
		"	3	1190	
		"	4	1532	
		"	5	1800	
10-INCH SEA-COAST HOWITZER. On barbette-carriage.	12.	Shell, 90 lbs.	1	580	
		"	2	891	Time, 3 seconds.
		"	3	1185	" 4 "
		"	3 30	1300	
		"	4	1426	" 5¼ "
		"	5	1650	" 6 "
8-IN. COLUMBIAD.*	10.	Shell, 50 lbs.	1	681	Time, 1.88 seconds
		"	2	1108	" 3.58 "
		"	3	1400	" 4.30 "
		"	4	1649	" 5.41 "
		"	5	1733	" 6.25 "
		"	6	1994	" 7.56 "
		"	7	2061	" 7.96 "
		"	8	2250	" 9.12 "
		"	9	2454	" 10.16 "
		"	10	2664	" 10.91 "
		"	11	2718	" 11.3 "
		"	12	2908	" 13. "
		"	13	3060	" 14.08 "
		"	14	3123	" 14.25 "
		"	15	3138	" 16. "
		"	20	3330	" 18.40 "
		"	25	3474	" 20. "
		"	30	3873	" 25. "
		Shot.	5	1697	" 6.20 "
		"	15	3224	" 14.19 "
10-IN. COLUMBIAD.*	15.	Shell, 100 lbs.	3	1068	Time, 3.20 seconds.
		"	5	1525	" 5.64 "
		"	8	2238	" 8.10 "
		"	10	2720	" 10.98 "
		"	12	2847	" 11.73 "
		"	20	3842	" 18.92 "

* Axis of gun 6 feet above the horizontal plane.

Ranges.—Continued.

KIND OF ORDNANCE.	Powder.	Ball.	Elevation.	Range.	Remarks.
	Lbs.		° ′	Yards.	
10-IN. COLUMBIAD. —Continued.	15.	Shell, 100 lbs.	30	4836	Time, 27.50 seconds.
		Shot,	15	3281	" 14.32 "
		125 lbs.	30	5163	" 27.08 "
	18.	"	0	394	Axis of gun 16 feet above the water.
		"	1	752	
		"	2	1002	
		"	3	1230	
		"	4	1570	
		"	5	1814	
		"	6	2037	Shot ceased to ricochet on water.
		"	8	2519	
		"	10	2777	
		"	15	3525	
		"	20	4020	
		"	25	4304	
		"	30	4761	
		"	35	5433	
	20.	"	39 15	5654	
	12.	Shell,	1	800	
		100 lbs.	2	1012	
		"	3	1184	
		"	4	1443	
		"	5	1604	
	18.	"	0	448	
		"	1	747	
		"	2	1100	
		"	3	1239	
		"	4	1611	
		"	5	1865	
		"	6	2209	
		"	8	2489	
		"	10	2848	
		"	15	3200	
		"	20	3885	
		"	25	4150	
		"	30	4651	
		"	35	4828	Time of flight 35 sec
15-IN. COLUMBIAD.	40.	Shell,	0	273	
		302 lbs.	1	484	
		"	2	812	
		"	3	1136	
		"	4	1310	
		"	5	1518	
		"	6	1760	
		"	7	1948	
		315 lbs.	8	2194	

Ranges.—Continued.

Kind of Ordnance.	Powder.	Ball.	Elevation.	Range.	Remarks.
	Lbs.		°	Yards.	
15-in. columbiad.—Continued.	40.	Shell, 315 lbs.	9	2236	Time, 8.87 seconds.
		"	10	2425	" 10.00 "
		"	12	2831	" 12.07 "
		"	15	3078	" 13.72 "
		"	20	3838	" 17.82 "
		"	25	4528	" 22.03 "
		"	28	4821	" 24.18 "
		"	30	5018	" 26.71 "
	45.	"	25	4595	" 23.20 "
	50.	"	25	4680	" 23.29 "
13-inch sea-coast mortar.	20.	Shell, 200 lbs.	45	4325	
10-inch sea-coast mortar.	10.	Shell, 98 lbs.	45	4250	Time, 36 seconds.
10-inch siege-mortar.	1.	Shell, 90 lbs.	45	300	Time, 6.5 seconds.
	1.5	"	45	700	" 12 "
	2.	"	45	1000	" 14 "
	2.5	"	45	1300	" 16 "
	3.	"	45	1600	" 18 "
	3.5	"	45	1800	" 19 "
	4.	"	45	2100	" 21 "
	Lbs. oz.				
8-inch siege-mortar.	0 10	Shell, 46 lbs.	45	500	Time, 10 seconds.
	13	"	45	600	" 11 "
	1	"	45	750	" 12¼ "
	1 2	"	45	900	" 13 "
	1 3	"	45	1000	" 13½ "
	1 4	"	45	1100	" 14 "
	1 6	"	45	1200	" 14½ "
	Oz.		°	Yards.	
24-pounder coehorn mortar.	0.5	Shell, 17 lbs.	45	25	
	1.	"	45	68	
	1.5	"	45	104	
	1.75	"	45	143	
	2.	"	45	165	
	2.75	"	45	260	
	4.	"	45	422	
	6.	"	45	900	
	8.	"	45	1200	

Height of Breech-Sight for Different Angles of Elevation.

Degrees.	Bronze Guns and Howitzers, Model of 1841. Height of Hausse, in inches.							Iron Guns and Howitzers, Models of 1839, 1841, and 1844. Height of Hausse, in inches.									
	Guns.			Howitzers.				Siege and Garrison.				Sea-Coast.				Columbiads.	
								Guns.		Howitzers.		Guns.		Howitzers.			
	12-pdr.	12-pdr. 1857.	6-pdr.	32-pdr.	24-pdr.	12-pr.	Mou'n 12-pr.	24-pdr.	18-pdr.	8-in.	24-pdr.	42-pdr.	32-pdr.	10-in.	8-in.	10-in.	8-in.
° ′ 0.0	—1.331	—2.500	—1.026	—1.300	—1.125	—.922	—.349	—2.907	—2.938	—.900	—1.050	—3.800	—3.500	—3.125	—2.850	—5.250	—4.500
0.30	—.666	—1.933	—.512	—.652	—.565	—.461	—.063	—1.938	—1.966	—.451	—.611	—2.796	—2.523	—2.169	—2.012	—4.225	—3.479
1.0	0.001	—1.365	0.000	.004	.006	.022	.224	—.969	—.992	.001	.029	—1.793	—1.645	—1.214	—1.174	—3.199	—2.458
1.30	0.668	—.798	0.512	.657	.572	.484	.511	0.000	—.018	.449	.568	—.789	—.567	—.258	—.336	—2.173	—1.436
2.0	1.334	—.230	1.025	1.310	1.138	.946	.799	.969	.957	.898	1.108	.216	.411	.699	.502	—1.147	—.414
2.30	2.001	.338	1.538	1.963	1.704	1.407	1.087	1.939	1.933	1.348	1.648	1.221	1.390	1.656	1.341	—.120	.608
3.0	2.668	.907	2.051	2.617	2.271	1.870	1.375	2.910	2.909	1.799	2.189	2.227	2.370	2.614	2.181	.908	1.632
3.30	3.336	1.476	2.565	3.272	2.838	2.332	1.663	3.882	3.886	2.250	2.730	3.234	3.350	3.572	3.022	1.937	2.656
4.0	4.005	2.045	3.077	3.927	3.406	2.795	1.951	4.885	4.864	2.701	3.271	4.242	4.332	4.532	3.863	2.966	3.681
4.30	4.675	2.616	3.594	4.583	3.974	3.259	2.240	5.829	5.843	3.153	3.814	5.251	5.315	5.493	4.705	3.997	4.708
5.0	5.345	3.187	4.110	5.239	4.544	3.724	2.529	6.804	6.824	3.606	4.357	6.261	6.299	6.455	5.549	5.030	5.736
5.30	6.017	3.759	4.627	5.897	5.114	4.189	2.819	7.781	7.806	4.059	4.901	7.273	7.284	7.419	6.394	6.064	6.766
6.0	6.689	4.332	5.144	6.556	5.686	4.655	3.109	8.760	8.790	4.513	5.445	8.287	8.272	8.384	7.240	7.100	7.797
6.30	7.363	4.906	5.663	7.216	6.258	5.121	3.399	9.740	9.775	4.968	5.991	9.303	9.261	9.351	8.088	8.137	8.830
7.0	8.038	5.481	6.182	7.878	6.831	5.589	3.691	10.722	10.763	5.423	6.538	10.320	10.252	10.320	8.937	9.177	9.866
7.30	8.715	6.057	6.703	8.541	7.406	6.058	3.983	11.706	11.752	5.880	7.086	11.340	11.245	11.291	9.789	10.219	10.903
8.0	9.393	6.635	7.224	9.205	7.982	6.527	4.275	12.693	12.744	6.338	7.635	12.362	12.240	12.264	10.642	11.204	11.943
8.30	10.073	7.214	7.747	9.871	8.559	6.998	4.568	13.682	13.739	6.797	8.186	13.387	13.238	13.240	11.497	12.310	12.985
9.0	10.754	7.795	8.272	10.539	9.138	7.471	4.862	14.674	14.736	7.257	8.738	14.414	14.239	14.218	12.355	13.360	14.031

To Estimate Distances, approximately.

Height of breech-sight for the different angles under which an object $6\frac{1}{2}$ feet high is seen, at the distance of

Kind of Gun.			200 Yds.	300 Yds.	400 Yds.	500 Yds.	600 Yds.	700 Yds.	800 Yds.	900 Yds.	1000 Yds.	1100 Yds.	1200 Yds.
			In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
Guns	Field	6-pdr.	.636	.424	.318	.254	.212	.182	.159	.141	.127	.116	.106
		12-pdr.	.827	.551	.413	.331	.276	.236	.207	.184	.165	.150	.138
	Siege	18-pdr.	1.209	.806	.604	.484	.403	.345	.302	.269	.242	.219	.201
		24-pdr.	1.202	.801	.601	.481	.401	.344	.300	.267	.240	.218	.200
	Garrison	32-pdr.	1.213	.809	.607	.485	.404	.346	.303	.269	.242	.220	.202
		42-pdr.	1.246	.831	.624	.493	.415	.356	.312	.277	.249	.226	.208
Howitzers	Mountain,	12-pdr.	.356	.238	.165	.143	.120	.102	.089	.079	.070	.065	.059
	Field	12-pdr.	.572	.382	.286	.229	.191	.164	.143	.127	.115	.104	.095
		24-pdr.	.702	.468	.351	.280	.234	.201	.176	.156	.140	.127	.117
		32-pdr.	.809	.540	.405	.324	.270	.231	.202	.180	.162	.147	.135
	Siege	24-pdr.	.671	.446	.335	.268	.223	.191	.166	.149	.134	.122	.112
		8-inch.	.558	.372	.279	.223	.186	.159	.139	.124	.112	.102	.093

To use the foregoing table, aim over the line of metal, first at the top of an object $6\frac{1}{2}$ feet high,—for instance, the cap of a foot-soldier; then aim at his feet, by using a breech-sight, without moving the gun. The distance found in the preceding table corresponding to this height of breech-sight will be the distance of the object from the gun.

Recoil of the Iron Carriages.

The recoil of the top carriage on its chassis is easily regulated by the condition of the rails: if there be not sufficient recoil, clean the rails and add a little oil; if the recoil be excessive, sprinkle a little sand on the rails. The carriage works better when the rails are clean.

Initial Velocities of Cannon-Balls.

(From experiments made with the Ballistic Pendulum, at Washington Arsenal.)

KIND OF GUN.	PROJECTILE. Kind.	PROJECTILE. Weight.	Charge of powder.	Initial velocity.
		Lbs.	Lbs.	Feet.
6-pdr. field-gun........	Shot..................	6.15	1.25 1.5 2.	1439 1563 1741
	Spherical case...... Canister.............	5.5 6.8	1. 1.	1357 1230
12-pdr. field-gun......	Shot..................	12.3	2.5 3. 4.	1486 1597 1826
	Spherical case...... Canister.............	11. 13.5	2. 2.	1392 1262
12-pdr. field-howitzer.	Shell..................	8.9	1. 1.25	1054 1178
	Spherical case...... Canister.............	11. 9.64	1. 1.	953 1015
12-pdr. siege and garrison gun.........	Shot..................	12.3	2. 3. 4.	1378 1674 1906
	Shell..................	8.9	2. 3.	1611 1929
12-pdr. gun, 25 calibres long. ...	Shot..................	12.3	2. 3. 4. 5. 6. 7. 8.	1411 1734 1933 2098 2239 2300 2324

Initial Velocities of Cannon-Balls.—Continued.

Kind of Gun.	Projectile. Kind.	Projectile. Weight.	Charge of powder.	Initial velocity.
24-pdr. siege and garrison gun.	Shot	24.25	3. 4. 6. 8.	1240 1440 1680 1870
	Shell	17.	3. 4.	1470 1670
	Canister	29.	3. 4.	1135 1303
	Grape	30.6	3. 4.	1108 1272
32-pdr. sea-coast gun.	Shot	32.3	4. 5.33 8. 10.67	1250 1430 1640 1780
	Shell	23.4	4. 5.33	1450 1657
	Canister	37.	4. 5.33	1172 1342
	Grape	39.75	4. 5.33	1133 1297

Initial Velocities of Balls fired from Small Arms.

Kind of Arm.	Charge.	Weight of ball.	Initial velocity.	
	Grains.	Grains.	Feet.	
Rifle musket	60	510	963	Elongated ball.
Rifle, 1855	60	510	914	"
Altered musket	70	740	879	"
Pistol carbine	40	468	603	"
Musket, 1841	110	412	1500	Round ball.

Loss of Velocity by the Windage of the Ball.

Kind of Gun.	Charge of powder.	Initial velocity of ball. Without windage.	Initial velocity of ball. With windage of $\frac{1}{40}$ diameter.	Loss of velocity by a windage of $\frac{1}{40}$ diameter.	
	Lbs.	Feet.	Feet.	Feet.	Per ct.
32-pdr. sea-coast...........	4.	1444	1271	173	12
24-pdr. siege...............	4.	1600	1433	167	10
	6.	1890	1723	167	9
12-pdr., 25 calibres......	2.	1617	1444	173	11
	3.	1915	1742	173	9
	4.	2124	1951	173	8
12-pdr. field, 16 calibres	2.	1528	1370	158	10
	3.	1793	1635	158	9
	4.	1992	1834	158	8
6-pdr. field..................	1.5	1734	1560	174	10

The loss of velocity by a given windage is directly as the windage, and inversely as the diameter of the bore, very nearly.

Ranges of Hale's War-Rockets.

Elevation.	Range, (first graze.) 2-inch.	Range, (first graze.) 3-inch.	Remarks.
°	Yards.	Yards.	
4 to 5	500 to 600	500 to 600	The rockets were fired from a trough 10 feet long.
8	700	800 to 1000	
10	800 to 900	1000 to 1200	
15	1200	1200 to 1400	Weight of 2-inch rocket........ 6 lbs.
47	1760	2200	" 3-inch " .... 16 "

Penetration of Shot in Masonry.

(From French Experiments made at Metz, 1834.)

Rubble-work of good quality; scarp wall built by Vauban.

Calibre.	Charge.	Distance in Yards.								
		27.	55.	109.	219.	328.	438.	656.	875.	1094.
		In.	In.	In.	In.	In.	In.	In.	In.	In.
36	1-3d	26.78	26.39	25.60	23.83	22.25	20.87	17.92	14.96	12.21
	1-2d	25.60	25.20	24.22	22.45	20.87	19.30	16.25	13.39	10.83
	1-3d	24.22	23.83	22.84	21.07	19.50	18.12	15.16	12.21	9.85
24	1-4th	22.65	22.25	21.46	19.89	18.22	16.74	13.78	11.23	9.06
	1-6th	20.08	19.69	18.90	17.33	15.75	14.38	11.81	9.65	7.88
	1-8th	17.33	16.93	16.15	14.57	13.20	11.81	9.65	7.88	6.50
	1-2d	22.45	21.86	20.87	19.10	17.53	15.95	12.80	10.05	7.68
	1-3d	21.07	20.68	19.69	17.92	16.35	14.77	11.81	9.26	7.29
16	1-4th	19.50	19.10	18.22	16.74	15.16	13.78	10.83	8.47	6.69
	1-6th	17.13	16.74	16.15	14.57	13.00	11.62	9.06	7.29	5.91
	1-8th	14.96	14.57	13.78	12.21	10.83	9.45	7.48	6.11	5.12
	1-3d	18.90	18.51	17.53	15.95	14.57	13.00	10.05	7.68	6.11
12	1-4th	17.72	17.33	16.54	14.96	13.39	11.81	8.86	6.89	5.51
	1-6th	15.56	15.16	14.38	13.00	11.42	10.05	7.48	6.11	4.93
	1-8th	13.78	13.39	12.60	11.03	9.65	8.27	6.50	7.68	4.33
8	1-3d	15.95	15.56	14.77	13.19	11.62	10.24	7.48	5.51	4.14

Penetration in Oak Wood, Beech, or Ash.

(From French Experimente made at Metz; 1834.)

Calibre.	Charge.	Distance in Yards.								
		27.	65.	109.	219.	328.	438.	656.	875.	1094.
Guns.		In.	In.	In.	In.	In.	In.	In.	In.	In.
36	1-3d	65.4	64.2	62.2	58.3	54.3	50.8	44.1	37.4	31.5
	1-2d	63.0	61.4	59.1	54.7	50.8	47.3	40.2	33.5	27.6
	1-3d	59.1	57.9	55.9	51.6	47.6	44.1	37.4	30.7	24.8
24	1-4th	55.5	54.3	52.3	48.4	44.9	41.3	35.0	28.4	22.8
	1-6th	49.2	48.4	46.5	42.9	39.4	36.2	29.5	24.0	19.3
	1-8th	42.5	41.6	40.2	36.6	32.7	30.3	24.4	19.7	15.8
	1-2d	54.7	53.2	50.8	46.5	42.5	39.0	31.9	25.6	19.7
	1-3d	51.2	50.0	48.0	43.7	40.2	36.6	29.9	23.6	18.6
16	1-4th	47.7	46.5	44.5	40.9	37.4	33.9	27.6	21.7	16.9
	1-6th	42.1	41.4	39.8	36.2	32.7	29.5	23.2	17.7	14.2
	1-8th	37.0	36.2	34 3	30.7	27.6	24.4	19.3	15.0	11.8
	1-3d	46.1	44.9	42.9	38.6	35.0	31.9	25.6	10.7	14.6
12	1-4th	43.3	42.1	40.2	36.6	33.1	29.9	23.6	18.1	13.4
	1-6th	37.8	37.0	35.4	31.9	28.4	25.2	19.3	15.0	11.4
	1-8th	33.9	33.1	31.1	27.6	24.4	21.7	16.5	13.0	9.8
8	1-3d	39.4	38.2	36.2	32.3	28.7	25.6	19.3	13.8	10.6
Howitzers.	Lbs.									
	4.4	28.4	27.6	26.0	22.4	19.3	16.5	13.0	10.6	9.1
8-in. Siege.	3.3	23.2	22.4	20.9	18.1	15.8	13.8	11.0	9.5	8.3
	2.2	10.1	15.4	14.2	12.6	11.4	10.2	8.7	7.9	7.5
	1.1	39.1	8.7	8.3	8.3	7.5	7.1	6.7	6.3	5.9
	3.3	33.1	31.9	30.3	26.8	23.6	20.5	15.0	11.8	9.8
6-in.	2.2	27.6	26.8	25.2	21.7	18.5	15.8	11.4	9.1	7.9
	1.65	22.8	22.1	20.5	17.3	14.6	12.6	9.8	8.3	7.1
24-pdr.	2.2	27.6	26.8	25.2	21.7	18.1	15.0	10.2	7.9	6.3
	1.1	18.9	18.1	16.5	13.4	11.0	9.5	7.5	6.3	5.1
12-pdr. Mountain.	0.6	15.0	14.2	12.6	10.2	8.3	7.1	5.9	4.7	3.9
	Graine.									
Musket-Balls.......	154	3.35	3.15	2.56	1.77	1.06	0.71	0.32		

Penetration of Shot in Compact Earth, (half sand, half clay.)

(From French Experiments made at Metz, 1834.)

CALIBRE.	CHARGE.	DISTANCE IN YARDS. 27.	65.	109.	219.	328.	438.	656.	875.	1094.
Guns.		In.	In.	In.	In.	In.	In.	In.	In.	In.
36	1-3d	109.1	106.3	102.4	97.3	93.4	89.4	82.3	75.6	69.7
24	1-2d	108.2	107.2	99.3	91.0	84.3	79.6	72.5	66.2	60.6
	1-3d	100.4	97.7	92.6	85.9	81.1	77.2	70.1	63.8	58.3
	1-4th	92.6	90.2	86.6	81.5	77.6	74.0	67.3	61.8	57.1
	1-6th	83.5	82.3	79.9	75.6	72.2	68.9	62.6	57.1	52.4
	1-8th	76.4	74.8	72.4	68.9	65.8	63.0	67.5	62.0	47.3
16	1-2d	94.5	91.0	85.9	77.6	72.2	67.7	61.4	65.9	50.4
	1-3d	86.6	83.5	79.6	73.6	69.3	65.8	59.9	64.4	49.2
	1-4th	80.7	78.3	75.2	69.7	66.5	63.4	57.9	62.4	47.3
	1-6th	72.9	70.9	68.1	65.0	61.8	59.1	63.6	48.8	44.5
	1-8th	63.0	65.4	63.8	60.6	57.9	55.1	50.4	45.7	41.3
12	1-3d	65.0	63.4	59.9	54.7	50.8	48.2	42.9	38.6	35.0
	1-4th	60.6	59.1	55.9	52.0	48.8	46.1	41.3	37.4	33.9
	1-6th	54.7	53.6	50.8	48.2	45.3	42.9	38.6	35.0	32.3
	1-8th	60.0	48.8	47.3	44.5	41.7	39.8	36.2	33.1	30.7
8	1-3d	56.3	54.7	52.0	46.9	43.3	40.2	35.4	31.9	28.7
Howitzers.	Lbs.									
8-in. Siege.	4.4	48.4*	47.3*	45.3*	41.7	38.6	35.4	30.3	26.0	23.2
	3.3	42.9*	41.7	40.2	37.0	33.9	31.1	27.2	24.0	21.7
	2.2	34.7	33.9	32.3	29.5	27.6	25.6	22.8	20.9	19.3
	1.1	22.8	22.4	21.7	20.9	20.1	19.3	17.7	16.5	15.8
6-in.	3.3	52.8*	61.2*	48.8	45.0	41.0	37.4	30.7	25.2	22.1
	2.2	45.3	44.1	42.5	38.6	35.0	31.9	26.4	22.4	19.7
	1.65	39.8	38.6	37.0	33.5	30.7	28.0	23.6	20.5	18.1
24-pdr.	2.2	44.5*	42.9*	41.0*	36.6	32.7	29.1	23.2	18.9	16.1
	1.1	33.5	32.3	30.7	27.6	24.8	22.4	18.1	15.4	13.4
12-pdr. Mountain.	0.6	27.2	26.4	24.8	21.7	19.3	17.3	14.6	12.2	10.2
	Grains.									
Musket-Balls.......	154.	9.85	9.45	8.66	6.91	4.33	3.15	1.58		

* With these charges, and at these distances, the shells were often broken.

Penetration of Shells.

(From French Experiments made at Metz, 1834.)

ELEVATION.	DISTANCE.	IN COMPACT EARTH. 8-in.	10-in.	12-in.	IN OAK WOOD. 8-in.	10-in.	12-in.	IN MASONRY. 8-in.	10-in.	12-in.
	Yds.	In.	In.	In.	In.	In.	In.	In.	In.	In.
30°	656	7.88	17.72	19.69	3.94	7.88	8.66	1.97	3.54	3.94
	1312	9.85	25.60	27.57	4.73	11.81	13.78	2.36	4.73	6.12
45°	656	11.81	19.69	21.66	5.91	9.85	10.63	3.15	3.94	4.33
	1312	15.75	27.57	29.54	7.88	13.78	15.75	3.94	5.51	5.91
60°	656	19.69	29.54	31.50	8.66	13.00	14.57	4.33	5.91	6.30
	1312	21.66	31.50	33.47	9.85	13.78	15.75	4.73	6.30	6.69
Falling with maximum velocity.		23.63	33.47	35.44	9.85	13.78	16.75	4.73	6.69	7.09

By multiplying the penetrations in the table for masonry by 1.25, 1.75, or 0.46, the penetration in masonry of medium quality, or of brick or in hard calcareous stone, (solid,) respectively, will be obtained.

Multiply the penetration in oak by 1.3 for the penetration in elm, by 1.8 for white pine, and by 2 for poplar.

Multiply the penetration in compact earth by 0.63 for the penetration in sand mixed with gravel.

By 0.87, for earth mixed with sand and gravel, twice the weight of water.
" 1.09, for compact mould and fresh earth mixed with sand, or half clay
" 1.44, for wet potter's clay.
" 1.50, for light earth, settled.
" 1.90, for light earth, fresh.

In general, sand, sandy earth mixed with gravel or small stones, chalk, and tufa, resist shot better than the productive earths, or clay, or earth that retains water.

According to the experiments, the holes made in masonry such as that referred to in the table, by shot striking it perpendicularly at a short distance, are formed of an exterior, funnel-shaped opening the mean diameter of which is about 5 times that of the shot, and of an interior part nearly cylindrical. The exterior cone appears to be produced by the reaction of the masonry, some fragments of which are projected backward to the distance of 45 or 50 yards. The train of fragments in front of the hole extends about 20 feet. Around the exterior opening the masonry is loosened to a distance about one-half greater than the diameter of the opening,—say 45 inches by the 24-pdr. shot, 35.5 inches by the 16-pdr., 31.5 inches by the 12-pdr. This loosening indicates the proper distance between the first shots from a breeching-battery. Nearly all the shot are broken, even at the charge of one-fourth, and the fracture is generally in meridional planes the pole of which is the point which strikes first. On the shot which are not broken, and on the fragments of those which are broken, small cracks or furrows, sometimes 0.02 inch deep, are observed, radiating from the same point.

The effect of shells fired horizontally against masonry is very small; they are broken at the moment of striking, or if fired with very low charges, so as not to break, they produce a very slight impression.

In oak, the fibres are displaced laterally by the passage of the shot, and afterward close up again, so as to leave an opening scarcely sufficient for measuring the depth of penetration. This effect explains the cause of vessels not being always sunk by shot striking below the water-line; but the timber is split longitudinally even by the smallest shot, to a length of 6.5 feet; the splinters are driven to the distance of 42 to 50 feet, and the largest timbers are soon destroyed.

In white pine, nearly all the fibres struck by the shot are broken, but the effect does not extend much beyond the opening made: this material is therefore preferable to oak for structures which are not intended to be proof against cannon-shot.

Penetration in Fascines, Wool, etc.

At the distance of 24 yards, a musket round ball penetrates 20 inches into a gabion stuffed with sap fagots; the ball from a wall piece, 23.63 inches. The resistance of fascines decreases very rapidly by the twigs being broken or separated by the balls.

A *rolling gabion*, stuffed with fascines, is proof against the ball of a wall piece at 15 yards; at the distance of 200 yards, and even more, it is pierced through by cannon-balls of the smallest calibre.

The penetration of balls in wool is more than double that in compact earth, even when the wool is contained in close, well-quilted mattresses pressed between hurdles. At 40 yards, a musket-ball (round) penetrates more than 40 inches into woollen mattresses thus placed together.

Penetration in Masonry.

(Experiments at West Point in 1853, and at Fort Monroe Arsenal in 1839.)

Calibre.	Charge.	Distance.	Penetration.				
			Granite.	Potomac Freestone.	Brick.	Concrete.	Boiler-plate .5 in. thick.
		Yds.	In.	In.	In.	In.	In.
10-inch columbiad..	18.	114	7.75	....	44.	....	
8-inch " ...	12.	200	....	....	....	24	
42-pdr. gun..........	10.5	......	4.0	....	18.	....	
" canister	1.5	......	....	....	....	....	.5
*32-pdr. gun shot...	8.	880	3.5	12.	15.25	....	
*8-inch sea-coast howitzer shell.....	6.	880	1.	4.5	8.5		

* Made at Fort Monroe Arsenal.

The solid shot broke against the granite, but not against the freestone or brick. The *general* effect is less in brick than in granite.

The shells broke into small fragments against each of the three materials.

The circumstances attending the penetration of the shot and shells corresponded with those stated below in the experiments at Metz. The wall used as a target at Fort Monroe Arsenal was built of dressed stone and of the best bricks, laid in hydraulic cement; but being an isolated wall, (10 feet square of each material, and 5 feet thick, with 3 counterforts,) and being battered before the masonry was perfectly set, the effect of the projectiles in *shattering* the masonry around the point struck was greater than indicated by the experiments referred to.

PENETRATION OF SHOTS AND SHELLS IN OAK.—[Computed by Major A. Mordecai, 1852.]

Kind of Gun	and Projectile.		Charge.	0.	100.	200.	400.	600.	800.	1000.	1200.	1400.	1600.
			Lbs.										
6-pdr. Field-Gun.	Shot	Velocity ft.	2.	1741	1534	1362	1094	896	744	624	529		
		Penetration in.	2.	33.5	29.	25.25	18.75	14.	10.5	7.75	5.75		
		Velocity ft.	1.5	1563	1386	1228	1003	827	690	581	495		
		Penetration in.	1.5	29.75	25.75	22.	16.5	12.25	9.25	6.75	5.25		
		Velocity ft.	1.25	1439	1283	1149	937	776	650	549	468		
		Penetration in.	1.25	27.	23.25	20.	15.	11.25	8.25	6.25	4.75		
12-pdr. Field-Gun.	Shot	Velocity ft.	4.	1826	1653	1503	1260	1070	919	796	694	609	536
		Penetration in.	4.	44.75	40.	36.	28.75	23.	18.5	14.75	11.75	9.5	7.5
		Velocity ft.	3.	1597	1454	1331	1126	964	828	724	635	559	494
		Penetration in.	3.	38.5	34.5	30.75	24.75	19.75	15.5	12.5	10.	8.	6.5
		Velocity ft.	2.5	1486	1358	1247	1060	911	789	688	604	533	472
		Penetration in.	2.5	35.5	31.75	28.25	22.75	18.	14.5	11.6	9.25	7.6	6
	Spher. case	Velocity ft.	3.	1600	1453	1326	1117	952	819	710	620	544	479
		Velocity ft.	2.6	1485	1349	1238	1049	897	774	673	589	518	457
		Velocity ft.	2.	1375	1258	1154	981	844	730	637	558	492	435
12-pdr. Field Howitzer.	Shell	Velocity ft.	1.25	1178	1054	947	775	643	539	455	387		
		Penetration in.	1.25	18.75	16.	13.75	10.	7.5	5.5	4.	3.		
	Spher. case	Velocity ft.	1.25	1000	925	858	742	647	567	500	441		
		Velocity ft.	1.0	900	835	777	675	591	519	458	406		
Mountain		Velocity ft.	0.5	640	598	561	494	437	388	345			

Kind of Gun	and Projectile.		Charge.	0.	100.	200.	400.	600.	800.	1000.	1200.	1400.	1600.	1800.	2000.	2200.	2400.	2600.
24-pdr. Field Howitzer.	Shells	Velocity ft.	2.5	1170	1076	992	851	735	640	560	493							
		Penetration in.	2.5	24.	21.25	19.	15.	12.	9.5	7.5	6.							
	Spher. case	Velocity ft.	2.5	1000	948	891	798	717	647	586	532	484	441					
32-pdr. Field Howitzer.	Shell	Velocity ft.	3.25	1150	1067	992	864	756	666	604	525	468	419					
		Penetration in.	3.25	25.5	23.	20.5	16.75	13.6	11.	9.25	7.25	5.5	4.5					
	Spher. case	Velocity ft.	3.25	1000	949	902	816	742	676	622	566	520	478					

12-pdr. Siege and Garrison Gun.	Shot	Velocity ft.	4.	1906	1722	1562	1305	1106	948	819	714	626	551	487				
		Penetration in.	4.	46.75	42.	37.5	30.	24.	19.25	15.75	12.25	10.	8.	6.25				
		Velocity ft.	3.	1674	1522	1390	1172	1000	862	749	656	576	509	452				
		Penetration in.	3.	40.75	36.5	32.5	26.	21.	16.75	13.25	10.75	9.	7.	5.5				
	Shells	Velocity ft.	3.	1900	1651	1449	1142	921	755	627	526	445						
		Penetration in.	3.	33.5	28.75	24.75	18.	13.25	9.75	7.	5.25	3.75						
		Velocity ft.	2.	1610	1416	1254	1002	817	676	565	476	404						
		Penetration in.	2.	28.	24.	20.5	15.	11.	8.	6.	4.25	3.25						
24-pdr. Gun.	Shot	Velocity ft.	8.	1870	1730	1607	1396	1224	1021	961	859	772	695	627	570	517	473	
		Penetration in.	8.	57.5	53.	48.75	41.	34.75	29.25	24.75	20.75	17.5	14.76	12.5	10.5	8.75	7.5	
		Velocity ft.	6.	1680	1561	1455	1273	1122	995	888	797	717	648	688	634	486	444	
		Penetration in.	6.	61.25	47.	43.25	36.5	30.75	26.	22.	18.5	15.54	13.	11.	9.25	8.	6.75	
	Shell	Velocity ft.	4.	1670	1513	1376	1154	979	840	726	633	554	488	431	382			
		Penetration in.	4.	37.25	33.75	29.75	23.5	18.5	14.75	11.5	9.25	7.25	5.75	4.76	3.75			
32-pdr. Gun.	Shot	Velocity ft.	10.66	1750	1637	15.34	1357	1208	1082	973	880	798	727	663	607	557	512	472
		Penetration in.	10.66	59.	54.75	60.75	43.5	37.5	32.	27.5	23.5	20.25	17.5	15.	13.	11.	9.5	8.25
		Velocity ft.	8.	1650	1546	1452	1288	1150	1032	931	843	766	698	638	585	537	494	455
		Penetration in.	8.	55.25	61.25	47.	40.75	35.	30.	26.	22.25	19.	16.25	14.	12.	10.5	9.	7.75
	Shell	Velocity ft.	6.33	1650	1510	1385	1181	1017	884	774	681	603	536	478	427			
		Penetration in.	6.33	40.	36.	32.5	26.5	21.5	17.25	14.	11.5	9.25	7.5	6.	5.			
42-pdr. Gun.	Shot	Velocity ft.	10.5	1600	1514	1435	1295	1174	1068	976	894	822	758	700	647	600	557	518
		Penetration in.	10.5	58.5	54.75	51.25	45.	39.5	34.5	30.5	26.75	23.5	20.5	18.	15.75	13.75	12.25	10.75
	Shell	Velocity ft.	7.	1600	1488	1389	1216	1073	953	851	764	688	622	565	512	467	426	
		Penetration in.	7.	44.25	40.75	37.5	31.5	26.5	22.25	18.75	15.75	13.25	11.25	9.5	8.	6.75	5.75	
8-inch S. C. Howitzer.	Shell	Velocity ft.	6.	1150	1091	1036	938	853	777	711	651	599	551	508	470			
		Penetration in.	6.	35.25	32.75	30.25	26.25	22.5	19.5	17.	14.5	12.5	11.	9.5	8.25			

				0.	100.	400.	800.	1200.	1600.	2000.	2400.	2800.	3200.	3600.	4000.	4400.	4800.
8-inch Columb'd.	Shot	Velocity ft.	10.	1375	1314	1154	981	852	737	642	562	495	438	388	345		
		Penetration in.	10.	56.	53.	44.5	35.25	28.5	22.5	18.	14.25	11.25	9.	7.25	5.75		
	Shell	Velocity ft.	10.	1570	1474	1236	997	818	681	573	485	413	355				
		Penetration in.	10.	50.75	47.	37.5	27.75	20.5	15.25	11.25	8.5	6.25	4.75				
10-inch Columb'd.	Shot	Velocity ft.	18.	1315	1270	1150	1014	900	800	715	643	580	525	477	433	395	361
		Penetration in.	18.	66.5	63.5	55.5	46.5	38.75	32.25	27.	22.5	19.	15.75	13.25	11.	9.5	8.
	Shell	Velocity ft.	18.	1475	1409	1233	1045	896	774	674	690	519	459	4.07	363	323	289
		Penetration in.	18.	60.	56.75	47.75	38.	30.25	24.	19.	15.25	12.	9.75	7.75	6.25	5.	4.

It has been ascertained by experiment that a musket round ball, having a velocity of 362 feet, at the moment of impact, will just pass through a white pine board 1 inch thick; and that, with the same velocity, the ball has sufficient force to shatter the leg-bone of an ox covered with one thickness of stout harness-leather. A musket-ball moving with this velocity would, therefore, inflict a wound which would disable a man or beast; or a spherical case shot having this velocity at the moment of bursting would be effective against troops in its immediate vicinity.

A musket-ball with an initial velocity of 583 feet will pass through one-inch white pine board at 100 yards: hence a spherical case shot, moving with that velocity at the moment of bursting, would be effective at 100 yards distant from the place of bursting. The remaining velocity at 100 yards as computed, is 394 feet.

Effects of Shot on Cast Iron.

Shot projected with even a small velocity will break pieces of cast iron of very large dimensions. A 24-pounder ball fired with a charge of $\frac{1}{12}$ and moving with a velocity of 883 feet in a second, split a block of cast iron 12 inches wide by 40 inches thick to the depth of 40 inches in two shots. The fragments of the block and of the broken shot are projected with sufficient velocity to produce the most destructive effects.

Cast iron, therefore, is not a proper material for gun-carriages, or for revetments of fortifications.

Penetration of Small Arms in White Pine seasoned.

Kind of Arm.	Weight of Charge.		Diameter of Ball.	Penetration.			
	Ball.	Powder.		30 yds.	200 yds.	600 yds.	1000 yds.
	Grs.	Grs.	In.	In.	In.	In.	In.
Rifle musket	500	....	.5775	....	11.	6.33	3.25
Altered musket	730	60	.685	....	10.5	6.33	3.5
Harper's Ferry rifle	500	70	.5775	....	9.33	5.66	3.0
Pistol carbine	450	40	.5775	....	5.75	3.0*	
Sharpe's carbine	463	60	.55	7.27			
Burnside's "	350	55	.55	6.15			

* At 500 yds.

Firing Hot Shot.

Furnaces for heating shot are erected at the forts on the sea-coast. These furnaces hold 60 or more shot. The shot being placed, and the furnace cold, it requires 1 hour and 15 minutes to heat them to a red heat. After the furnace is once heated, a 24-pdr. shot is brought to a red heat in 25 minutes; the 32 and 42 require a few minutes longer. Two or three men are required to attend a furnace.

GRATES.—In siege-batteries, or in other situations where there are no furnaces, a *grate* is used for heating shot. This grate consists of 4 bars, 1.75 inch square, 3 feet long, placed diagonally, 4 inches apart, resting on 3 iron stands with legs 1 foot high.

To use the grate.—Make an excavation 1 foot deep and width of grate, with no slope at the sides or in rear, open in front. Place the grate in it, on stones or bricks, rising about 4.5 inches above the bottom; make a roof over it with hoops of flat iron, covered with sods and with 18 inches of earth, leaving in the back part a chimney 6 inches square. Put the shot on the grate, leaving about one-fourth of the length free in front; on this part, and under the front of the grate, put the wood, cut into pieces about 14 inches long and 2 inches or 2.5 inches thick. Make use of a thick sod, as a register, to regulate the draught of the chimney, so that no flame shall issue from the front of the furnace. This little furnace, which will contain about fifteen 24-pdr. balls, heats them to a red heat in 1 hour, and will supply 3 guns: it requires the attendance of one man.

IMPLEMENTS.—2 *pokers*, for stirring the fire, made of $\frac{3}{4}$-inch round iron, $5\frac{1}{2}$ feet long, the end bent at a right angle; 2 *iron forks*, for taking out the shot. These forks are immersed alternately in water to cool them. 1 *rasp*, to rub the scales from the balls when they have been overheated; 1 *pair tongs* with circular jaws, for taking up shot; 1 *iron rake*, to remove the cinders, &c., from the ash-pit; 1 *trough or tub*, 1 *bucket*, 1 *barrel*; 1 *rammer*, with the head covered by a circular plate of sheet iron, of rather larger diameter than the ball, to remove the clay which may stick to the sides of the bore when clay wads are used; 1 *ladle*, (to each piece,) for carrying the balls, formed of an iron ring the interior of which is bevelled to fit the ball, with 2 arms inserted into wooden handles; for small calibres it is made with 1 handle.

Wads may be made of good clay, free from sand or gravel, moistened just enough to work well; the wads are cylindrical, 1 calibre long. But it is preferable to use *hay wads* that have been steeped in water for 15 minutes and allowed to drip.

Cartridges for hot shot are made of cannon cartridge-paper or parchment well pasted, to prevent the powder from sifting out; they should be carefully examined before use, to see that there are no holes in them. It is best to use two cartridge-bags, one within the other.

Manner of loading.—Elevate the muzzle sufficiently to allow the ball to roll in; ram the cartridge home carefully, and a *dry* hay wad over it; then a wet hay or clay wad; prick and prime; insert the ball, and put a wet hay or clay wad over it; this second clay wad may be only ½ calibre long. It is a good precaution, also, to pass a wet sponge into the gun just before putting in the shot. When wet hay wads are used, steam is seen to issue from the vent as soon as the ball gets home; this is the effect of the heat of the ball upon the water contained in the wad; no danger can result from it, as the ball may be allowed to cool in the gun without the charge taking fire; but it is better to fire without much delay, as this steam would injure the powder.

The penetrations of cold and hot shot into wood are equal under the same circumstances. A red-hot shot retains sufficient heat to set fire to wood after having struck the water several times. The fire is communicated more rapidly and certainly to the wood when the ball does not penetrate more than 10 or 12 inches, because at a greater depth the communication with the external air is not sufficiently free. It is proper, therefore, to fire with small charges, ¼ to ⅙ weight of the shot, according to the distance, in order that the shot may remain in the wood and not penetrate too deep.

Expansion of Shot heated to a White Heat.

Calibre.	8-in.	42.	32.	24.	18.	12.
Expansion .... in.	0.149	0.11	0.10	0.08	0.06	0.04

Heated shot do not return to their original dimensions on cooling, but retain a permanent enlargement, as will appear from the following table, giving the mean of 16 trials by Lieutenant (now Captain) Rodman, of the Ordnance Department:

8-inch Shot.	First Heating.			Second Heating.		
	Diameter.	Expansion.		Diameter.	Expansion.	
	In.	In.	Per cent.	In.	In.	Per cent.
Original..........	7.840	....	0.000			
White heat........	7.989	0.149	.019	8.017	0.177	0.022
Cherry red........	7.963	.123	.016			
After cooling.....	7.895	.054	.007	7.939	.099	.012

CHAPTER FOURTEENTH.

MATERIALS.

TIMBER.

The selection, inspection, and seasoning of timber for ordnance purposes require especial attention. The quality of the wood, and the defects to which it is subject, depend much on the soil, the exposure, and particularly the climate in which it grows.

In the United States, the climate of the States in the North and Middle is most favorable to the growth of the timber used for ordnance purposes.

Kinds of Timber used.

The kinds of wood, and the uses to which they are principally applied in ordnance construction, are as follows, viz.:

White Oak, (*Quercus alba.*)—The bark is a grayish white, the leaf long, narrow, and deeply indented; the wood is of a straw color, with a reddish tinge, tough and flexible. It is the principal timber used in the construction of all kinds of artillery-carriages.

White Beech, Red Beech, (*Fagus sylvestris, Fagus ferruginea,*) are the most suitable for saddle-trees, fuzes, and mallets; also for plane-stocks and various other tools.

White Ash (*Fraxinus Americana*) is straight-grained, tough, and elastic; it is used for sponge and rammer staves, shafts for light carriages, and, in case of necessity, for handspikes, tool-handles, and sabots. There is but little difference in quality throughout the whole thickness; the outside is rather tougher. It lasts a long time when protected, but rots quickly when exposed to the weather.

Elm (*Ulmus Americana*) is well suited for fellies and for small naves.

Hickory (*Juglans tomentosa*) is very tough and flexible; the most suitable wood for handspikes and tool-handles, and for wooden axle-trees.

Black Walnut (*Juglans nigra*) is hard and fine-grained; it is used for ammunition-chests, and may be used for naves of field-carriages. It is used exclusively for the stocks of small arms.

White Poplar, or Tulip-Tree, (*Liriodendron tulipifera,*) is a soft, light, fine-grained wood, which grows to a great size; it is used for sabots, cartridge-blocks, etc., and for the lining of ammunition-chests.

White Pine (*Pinus strobus*) is soft, light, fine-grained, and easily wrought. It is used for arm-chests and packing-boxes generally, and for building purposes.

Cypress (*Cupressus disticha*) is a soft, light, straight-grained wood, which grows to a very large size. It may be used for many of the purposes for which oak is used, but is much inferior to it in strength and hardness, though it resists better than oak the action of a moist, hot climate.

Bass-Wood, or American Lime, (*Tilia Americana,*) is very light and soft, not easily split, and is excellent for sabots and cartridge-blocks.

Black Gum (*Nyssa sylvatica*) is a fine-grained wood, of medium hardness and density, very difficult to split, and well suited for sponge and rammer heads, and for naves of carriages. It is also used for bowls for laboratory purposes.

Dog-Wood (*Cornus florida*) is hard and fine-grained, suitable for mallets, drifts, etc.

Selection of Standing Trees.

Wood grown in a moist soil is less firm and decays sooner than that grown in a dry, sandy soil, but the trees are generally larger.

The best timber is generally found on a dark soil mixed with stones and gravel. Poplar, cypress, willow, and some others which grow best in a wet soil, are exceptions to this rule.

The hardest and most dense woods, and those least subject to decay, grow at the South; but they are more liable to split and warp in seasoning.

Trees grown on plains or in the centre of forests are less dense than those from the edge of the forest, from the sides of hills, or from open ground; but they are generally more free from limbs and of finer growth. The aspect most favorable to the production of sound, straight timber, free from defects, is that which is sheltered from the prevalent winds. The vicinity of salt water is favorable to the strength and hardness of white oak.

Trees should be selected in the latter part of July or first part of August; for at this season the leaves of the sound, healthy tree are fresh and green, while those of the unsound are beginning to turn yellow. A sound, healthy tree will be known by its top branches being vigorous and well covered with leaves, the bark even and of a uniform color. A rounded top, a sparse covering of leaves, some of the leaves turning yellow before the rest, a rougher bark than common, covered with parasitic plants, streaks or spots, indicate a tree on the decline. The decay of branches at the top, of large branches, and the separation of the bark from the wood, are infallible signs that the wood is impaired.

Felling Timber.

The most suitable season for felling timber is that in which vegetation is at rest,—which is the case in midwinter and in midsummer. Recent experiments indicate the latter season, say the month of July, as the proper season; but the usual practice has been to fell trees for timber between the first of December and the middle of March.

The tree should be allowed to attain its full maturity before being felled. Oak matures at seventy-five to one hundred years and upward, according to circumstances. The age and rate of growth of a tree are indicated by the number and size of the rings of annual increase in a cross-section.

The tree should be cut as near the ground as possible, the lower part being the best timber. Leaning trees should always be cut so as to fall at right angles to the direction of greatest inclination; and all trees, especially oak, should be cut entirely through the heart while standing, and the woodman should allow sufficient kerf to enable him to cut the tree completely off, by rapid strokes of the axe, after the tree has started to fall. These precautions will prevent splintering at the butt.

Getting out Timber.

As soon as the tree is felled, it should be immediately stripped of its bark and raised from the ground. A short time only should elapse before the sap-wood is taken off and the timber reduced nearly to the dimensions required for use. This is done, generally, by the saw; but those pieces requiring great strength and toughness, such as spokes, poles, handspikes, and splinter-bars, should be split. These pieces should always be taken from the butt cut of young, straight-grained trees of such size as to furnish but one piece between the sap and centre-heart, the width in the direction of the radius.

Naves should be taken from the butts of trees of suitable size to leave them, after the removal of the sap-wood, 1½ inch greater in diameter than the finished size. They should be cut off square about two inches longer than the finished length, and bored through their axes with an auger ½ inch less than the small end of the nave-box which they are to receive. This facilitates their seasoning and diminishes cracking.

Pieces for fellies should always be got out so that the planes of their broad faces shall run nearly toward the centre of the tree. *Slab pieces* are not fit for this purpose.

Inspection of Timber.

Examine the timber all over carefully, whenever it can be done, after several days of fine weather, in order to see better certain defects which moisture renders less apparent.

The quality of the wood is in some degree indicated by the color, which should be nearly uniform in the heart-wood, a little deeper toward the centre, and free from sudden transitions. White spots here and there indicate decay, and should cause the rejection of the piece. All pieces con taining sap-wood should be rejected, except hickory and ash; in this kind of wood the sap-wood is generally the toughest and best. The sap-wood is known by its white color; it is next to the bark, and very soon rots, and should never be used. Sometimes there are rings of light-colored wood found surrounded by good, hard wood; this may be called the second sap, and should cause the rejection of the piece in which it occurs.

Reject pieces containing the centre-heart, except in timber which, from its size, cannot be procured free from it. Even in these it is better to use *built beams* of smaller pieces free from centre-heart, on account of the great difficulty in seasoning such large pieces, and their extreme liability to being attacked by dry-rot during the process.

In pieces which have been got out by splitting, the occurrence of short bends indicates that they have been taken from the upper part of the tree; and *the running-out* of the grain, so as to show the ends of the fibres along the side of the stick, is an unfailing indication of brashness. Reject the piece in which either occurs.

Pieces for handspikes should be free from knots near the fulcrum-end. After inspection, each stick is marked on each end, with white lead, with the initials of the contractor, the year when received,—a letter designating the purpose for which the timber is intended, and the number of pieces contained in each stick. On small sticks, as spokes, it is sufficient to mark the contractor's name and date on one end, the shape of the piece showing for what it is intended.

Defects of Timber,—especially of Oak.

Wind-shakes are cracks separating the concentric layers of wood from each other; a circular crack: it is a serious defect.

Splits, checks, and cracks, extending toward the centre, if deep and strongly marked, render the timber unfit for use, unless the purpose for which it is intended will admit of its being split through them.

These defects are found in young trees as well as old, and are no signs of the alteration of the quality of the timber. They always increase in extent in seasoning.

Brash-wood is generally consequent on the decline of the tree from age. The wood is porous, of a reddish color, and breaks short, without splinters, and, in marked cases, the chips crumble to pieces. This wood is entirely unfit for artillery-carriages.

Belted timber (that which has been killed before being felled, or which has died from other causes) should be rejected.

Knotty timber: that containing a great many knots, though sound; usually of stunted growth. It is difficult to work, and weak when cross-strained: reject.

Twisted wood, the grain of which winds spirally, is unfit for long pieces: it may be used in short ones, as naves or short transoms, etc.

Dry-rot.—This is indicated by yellow stains. Elm and beech are soon affected, if left with the bark on.

Large or decayed knots should cause the piece to be rejected.

Seasoning and Preserving Timber.

Timber freshly cut contains about 37 to 48 per cent. of liquids. By exposure to the air in seasoning one year, it loses from 17 to 25 per cent., and seasoned wood still retains from 10 to 15 per cent.

Timber of large dimensions is improved and rendered less liable to warp and crack in seasoning by immersion in water for some weeks, according to the size.

For the purpose of seasoning, timber should be piled under shelter and be kept dry: it should have a free circulation of air about it, without being exposed to strong currents. Place the bottom pieces on skids, which should be sound, raised not less than 2 feet from the ground; leave a space of an inch between the pieces of the same horizontal layers; place slats or piling-strips between different layers, one near each end of the pile, and others at short distances to keep the timber straight. These strips should be one over the other, and in large piles should not be less than 1 inch thick. Spokes are piled in square piles, the length of one piece, omitting the slats. Light timber may be piled in attics, heavy timber on the ground-floor. Each pile should contain but one kind of timber, and be marked with the date of inspection and the number and kind of pieces it contains. Pieces of the same kind and of different dates of receipt, if piled one on the other, should have that which was received first piled on top. The piles should be at least 2½ feet apart: this secures free access at all times to the different kinds of pieces in store.

Timber should be repiled at intervals varying with the time it has been in store, and all pieces showing evidences of decay should be thrown out, to prevent their affecting those which are still sound.

Timber store-houses are best provided with blinds, which keep out the rain and snow, but which can be turned to admit the air freely in fine weather. They should be kept entirely free from pieces of decayed wood.

This gradual mode of seasoning is considered the most favorable to the strength and durability of timber, but various methods have been proposed for hastening the process. For this purpose, *steaming* timber has been applied with success; and the results of experiments with Mr. Kyan's process of saturating timber with a solution of corrosive sublimate have been highly satisfactory: this is said to harden and season the wood, at the same time that it secures it from the dry-rot and from the attacks of worms. The process of Mr. Earle, which consists in saturating the wood with a hot solution of the sulphates of copper and iron, mixed together, has been tried by the Ordnance Department, and found to impair the strength without increasing the durability of the timber. *Kiln-drying* is serviceable only for boards and pieces of small dimensions, and is apt to cause cracks and to impair the strength of wood, unless performed very slowly. *Charring* or *painting* is highly injurious to any but seasoned timber, as it effectually prevents the drying of the inner part of the wood, in which, consequently, fermentation and decay soon take place.

Timber piled in badly-ventilated sheds is apt to be attacked with *dry-rot.* The first outward indications are yellow spots on the ends of the pieces and a yellowish dust in the checks and cracks, particularly where the pieces rest on the piling-strips: when cut, the timber is of a dull, reddish-brown color, dotted over with small white specks, and it is brittle and very weak.

Timber requires from 2 to 8 years to season thoroughly, according to its size. It should be worked as soon as it is thoroughly dry, for it begins to deteriorate after that time. Very old timber, as the workmen say, loses its life.

Oak timber loses about *one-fifth of its weight* in seasoning, and about *one-third of its weight* in becoming perfectly dry.

Measuring Timber.

Sawed or hewn timber is measured by the cubic foot, or more commonly by *board measure,* the unit of which is a superficial foot of a board 1 inch thick. Small pieces, especially those which are got out by splitting, (such as spokes,) and *shapes,* or pieces roughed out to a particular pattern, (such as stocks for small arms,) are often purchased by the piece.

Usual rule for measuring round timber:

Multiply the length by the square of one-fourth the mean girth, for the solid contents; or, $\frac{L C^2}{16}$; L being the length of the log, and C half the sum of the circumferences of the two ends. But when round timber is procured for use in the Ordnance Department, it should be measured according to the square of good timber which can be obtained from the log.

To find the number of feet, *board measure,* in any piece of timber of a given width, multiply the tabular *area,* for that width, by the length in feet and the thickness in inches.

TABLE, *showing the Superficial Feet in one Lineal Foot of Boards of various widths.*

Width.	Area.	Width.	Area.	Width.	Area.
In.	Sup. ft.	In.	Sup. ft.	In.	Sup. ft.
0.25	0.0208	4.25	0.3542	8.25	0.6875
0.5	0.0417	4.5	0.375	8.5	0.7083
0.75	0.0625	4.75	0.3958	8.75	0.7292
1.	0.0833	5.	0.4167	9.	0.75
1.25	0.1042	5.25	0.4375	9.25	0.7708
1.5	0.125	5.5	0.4583	9.5	0.7917
1.75	0.1458	5.75	0.4792	9.75	0.8125
2.	0.1667	6.	0.5	10.	0.8333
2.25	0.1875	6.25	0.5208	10.25	0.8542
2.5	0.2083	6.5	0.5417	10.5	0.875
2.75	0.2292	6.75	0.5625	10.75	0.8958
3.	0.25	7.	0.5833	11.	0.9167
3.25	0.2708	7.25	0.6042	11.25	0.9375
3.5	0.2917	7.5	0.625	11.5	0.9583
3.75	0.3125	7.75	0.6458	11.75	0.9792
4.	0.3333	8.	0.6667	12.	1.0000

IRON.

Iron is obtained from its ores, in which it generally exists in the state of an oxide, combined with earthy or stony matters, and frequently with *carbon, sulphur, arsenic, magnesia, manganese,* &c. Iron-ores are classed and named according to their different combinations, as *magnetic, specular, micaceous, clay iron-stone, red hematite, brown hematite:* the last named is the ore from which the Salisbury and the Juniata irons are extracted; the first, that from which the Swedish iron is obtained; and the clay iron-stone that from which the iron of England is made.

The foreign substances which iron is found to contain modify in a marked manner its essential properties. *Carbon* adds to its hardness, but destroys some of its characteristic qualities, and produces cast iron or steel according to the proportion of carbon it contains. *Sulphur* renders it fusible, difficult to weld, and brittle when heated, *hot short. Phosphorus* renders it *cold short,* but may be present in the proportion of $\frac{2}{1000}$ to $\frac{3}{1000}$ without affecting injuriously its tenacity. *Antimony, arsenic,* and *copper* have the same effect as sulphur,—the last in a greater degree.

Cast Iron.

The process of making cast iron depends much on the kind of fuel used: charcoal, coke, bituminous and anthracite coals, are all used. When anthracite coal is employed, the ore is placed at once in the blast-furnace;

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when charcoal is used, the ore is first *roasted*, by distributing it in alternate layers with waste coal, wood, or, sometimes, with charcoal, and the pile thus formed is ignited and burned in the open air. For the more refractory ores a kiln similar to that used for burning lime is required. The ore is rendered, by this operation, more porous and easily broken into small pieces, by which it is more readily acted upon in the smelting-furnace The small pieces would be disadvantageous in an anthracite furnace.

Smelting is the process by which the iron is separated from the refractory substances with which it is combined in the ore. It consists in raising the ore to a high heat in contact with carbon and a suitable flux in the blast or smelting furnace. The flux unites with the earthy matter of the ore, forming a glassy substance called *slag* or cinder, and the carbon unites with the oxygen of the ore, setting the iron free, which in turn unites with a portion of the carbon and forms a fusible compound, *carburet of iron*, or *cast iron*.

The melted iron and slag descend to the bottom of the furnace, the slag forming a covering to the pool of iron and protecting it from the action of the blast. As they accumulate, the slag runs off over the dam, and is a good indication, to an experienced eye, of the quality of metal the furnace is making.

The furnace is generally tapped once every twelve hours, and the metal is run out into channels formed in the sand, and is known as *pigs*.

Limestone is the flux used for most ores; clay is sometimes required to mix with ores containing much limestone.

A larger yield from the same furnace, and a great economy in fuel, are effected by the use of a *hot blast*. The greater heat thus produced causes the iron to combine with a larger percentage of foreign substances, and the strength of the cast iron is thus injured.

Cast iron for cannon and for all purposes requiring great strength should be smelted with the cold blast.

Pig iron, according to the proportion of carbon which it contains, is divided into *foundry-iron* and *forge-iron*, the latter being adapted only to conversion into malleable iron; while the former, containing the largest proportion of carbon, can be used either for casting or for making bar iron.

There are many varieties of cast iron, differing from each other by almost insensible shades; the two principal divisions are *gray* and *white*, so called from the color of the fracture when recent. Their properties are very different.

Gray iron is softer and less brittle than white iron; it is in a slight degree malleable and flexible, and is not sonorous; it can be easily drilled and turned in the lathe, and does not resist the file. It has a brilliant fracture, of a gray, or sometimes a bluish-gray, color; the color is lighter as the grain becomes closer, and its hardness increases at the same time.

It melts at a lower heat than white iron, becomes more fluid, and preserves its fluidity longer; it runs smoothly; the color of the fluid metal is red, and deeper in proportion as the heat is lower; it does not stick to the ladle; it fills the moulds well, contracts less and contains fewer cavities than white iron; the edges of a casting are sharp, and the surface smooth, convex, and covered with carburet of iron. A medium-sized grain, bright gray color, lively aspect, fracture sharp to the touch, and a close compact texture, indicate a good quality of iron. A grain either very large or very small, a dull, earthy aspect, loose texture, dissimilar crystals mixed together, indicate an inferior quality.

Gray iron is used for ordnance purposes where the pieces are to be bored or fitted.

Its tenacity and specific gravity are *diminished* by annealing. Its mean specific gravity is 7.200.

White iron is very brittle and sonorous; it resists the file and the chisel, and is susceptible of high polish; the surface of a casting is concave; the fracture presents a silvery appearance, generally fine-grained and compact, sometimes radiating, or lamellar.

When melted it is white, and throws off a great number of sparks, and its qualities are the reverse of those of gray iron; it is, therefore, unsuitable for ordnance purposes. Its tenacity is *increased* and its specific gravity *diminished* by annealing. Its mean specific gravity is 7.500.

Mottled iron is a mixture of white and gray; it has a spotted appearance; it flows well and with few sparks; the casting has a plane surface, with edges slightly rounded. It is suitable for making shot and shells.

A fine mottled iron is the only kind suitable for making castings which require great strength, such as cannon. The kind of mottle will depend much on the size of the casting.

Besides these general divisions, the manufacturers distinguish more particularly the different varieties of pig metal by numbers, according to their relative hardness.

No. 1 is the softest iron, possessing in the highest degree the qualities described as belonging to gray iron; it has not much strength, but on account of its fluidity when melted and of its mixing advantageously with old or scrap iron, and with the harder kinds of cast iron, it is of great use to the founder, and commands the highest price.

No. 2 is harder, closer grained, and stronger than No. 1; it has a gray color and considerable lustre. It is the kind of iron most suitable, in general, for making shot and shells.

No. 3 is still harder than No. 2. Its color is gray, but inclining to white; it has considerable strength, but it is principally used by the founder for mixing with other kinds of iron.

No. 4 is *bright* iron; No. 5, *mottled*; No. 6, *white*,—which is unfit for general use by itself.

The qualities of these various kinds of iron seem to depend on the proportion of carbon, and on the state in which it is found in the metal. In the darker kinds of iron, where the proportion is sometimes 7 per cent. of carbon, it exists partly in the state of graphite or plumbago, which makes the iron soft. In white iron, the carbon is thoroughly combined with the metal, as in steel.

Cast iron frequently retains a portion of foreign ingredients from the ore, such as earths, or oxides of other metals, and sometimes sulphur and phosphorus, which are all injurious to its quality. Sulphur hardens the iron, and, unless in a very small proportion, destroys its tenacity.

These foreign substances, and also a portion of the carbon, are separated by melting the iron in contact with air, and soft iron is thus rendered harder and stronger. The effect of remelting varies with the nature of the iron and the kind of ore from which it has been extracted; that from the hard ores, such as the magnetic oxides, undergoes less alteration than that from the hematites; the latter being sometimes changed from No. 1 to *white* by a single remelting in the air furnace.

The color and texture of cast iron depend greatly on the size of the casting and the rapidity of cooling; a small casting, which cools quickly, is almost always *white*, and the surface of large castings partakes more of the qualities of white metal than the interior.

All cast iron expands forcibly at the moment of becoming solid, and again contracts in cooling; gray iron, as before remarked, expands more and contracts less than other iron.

The contraction is about $\frac{1}{100}$ for gray and strongly-mottled iron, so that the dimensions of a *pattern* for casting should be about $\frac{1}{100}$ larger than the size required for the casting.

Malleable Iron.

Malleable iron is made from the pig, in the *bloomery-fire* or in the *puddling-furnace*,—generally in the latter.

The process consists in melting the cast iron and keeping it exposed to a great heat, constantly stirring the mass, bringing every part of it evenly under the action of the flame, until it loses its remaining carbon,—when it becomes malleable iron.

The bloomery resembles a large forge-fire, where charcoal and a strong blast are used, and the refined metal or the pig iron, after being broken into pieces of the proper size, is placed before the blast, directly in contact with the charcoal; as the metal fuses, it falls into a cavity left for that purpose below the blast, where the bloomer works it into the shape of a *ball*, which he places again before the blast, surrounded with fresh charcoal; this operation is generally again repeated, when the ball is ready for the *shingler*.

The PUDDLING-FURNACE is a reverberatory furnace, with a cast-iron bottom lined generally with a pure and refractory iron ore, where the flame of bituminous coal is made to act directly on the metal.

The operation of puddling is a most important one, as the quality of the iron depends so much upon the skill with which it is conducted.

The metal is first melted, and the puddler then begins to stir it, exposing each portion in turn to the action of the flame, and continues this as long as he is able to work it. When it has lost its fluidity, he forms it into puddler's balls, weighing from 80 to 100 lbs., which are next passed to the shingler.

SHINGLING is performed in a strong *squeezer* or under the trip-hammer. Its object is to press out as perfectly as possible the liquid cinder which the ball still contains: it also forms the ball into shape for the puddle-rolls. A heavy hammer, weighing from 6 to 7 tons, effects this object most thoroughly, but not so cheaply as the squeezer. The ball receives from 15 to 20 blows of the hammer, being turned from time to time as required: it is now called a *bloom*, and is ready to be rolled or hammered. Or the ball is passed once through the squeezer, and is still hot enough to be passed through the puddle-rolls.

PUDDLE-ROLLS.—By passing through different grooves in these rolls, the bloom is reduced to a *rough bar* from three to four feet in length, its name conveying an idea of its condition, which is rough and imperfect.

PILING.—To prepare rough bars for this operation, they are cut, either hot or cold, by means of a strong pair of *shears*, into such lengths as are best adapted to the size of the finished bar required; the sheared bars are piled, one over the other, to the number of from two to six or more pieces, according to the size required,—when the pile is ready for balling.

BALLING.—This operation is performed in the balling-furnace, which is similar to the puddling-furnace, except that its bottom or hearth is made up, from time to time, with sand; it is used to give a welding-heat to the piles to prepare them for rolling.

FINISHING-ROLLS.—The *balls* are passed successively between rollers of various forms and sizes according to the shape of the finished bar required.

The bars are straightened on a cast-iron bed, with heavy wooden beetles.

The *quality* of the iron depends on the kind of pig used, the skill of the puddler, and the absence of deleterious substances in the furnace.

The strongest cast irons do not produce the strongest malleable iron.

For many purposes, such as sheets for tinning, best boiler-plate, and bars for converting into steel, *charcoal iron* is used exclusively; and, generally, this kind of iron is to be relied upon for strength and toughness with greater confidence than any other,—though iron of superior quality is made from pigs made with other fuel and with the hot blast; iron for gun-barrels has been lately made from anthracite hot-blast pigs.

Iron is improved in quality by judicious working, reheating it, and hammering or rolling: other things being equal, that is the best iron that has been wrought the most.

Piles are sometimes made of good iron on top and bottom and poorer iron in the middle: this is easily detected in the fracture. Reject it, where strength and toughness are required.

Bar Iron.—The iron used in ordnance constructions is generally furnished in bars of different sizes, or in *shapes*. It should be of the best quality of iron, highly refined.

The quality of iron is generally judged of by its *grain* as shown in a fresh fracture.

The sample should be 1 inch square, or, if a flat bar, ½ inch thick. Cut a notch on one side with a cold-chisel, and bend the bar down over the edge of an anvil, or give it a heavy blow, when lying flat on the ground, with a sledge-hammer; if the fracture exhibit long, silky fibres, of a leaden-gray color, cohering together and twisting or pulling apart before breaking, it denotes a tough, soft iron, which is easy to work and hard to break, suitable for sheet iron, wire, &c., but it may weld badly. A medium, even grain, mixed with fibres as above, but without bright specks or dark spots, is also a favorable indication. In general, a short, blackish fibre indicates iron badly refined and mixed with carbon, plumbago, or oxide; if worked very hot, it may be improved, but there will be a great waste. *A very fine, close grain* denotes a hard, steely iron, which is apt to be *cold-short*, hard to work with the hammer or file. *A coarse grain*, with a brilliant, crystallyzed fracture, or yellow or brown spots, denotes a brittle iron, inclined to be *cold-short*, but working easily when heated, and making a good weld. But this test is not always sufficient, as the same iron will present different appearances according to the manner in which it has been forged and the degree of heat to which it has been subjected. Numerous cracks on the edges of the bar generally indicate a *hot-short* iron, which cracks or breaks when punched or worked at a red heat, and will not weld; it is strong when cold, and may be useful in that state, but, if worked, care should be taken not to subject it to strains at a red heat. *Blisters*, *flaws*, and *cinder-holes* are caused by imperfect welding at too low a heat, or by the iron not being properly worked, and do not always indicate an inferior quality.

The surest test of the quality of iron is to submit it to the following proofs:—

Test when cold.—Bend the iron, if in small bars, several times back and forth in different directions, at sharp angles, with heavy blows of a hammer, and twist it in a vise. Large pieces are reduced in size at one end, and submitted to the same tests. Round bars have a screw-thread cut on them, and are then bent according to the use for which they are intended. Pieces which are to have holes in them are tested by punching holes in them cold.

Test when hot.—Draw out the iron, bend and twist it; split it, and turn back the two parts, to see if the split extends up; punch a long hole in the direction of the fibre, and another at right angles to it; punch holes of different forms,—some near the edge; weld the iron to iron and to steel; make chains from small rods; observe if cracks or flaws weld easily; finally, forge some of the most difficult pieces for which the iron is intended.

NOTE ON FORGING.—Good iron is often injured by being unskilfully worked. Care should be taken that the iron while heating is not exposed to the air, which would assist in forming scales of oxide on its surface: it is to prevent this that the workman from time to time throws sand or clay on his iron to protect it. When iron is at a white heat, immediate contact with coal tends to carbonize it and make it *steely*. Iron heated for any purpose, and especially for welding, should be heated as rapidly as possible, in order to expose it the least possible time to the action of the air and coal; for this purpose, the strongest fuel, with an abundant, steady blast, is necessary. Defects in iron caused by unskilful working may be remedied in part: if, for example, iron has been *burned*, give it a smart heat, protected as much as possible from the air; if the iron has been injured by *cold-hammering*, a moderate annealing-heat will restore it; if the iron has become hard and steely, give it one or more smart heats, to extract the carbon.

Inspection of Iron for Garrison and Sea-Coast Carriages.

The *cheek-plates* should be made of iron of good quality, uniform in thickness, a plane surface, and cut near to the required size. Verify the size by a wooden frame made of the required shape, and the thickness by an iron gauge. Try the quality of the iron by punching holes near the edge at the place for the trunnion-holes.

The *rails* should be straight on the top, bottom, and edge of the flange: try them by laying a straight-edge on them. The web should be a plane surface, without corrugations,—at right angles to the flanges, which should be smooth and free from breaks or cracks.

Examine that the welds are all good, that there are no seams, and that the iron has not been burned. Verify the cross-section of the rail by a profile cut from sheet iron or mahogany; measure the length with a rod of the correct length.

See that the trough-beams and angle-iron are straight, and their edges sound, without cracks. Verify their length.

Examine the bar-iron by the tests given above for bar-iron, and where the pieces are cut to lengths, verify them.

Weigh several pieces of each kind of the exact length, sufficient to get a fair mean weight, from which the weight of the whole can be calculated.

Puddled Steel.

If, in the operation of puddling, the process be stopped at a particular time determined by indications given by the metal to an experienced eye, an iron is obtained of greater hardness and strength than ordinary iron, to which the name of semi-steel, or puddled steel, has been applied. The principal difficulty in its manufacture is that of obtaining uniformity in the product, homogeneity and solidity throughout the entire mass. It is much improved by reheating and hammering under a heavy hammer.

A tenacity of 118,000 lbs. to the square inch has been obtained from semi-steel made in this country in this way. Field-pieces have been made of this material, and it is believed that it will answer well for this purpose.

Steel.

Steel is a compound of iron and carbon, in which the proportion of the latter is from 5 to 1 per cent., and even less, in some kinds. Steel may be distinguished from iron by its fine grain; its susceptibility of hardening by immersing it, when hot, in cold water; and with certainty by the action of diluted nitric acid, which leaves a black spot on steel, and on iron a spot which is lighter colored in proportion as the iron contains less carbon.

There are many varieties of steel, the principal of which are:

Natural steel, which is obtained by reducing the rich and pure kinds of iron-ore with charcoal, and refining the cast iron, so as to deprive it of a sufficient portion of carbon to bring it to a malleable state. It is made principally in Germany, and is used for making files and other tools.

The India steel, called *wootz*, is said to be a natural steel, containing a small portion of other metals.

Blistered steel, or steel of cementation, is prepared by the direct combination of iron and carbon. For this purpose, the iron in bars is put in layers alternating with powdered charcoal, in a close furnace, and exposed for 7 or 8 days to a heat of about 70° Wedgewood, and then suffered to cool for as many days more. The bars on being taken out are covered with blisters, have acquired a brittle quality, and exhibit in the fracture a uniform crystalline appearance. The degree of carbonization is varied according to the purposes for which the steel is intended, and the best qualities of iron (Russian and Swedish) are used for the finest kinds of steel.

Tilted steel is made from blistered steel moderately heated and subjected to the action of a tilt-hammer, by which means its tenacity and density are increased and it is thus adapted to use.

Shear steel is made from blistered or natural steel refined by piling thin bars into fagots, which are brought to a welding-heat in a reverberatory furnace, and hammered or rolled again into bars; this operation is repeated several times to produce the finest kinds of shear steel, which are distinguished by the names of *half-shear*, *single shear*, and *double shear*, or steel of 1 *mark*, of 2 *marks*, of 3 *marks*, etc., according to the number of times it has been piled.

Cast steel is made by breaking blistered steel into small pieces and melting it in close crucibles, from which it is poured into iron moulds; the *ingot* is then reduced to a bar by hammering or rolling, as described under the head of malleable iron, these operations being performed with great care. Cast steel is the finest kind of steel and best adapted for most purposes: it is known by a very fine, even, and close grain, and a silvery, homogeneous fracture; it is very brittle, and acquires extreme hardness, but is difficult to weld without the use of a flux. The other kinds of steel have a similar appearance to cast steel, but the grain is coarser and less homogeneous; they are softer and less brittle, and weld more readily. A fibrous or lamellar appearance in the fracture indicates an imperfect steel. A material of great toughness and elasticity, as well as hardness, is made by forging together steel and iron, forming the celebrated *damask-steel*, which is used for sword-blades, springs, etc.; the damasked appearance is produced by the action of a diluted acid, which gives a black tint to the steel parts, whilst the iron remains white.

Various *fancy steels*, or alloys of steel with *silver*, *platinum*, *rhodium*, and *aluminium*, have been made with a view to imitating the Damascus steel, wootz, etc., and improving the fabrication of some of the finer kinds of surgical and other instruments.

Properties of Steel.—The best steel possesses the following characteristics: heated to redness and plunged into cold water, it becomes hard enough to scratch glass and to resist the best files; the hardness is uniform throughout the piece; after being tempered it is not easily broken; it welds readily; it does not crack or split; it bears a very high heat, and preserves the capability of hardening after repeated working; the grain is fine, even, and homogeneous, and it receives a brilliant polish. Its specific gravity is 7.816, being greater than that of iron.

Test.—Break a few bars, taken at random; make tools of them and try them in the severest manner.

Hardening and Tempering Steel.—On these operations the quality of manufactured steel in a great measure depends.

Hardening is effected by heating the steel to a cherry red, or until the scales of oxide are loosened on the surface, and plunging it into a liquid, or placing it in contact with some cooling-substance; the degree of hardness depends on the heat and the rapidity of cooling. Steel is thus rendered so hard as to resist the hardest files, and it becomes at the same time extremely brittls. The degree of heat and the temperature and nature of the cooling-medium must be chosen with reference to the quality of the steel and the purpose for which it is intended. Cold water gives a greater hardness than oils or other fatty substances, sand, wet iron scales or cinders, but an inferior degree of hardness to that given by acids. Oil, tallow, etc., prevent the cracks which are caused by too rapid cooling. The lower the heat at which the steel becomes hard, the better.

Tempering.—Steel in its hardest state being too brittle for most purposes, the requisite strength and elasticity are obtained by tempering,—or *letting down the temper*, as the workmen term it,—which is performed by heating the hardened steel to a certain degree and cooling it quickly. The requisite heat is usually ascertained by the color which the surface of the steel assumes from the film of oxide thus formed. The degrees of heat to which these several colors correspond are as follows:—

At 430°	Fahr.,	a very faint yellow.	Suitable for hard instruments; as hammer-faces, drills for hard substances, etc.
At 450°	"	a pale straw color.	
At 470°	"	a full yellow.........	For instruments requiring hard edges without elasticity; as shears, scissors, tools for turning iron and steel.
At 490°	"	a brown color........	
At 510°	"	brown, with purple spots	For tools for cutting wood and soft metals; such as plane-irons, chisels, knives, etc.
At 538°	"	purple................	
At 550°	"	dark blue	For tools requiring strong edges without extreme hardness; as cold-chisels, axes, table-cutlery, etc., which will break before bending.
At 560°	"	full blue..............	
At 600°	"	grayish blue, verging on black......	For spring-temper, which will bend before breaking; saws, sword-blades, etc.

If the steel be heated higher than this, the effect of the hardening-process is destroyed.

Case-hardening.—This operation consists in converting the surface of wrought iron into steel, by cementation, for the purpose of adapting it to receive a polish or to bear friction, etc.; this is effected by heating the iron to a cherry red, in a close vessel, in contact with carbonaceous materials, and then plunging it into cold water. Bones, leather, hoofs, and horns of animals are generally used for this purpose, after having been burnt or roasted so that they can be pulverized. Soot is also frequently used.

Welding-Composition for Iron or Steel.

Borax	10 parts.
Sal-ammoniac	1 "

Pound them together, and melt them in a crucible into a clear liquid; pour it out on an iron plate, and, when cold, pulverize it for use.

Composition No. 2.

Borax	5. lbs.
Sal-ammoniac	1.0 "
Prussiate of potash	.5 "
Rosin	.5 "
Alcohol	.5 pint.
Water	.5 "
Iron-filings	.5 lb.

Put all the materials in an iron pan together, and melt them over a gentle fire, so that the composition shall boil for a few minutes, stirring it until it shall become finally dry and charred; then pulverize, and use it in the same manner as borax, applying it to the parts to be welded when at a red heat.

Sheet Iron.

Sheet iron is made by rolling. It should be soft and tough, its surface very smooth, without holes or thick scales; it is generally of a bluish color, sometimes clouded; the sheet should be of regular thickness, elastic, and crackling when bent in the hands. When bent at a right angle, there should be no appearance of fracture on the exterior.

Russia sheet iron has a planished, glossy, and smooth surface of gray oxide of iron; it should be free from rust or flaws, and be very soft and tough. Punch holes in it near the edge, and see that there are no flaws or cracks after this operation.

The severest test of sheet iron consists in hammering a part of the sheet into a concave form.

SHEET STEEL is manufactured in the same way, and should have the same qualities, as sheet iron, with greater elasticity and hardness in a thinner sheet.

For the weight of sheet iron, see Tables on pages 422 and 443.

Sheet Tin.

Sheet tin is made by coating sheet iron with tin. The iron is first *scoured,* or thoroughly cleaned, by means of an acid, and then immersed in melted tin. There are two kinds,—called *single tin* and *double tin,* differing in thickness and in the quantity of tin with which the iron is coated. The surface of the sheets should be bright and smooth, free from specks, beads, and blisters.

Dimensions of Sheet Tin.

Kind.	Size.	Mean Thickness.		Weight.	Remarks.
	In.	Wire Gauge.	In.	Lbs.	
Single tin....	10 × 14	31	0.0125	0.5	There are usually 225 sheets in a box.
Double X.....	10 × 14	27	0.018	0.75	
Roofing.......	20 × 14	27	0.018	1.5	112 sheets in a box.

A *square* of roof (100 square feet) requires about 71 sheets of roofing-tin.

Thickness and Weight of Sheet Metals.

Thickness by the Gauge.	Weight per Square Foot in Pounds.			
	Thickness in Inches.	Sheet and Boiler Iron.	Sheet Cast Steel.	Sheet Copper.
No. 0	0.340	13.7	14.0	15.6
" 1	0.300	12.1	12.4	13.8
" 2	0.284	11.4	11.7	13.0
" 3	0.259	10.4	10.6	11.9
" 4	0.238	9.60	9.80	11.0
" 5	0.220	8.85	9.02	10.1
" 6	0.203	8.17	8.33	9.32
" 7	0.180	7.24	7.38	8.25
" 8	0.165	6.65	6.78	7.59
" 9	0.148	5.96	6.08	6.80
" 10	0.134	5.40	5.51	6.16
" 11	0.120	4.83	4.93	5.51
" 12	0.109	4.40	4.50	5.02
" 13	0.095	3.83	3.91	4.37
" 14	0.083	3.34	3.41	3.81
" 15	0.072	2.90	2.96	3.31
" 16	0.065	2.62	2.67	3.00
" 17	0.058	2.34	2.39	2.67
" 18	0.049	1.97	2.01	2.25
" 19	0.042	1.69	1.72	1.93
" 20	0.035	1.41	1.42	1.61
" 21	0.032	1.29	1.31	1.47
" 22	0.028	1.13	1.15	1.29
" 23	0.025	1.00	1.02	1.14
" 24	0.022	0.885	0.903	1.01
" 25	0.020	0.805	0.820	0.918
" 26	0.018	0.724	0.738	0.826
" 27	0.016	0.644	0.657	0.735
" 28	0.014	0.563	0.574	0.642
" 29	0.013	0 523	0.533	0.597
" 30	0.012	0.483	0.493	0.551
" 31	0.010	0.402	0.410	0.480
" 32	0.009	0.362	0.370	0.420
" 33	0.008	0.322	0.328	0.370
" 34	0.007	0.282	0.288	0.323
" 35	0.005	0.230	0.235	0.262
" 36	0.004	0.170	0.173	0.194

Files and Rasps.

LIST OF FILES AND RASPS REQUIRED FOR USE AT AN ARSENAL OF CONSTRUCTION.

No.	Kind.	Length.	Width.	Thickness.	Weight.	Remarks.
		In.	In.	In.	Lbs. oz.	
1	Flat rough (ruffs).....	14.	1.35	0.35	1 4	Flat, tapering
2	Do. do.	12.	1.17	0.3	0 15	
3	Do. bastards...........	12.	1.17	0.3	0 14	
4	Do. do.	8.	0.7	0.2	0 5	
5	Half-round bastards..	12.	1.14	0.32	0 11	
6	Do. do.	9.	0.85	0.25	0 5½	
7	Do. do.	6.	0.56	0.2	0 1½	
8	Round bastards.......	12.	....	0.5	0 8½	
9	Do. do.	9.	....	0.23	0 2	
10	Do. do.	6.	....	0.23	0 ¾	
11	Do. do.	4.5	....	0.16	0 ¼	
12	Square do.	12.	0.5	0.5	0 9	
13	Do. do.	8.	0.32	0.32	0 3	
14	Do. do.	6.	0.24	0.24	0 2	
15	Do. do.	4.	0.2	0.2	0 ¾	
16	Flat, single cut (floats)...............	12.	1.12	0.22	0 10½	1 edge rounded.
17	Flat, hand, smooth,	12.	1.16	0.31	1 2	Safe edge.
18	Do. do.	9.	0.96	0.27	0 10	Do.
19	Do. do.	8.	0.83	0.2	0 6	Do.
20	Do. do.	4.	0.44	0.1	0 ¾	Do.
21	Half-round, hand, do.	12.	1.15	0.33	0 12	
22	Do. do.	9.	0.84	0.27	0 5½	
23	Do. do.	6.	0.6	0.18	0 1½	
24	Taper, handsaw.......	4.5	△	0.4	0 1¼	
25	Flat, shoeing rasp....	14.	1.5	0.35	1 8	
26	Half-round do.	12.	1.14	0.32	0 11	Without tang.

English files are generally used at the arsenals and armories.

Files should be made of the best cast steel. The teeth are generally cut at an angle of 60° with the centre-line; at a smaller angle the teeth are apt to choke, and at a greater angle they do not cut.

In choosing files, they should be examined to see that they are straight. that they are free from cracks and flaws, and that they are cut regularly. The teeth should not be turned or broken by filing on iron or tempered steel. One out of each dozen may be tried on a piece of tempered steel. such as the tang of a file screwed in a vise; the file should "take" in its whole length, both on the flat and edge, and should not cut in drawing back; it should not make furrows, or show a tendency to deviate from the direction given to it by the hand. The quality of the steel may be determined by breaking some of the files and working the steel in the forge.

Wood-Screws.

Wood-screws are classed by the length in inches, and by the number, which indicates the size of the wire, or body of the screw.

The following table of dimensions, derived from measurements of the screws made by the New England Screw Company, at Providence, Rhode Island, will be found convenient for reference.

No.	Diameter of Body.	Head.		Number of threads to 1 inch.	Remarks.
		Diameter.	Thickness.		
	In.	In.	In.		
3	0.10	0.20	0.06	24	The length of thread cut is two-thirds the length of the screw
4	.11	.22	.065	24	
5	.13	.26	.075	20	
6	.15	.30	.08	20	
7	.16	.32	.085	18	
8	.17	.34	.09	14	
9	.19	.38	.095	13½	
10	.20	.40	.10	13	
11	.21	.42	.11	12	
12	.22	.44	.12	11	
13	.23	.46	.13	11	
14	.24	.48	.14	10	
15	.25	.50	.15	10	
16	.26	.52	.16	9½	
17	.27	.54	.17	9	
18	.28	.56	.18	8½	
20	.30	.60	.20	8	
21	.32	.64	.21	8	
22	.35	.70	.22	7½	
24	.38	.76	.24	7	
26	.40	.80	.26	7	

Cut Nails.

Nos.	2*d.*	3*d.*	4*d.*	6*d.*	8*d.*	10*d.*	12*d.*	20*d.*
Length .... inches.	1.	1.25	1.5	2.	2.5	3.	3.5	4.
Number in 1 lb.........	550	450	340	150	100	60	40	25

Spikes are large nails, *wrought* or *cut:* the size is designated by the length in inches.

Bellows-nails and *clout-nails* are short wrought nails, with large heads, slightly convex: they are used chiefly for nailing leather, canvas, etc., on wood.

Bellows-nails 1.13 inch long, 0.1 inch thick, with heads .75 inch to 1 inch in diameter, should weigh about 120 to 1 lb.

Tacks are classed by the length in inches, or by the weight of 1,000, in ounces.

Sprigs, brads, finishing-nails, are classed by the length in inches.

Alloys.

Bronze.—Gun-metal: 90 copper and 10 tin.

Bell-metal.—78 copper and 22 tin.

Fine brass.—2 copper and 1 zinc.

Brass for parts of small arms and of gun-carriages.—80 copper, 17 zinc, and 3 tin.

Sheet brass.— 3 copper and 1 zinc.

Silver solder.—4 silver and 1 copper; or 2 silver and 1 brass wire.

Hard solder.—1 zinc and 2 brass.

Plumber's solder.—1 tin and 1 lead.

Tinner's solder.—1 tin and 2 lead.

Pewterer's solder.—2 tin and 1 lead.

Fusible alloy.—2 tin; 3 lead; 5 bismuth: melts at 197°.

Type-metal.—11 lead, 2 antimony, and $\frac{1}{4}$ tin.

German silver.—$40\frac{1}{2}$ copper; $31\frac{1}{2}$ nickel; $25\frac{1}{2}$ zinc; $2\frac{1}{2}$ iron.

" " for casting.—60 copper; 20 zinc; 20 nickel; 3 lead.

Pewter.—4 tin and 1 lead.

An alloy that expands in cooling.—9 lead, 2 antimony, and 1 bismuth; useful for filling small cavities in cast iron.

Babbit's metal, for journal-boxes.—9 tin and 1 copper.

Pickle for Cleaning Iron.—To a mixture of equal parts of nitric and muriatic acids add twelve times their joint volume of water.

Liquor for Tinning or Soldering.—Dissolve 3 ounces of zinc in a pint of muriatic acid, letting it stand in a warm place about 8 hours; strain the solution through a cotton or linen cloth; add a teaspoonful of pulverized sal-ammoniac to a pint of the solution, and let it boil for ten minutes; when cool it is fit for use.

To Tin Iron.—Immerse the iron in the cleaning-pickle; if the surface be rough, let it remain in the pickle about 4 hours, or until all the scales can be rubbed off. Then dip the iron into the solution of zinc, and immediately afterward into the melted tin, which must be kept a little above the melting-point. Let it remain in the melted tin until the latter has ceased to be agitated, when the iron will have become warm enough for the tin to adhere; on taking it out, wipe or shake off the surplus tin.

To Tin Copper.—It is only necessary to dip the copper into the solution of zinc and then into the bath of tin; or to clean the copper with diluted sulphuric acid before immersing it in the tin.

STORAGE AND PRESERVATION OF METALS.

Metals are stored on the ground-floors of dry and well-aired buildings, which should be kept open in fine weather only.

Bar-iron and *steel*, and pieces rough-forged, (*shapes*,) divided according to kind and size, on racks, or standing upright in frames; *unserviceable iron* and *scraps*, in piles marked with the weight. *Sheet iron* and *tin*, oiled, and placed on edge, in frames. *Wire*, oiled, in coils, hung on hooks; arranged according to kind and size.

Heavy chains, coiled up in piles.—*Small chains*, in bundles of 10 or 20, in boxes or on shelves.

Finished work, according to kind, in piles or in boxes.

Pig metal, in square piles; the flat sides lying together.

The iron and steel parts of implements, etc., covered with a black varnish, made of white varnish and lampblack, for intrenching and other heavy tools; of white varnish and ivory-black, for polished tools. (See Chapter VII.)

Artificer's tools and *files*, according to kind, in a dry place, with suitable divisions; they should be sprinkled with powdered charcoal, or fine quicklime, to protect them from rust.

Nails, according to kind and size, in bins or kegs. *Anvils* and other heavy pieces, on skids on the floor. Every division, bin, pile, and box should be marked with a label showing the character of the article contained in it, its kind, its distinctive number or size, the quantity, weight, &c.

ROPES.

The size of a rope is designated by the circumference or girth measured with a thread: thus, a 3-inch rope measures 3 inches round. *The length* is usually expressed in fathoms.

STRENGTH.—The utmost strength of good hemp rope is 6,400 lbs. to the square inch; the weight which it will bear before breaking is expressed in *tons* by *one-fifth of the square of the girth in inches;* in practice, a rope should not be subjected to more than half this strain. It stretches from $\frac{1}{7}$ to $\frac{1}{5}$, and its diameter is diminished from $\frac{1}{7}$ to $\frac{1}{4}$, before breaking. A difference in the quality of the hemp may produce a difference of $\frac{1}{4}$ in the strength of ropes of the same size.

White rope is stronger than tarred rope, and the difference is increased by age and service: therefore such ropes only as are to be immersed in water should be tarred.

Oil or grease diminishes the strength of rope without adding to its durability.

The strength of Manilla rope is less than that of hemp rope.

QUALITY.—The quality of hemp is in some measure indicated by its color: the best is of a pearl gray; the next, greenish; then, the yellow;

a brown color indicates that it has been rotted too long and has begun to decay. Brown spots show that it has moulded and the spots are decayed. The odor should be strong, but free from a musty, tainted smell. It should be well combed, pliant, and free from stalks. The yarns should be fine spun and slightly twisted; they are from $\frac{1}{4}$ to $\frac{1}{2}$ of an inch in girth. A rope is defective when the yarns are of unequal sizes or unequally twisted; when it is fuzzy before being used; and when it contains pieces of stalk, indicating that the hemp was not well combed.

Twisting or Laying.—The number of *yarns* in a *strand* of cordage varies from 16 to 25, and several strands are combined, or *laid*, to form a large rope. A rope is said to be twisted $\frac{1}{3}$ or $\frac{1}{4}$ when it is $\frac{1}{3}$ or $\frac{1}{4}$ shorter than the strand. For artillery service, ropes should be twisted $\frac{1}{4}$.

The degree of twisting may be determined by constructing a right-angled triangle, the base of which is the circumference of the rope, and the height the length of one revolution of the strand, measured parallel to the axis; the difference between this height and the hypothenuse is the quantity by which the rope is twisted.

Preservation in Store.—Ropes should be placed in the upper stories of a building, coiled up and labelled; large ropes on skids, so as to allow the circulation of air; small ropes hung up to the joists, on pins or hooks. Ropes should not be coiled until they are perfectly dry: they should be uncoiled every year, and stretched out for several days at the beginning of the dry season.

Ropes which have been too long in store lose their strength.

COAL.

Charcoal.

Charcoal is made from either hard or soft wood; that from the former, such as oak, maple, beech, chestnut, is the most serviceable, giving the greatest quantity of heat for an equal weight of coal.

For ordinary purposes it is burned in heaps or stacks. Wood from 18 to 20 years old is to be preferred. It may be charred immediately after being felled; if left for a year exposed to the weather before being burned, it produces an inferior coal.

Select sound wood; cut it into pieces from 4 to 5 feet long, and split those which are more than 4 inches in diameter.

It is well to make stacks, as far as practicable, of wood of the same kind, or of such as differ from each other but little in their general nature. If it be necessary to use soft and hard woods in the same stack, place the former on the outside.

Making Charcoal.—Choose a dry spot on which to place the stack, sheltered from the wind: level the ground. Plant a stake in the middle of the space, and cover the bottom of the pile with wood placed in a direction converging toward the centre, the intervals being filled up with small sticks; place the rest of the wood around the stake, the pieces nearly upright and close together, in several tiers, covering the whole with a layer of wood placed as close together as possible; leave one or more horizontal openings near the ground, from the exterior to the centre. Cover the stack, commencing at the top, with leaves and a coat of wet sod about 4 inches thick, leaving open a space 6 inches high, all round the bottom, for the escape of the air and steam.

Draw out the stake, and set fire to the pile, either by means of the hole left by the stake, or through the horizontal gallery, which may have been previously filled with combustible materials. Push the fire actively until the flame comes out at the top of the stack, in order to ignite the whole of the bottom part, and to expel the steam, which would otherwise occasion explosions. Then close the hole at the top, and cover the lower part of the pile, leaving small openings at intervals; the smoke should now escape equally from all parts of the stack, except toward the top, which is kept closed in order to prevent a draught. When the stack has *sweated* sufficiently, increase the thickness of the coating of earth; moderate the fire, and direct it, by means of openings on the sides, in such a manner that the combustion may be equal in every part and that the fire may be always drawn toward the bottom. Leave the holes open as long as the smoke is black and thick, and close them when it becomes light and of a bluish color.. The charring is completed when the flame escapes through the openings at the bottom; then stop the holes and cover the pile well with earth, which should be renewed after 24 hours; extinguish the fire entirely, and let the pile stand 12 or 24 hours more. Open it on one side only; select the coal, and separate what is imperfectly burnt. Wood furnishes in this way, on an average, about 16 or 17 per cent. of charcoal.

Large stacks are the most advantageous: as much as 50 or 60 cords of wood may be put iuto one.

Properties.—Charcoal of good quality burns slowly in the air, without flame; it is clean, hard, compact, brittle, sonorous, and of a fine black color; its fracture is shining, iridescent, and of a conchoidal form.

When not perfectly charred, it is tough, of a grayish color, and burns with a white flame and smoke. When too much burnt, it is of a dull black, soft and unelastic. By exposure to the air, charcoal absorbs from 10 to 20 per cent. of moisture, and its qualities are thereby impaired: it should therefore be kept under cover.

Pit-Coal.

Bituminous Coal.—There are two principal varieties.

Open-burning coal kindles quickly and burns well, but produces much flame and smoke, and is soon consumed; it lies open in the fire, and does not cake. Of this kind is the English cannel coal.

Close-burning coal melts and swells in the fire and runs together, forming what blacksmiths call a *hollow fire*, or a dome over the nozzle of the bellows, under which the iron is heated equally and covered from the air. This kind of coal forms a very hot fire and leaves little residuum: it is, there fore, the most suitable for smiths' use. The Newcastle coal and the Virginia, Maryland, North Carolina, and Pennsylvania bituminous coals are of this kind.

ANTHRACITE COAL is now extensively used for the forge, in fireplaces specially contrived for the purpose. It ignites with difficulty, and does not cake or melt in the smallest degree, but produces a very hot, open fire.

Coal is not injured, but, on the contrary, rather improved, by exposure to air and moisture.

Mean Weight of Coals.

KIND.	Specific gravity.	FOR STOWAGE.	
		Weight of 1 cubic foot.	Cubic feet to 1 ton.
		Lbs.	
Bituminous	1.355	51.4	43.58
Anthracite (egg size)	1.500	55.8	40.14

Coke.

Coke is produced by charring bituminous coal, in order to expel the bitumen and sulphur; this is usually done in close furnaces or ovens. Good coke has a dull fracture, is very porous and cellular; it gives very little ashes when burned; it is injured, like wood charcoal, by absorbing water.

Coal furnishes 60 to 70 per cent. of coke by weight; the volume being increased 5 to 20 per cent.

COAL-TAR is a bituminous product obtained by the distillation of coal in making gas, etc.

TAR, PITCH, TURPENTINE.

The following are the principal varieties of products from resinous trees, such as the pine.

TURPENTINE.—This is extracted from the tree in warm weather, by cutting a deep notch, or *box*, near the base, and scoring the tree by scraping off the bark above the box; the first year's running produces the *virgin* or *white turpentine*, and the second year's is nearly as good; after that the turpentine becomes each year darker and stiffer, the tree yielding less of what is called *dippings*, and more *scrapings;* the latter kind of turpentine is hard and yellow. A tree will bear tapping fourteen to sixteen years, on two sides alternately,—the scoring being extended upwards from twelve to fifteen inches each year.

Spirits of Turpentine is the *essential oil* obtained by distillation from the native turpentine.

Rosin, or Colophony, is the residuum of the distillation of turpentine. Its quality depends on that of the turpentine, and on the care used in distillation; the finest quality is of a light straw color.

Tar is obtained from the heart of the pine-tree by *smouldering*, or a smothered combustion, effected in stacks, nearly in the manner described for making charcoal. The tar runs off into trenches dug for the purpose. Tar is semi-fluid, transparent in thin portions, and of a reddish color; it has a strong, peculiar odor. It is rendered more fluid by heat; and it burns with a bright flame, leaving a light and dry coal. It is refined by heating it in an iron vessel, and pouring it off, after it has been kept for some time in a liquid state; by this means water and pyroligneous acid are driven off, and the earthy particles are separated by settling.

It is used for coating cordage, and for wood which is not to be immersed in water.

Pitch is made by boiling tar down to the requisite consistency, either by itself or combined with a portion of rosin; it becomes solid on cooling, but is soon softened by the heat of the hand, in which state it is very adhesive; when of good quality, it is clear and hard.

It is used for coating wood which is to be immersed in water, and is applied hot, with a *mop*.

Venice Turpentine is obtained from the *larch;* but what is commonly called by that name is a compound of melted rosin and spirits of turpentine.

Chemical Equivalents of some of the Elementary Bodies.

Name.	Symbol.	Equivalent.	Name.	Symbol.	Equivalent.
Oxygen	O.	8.	Calcium	Ca.	20.
Sulphur	S.	16.	Magnesium	Mg.	12.
Bromine	Br.	80.	Strontium	Sr.	43.75
Chlorine	Cl.	35.5	Aluminium	Al.	13.75
Fluorine	Fl.	19.	Chromium	Cr.	26.75
Iodine	I.	127.	Cobalt	Co.	30.5
Antimony	Sb.	122.	Copper	Cu.	31.75
Arsenic	As.	75.	Iron	Fe.	28.
Bismuth	Bi.	214.	Lead	Pb.	103.5
Nitrogen	N.	14.	Nickel	Ni.	29.5.
Phosphorus	P.	31.	Manganese	Mn.	27.5
Boron	Bo.	11.	Tin	Sn.	59.
Carbon	C.	6.	Zinc	Zn.	37.75
Silicon	Si.	21.	Gold	Au.	98.5
Hydrogen	H.	1.	Mercury	Hg.	100.
Sodium	Na.	23.	Platinum	Pl.	99.
Potassium	K.	39.	Silver	Ag.	108
Barium	Ba.	68.5	Palladium	Pd.	53.3

Strength of Materials.

(These tables are made up, with the exception of those materials marked *, from the results obtained by experiments made, by direction of the Ordnance Department, by Capt. T. J. Rodman.)

Material.	Locality.	Time of seasoning.	Specific gravity.	Crushing-force per square inch.	Tensile strength per square inch.	Transverse resistance, $S=\frac{L\ W}{4bd^2}$.
		Years.		Lbs.	Lbs.	Lbs.
Ash	Ohio	15	.61720	8,783	24,033	2,118
"	Pennsylvania	3	.55039	4,475	14,266	1,466
"	Canada	9	.55606	5,571	15.000	......
"	New York	7	.51420	4,783	11,786	......
"	Vermont	2	.73674	5,858	10.803	2,664
"	Virginia	1	.61023	6.663	23.167	1,528
"	Oregon	1	.67698	5,789	14,700	1,438
* "	England	...	......	8,683	17,000	168
Birch	Maine	4	.69618	7,969	15,333	2,196
Bass	"	12	.50253	5,271	12,600	1,913
"	Canada	9	.48229	4,609	14,953	......
Box	Africa	5	.89975	10,513	23,600	......
Balm of Gilead	Oregon	1	.46670	5,811	12,033	2,240
Beech	Canada	9	.67245	5,780	14,800	......
"	New Hampshire	8	.73499	6,908	18,033	2,293
* "	England	...	......	7,733	11,500	129
Chestnut	Massachusetts	5	.54493	5,621	13.066	1,025
"	New York	5	.46870	5,111	11,891	......
Cypress	Alabama	2	.55307	8,492	17,707	1,011
Cherry	Pennsylvania	2	.57871	6,149	12,390	1,315
Cedar, red	Oregon	4	.37591	5,971	10,300	286
Dog-Wood	Virginia	1	.86253	7,416	23,253	1,720
Elm	Massachusetts	43	.72395	6,286	15,107	2,056
"	"	1	.77464	6,641	15,700	......
Fir, yellow	Oregon	1	.63074	9,217	13,633	1,824
" "	"	2	.55893	7,488	16,833	1,290
Fir, red	"	2	.46164	7,083	12,867	1,138
Fir, white	"	2	.46800	6,644	14,533	699
Gum. black	Alabama	1	.61519	6,703	15.860	1,481
Hickory	Ohio	13	.84227	9,887	25,900	2,727
"	North Carolina	3	.82624	6,125	18,000	......
"	Eastern Virginia	1	.95639	5,492	35,500	......
" red	Massachusetts	7	.87491	10,942	27,133	2,900
"	New York	7	.72945	7,725	12.866	2,756
" white	Massachusetts	7	.99161	8.925	38,700	2,886
"	Alabama	1	.90384	11.213	40,067	2,803
"	Virginia	1	.91088	9,733	36,666	3,392
Holly	"	1	.64102	5,246	18,567	564
Hemlock	Oregon	1	.45318	6,817	16,533	1,292
Hackmatack	Maine	1	.58976	......	......	1,310
Lignum-vitæ	South America	4	1.25760	9,854	16,000	2,680
Locust	Pennsylvania	1	.82612	9,113	27.517	2.413
Mahogany	St. Domingo	4	.76209	7,390	12,350	1,666
Maple	Canada	9	.68056	7,716	22,933	......
"	Maine	4	.73529	8,621	21,720	1,929
"	Oregon	1	.49128	4,443	10.400	973
Oak, white	New England	18	.74982	6.668	19,600	1.830
" "	Western New York	12	.75565	6,620	19,166	1,876
" "	Ohio	13	.69549	6,258	19,066	1.459
" "	Monongahela River	13	.74915	6,592	20.333	2,036
" "	Ohio	5	.84642	9.108	19,466	2.890
" "	New York	11	.63212	4.691	12 300	1.778
" "	Maryland	19	.72948	6,992	17,666	2 426
" "	Massachusetts	43	.88206	5,800	16,766	2.443
" "	"	7	.83364	7,292	19,200	1,950
" "	" pasture,	7	.80126	6,962	16,200	2,266

Strength of Materials.—Continued.

Material.	Locality.	Time of seasoning.	Specific gravity.	Crushing-force per square inch.	Tensile strength per square inch.	Transverse resistance, $S=\frac{LW}{4bd^2}$.
		Years.		Lbs.	Lbs.	Lbs.
Oak, white	Canada	9	.66656	6,000	16,646	......
" "	Connecticut	14	.76118	5,199	13,333	......
" "	"	18	.81948	7,089	21,000	......
" "	North Carolina	8	.77402	6,550	21,100	......
" "	Alabama	2	.73067	5,744	18,307	1,652
" "	Virginia	1	.77058	6,902	19,033	1,793
" "	Oregon	1	.80996	6,072	18,467	1,572
" "	James River, Va.	13	.78237	6,667	25,222	1,823
*" "	England	......	.932	10,058	15,000	1,410
" yellow	New Hampshire	13	.71132	6,279	25,000	1,915
" live	Alabama	3	1.02171	6,531	16,383	1,630
" "		......	1.1037	7,279	15,800	1,333
Pine, pitch	North Carolina	"	1.0801	8,947	11,400	......
" white	Allegheny River, Pa.	4	.41926	5,017	11,433	1,133
" "	New York	5	.46064	5,775	11,933	1,152
" "	Maine	13	.35953	5,617	11,960	1,182
" yellow	Florida	6	.67212	8,350	18,000	1,466
" "	North Carolina	......	.63002	7,836	12,600	1,946
" "	Alabama	1	.52843	8,201	17,946	1,709
" "	Virginia	2	.62795	7,867	19,200	1,528
" sugar	Nevada Co., Cal.	1	......	......	......	887
" "	Humboldt Co., Cal.	1	......	......	......	943
Poplar	Ohio	3	.49802	5,742	14,933	1,210
"	New York	2	.47720	6,075	9,066	979
"	Virginia	1	.43233	6,579	8,200	1,297
Red Wood	California	1	.38659	6,083	10,833	753
Spruce	Maine	1	.44416	6,862	13,666	1,028
"	Oregon	1	.43685	5,092	10,867	994
Teak	East Indies	4	.96057	10,819	30,800	3,093
Walnut, black	Western States	7	.52932	7,471	16,633	2,053
" "	Virginia	1	.64917	7,500	16,300	1,365
" "	Michigan	2	.59187	5,782	17,580	......
" "	Canada	9	.52370	5,989	16,133	......
* " "	England	......	......	7,227	8,130	......
*Brass, cast		......	8.396	10,300	18,000	......
*Brass wire		......	......	......	49,000	......
*Bronze		......	8.700	......	42,000	......
*Cast iron, common pig		......	7.000	......	15,000	6,000
*Do., good common iron		......	7.180	......	20,000	7,500
* " " for guns		......	7.280	105,000	32,000	......
* " " in bars		......	7.320	130,000	34,000	11,500
*Bar-iron		......	7.855	40,000	57,000	6,500
* " Salisbury		......	......	......	66,000	......
* " Swedish		......	......	......	72,000	......
*Copper, cast		......	8.712	......	24,138	......
* " bolts		......	8.878	......	33,000	......
* " wire		......	......	......	60,000	......
*Cast steel		......	7.846	140,000	128,000	23,000
*Shear-steel		......	......	......	124,000	......
*Puddled steel		......	......	......	105,000	......
*Gold, cast		......	10.258	......	20,000	......
*Silver, cast		......	10.476	......	40,000	......
*Platinum wire		......	22.069	......	56,000	......
*Tin, cast		......	7.291	......	4,800	......
*Zinc		......	6.861	......	7,500	......
*Lead, cast		......	11.352	......	1,800	......
*Brick		......	......	3.5[illegible] to 13,000	......	......
Granite	Rockfort, Mass	......	2.645	15,300	578	275

Strength of Material.

SHEARING.

Angle formed by shear-blades, 3 degrees.

Sheet Metals.

Iron.		Copper.		Brass.		Steel, Puddled.	
Thickness.	Pressure.	Thickness.	Pressure.	Thickness.	Pressure.	Thickness.	Pressure.
In.	Lbs.	In.	Lbs.	In.	Lbs.	In.	Lbs.
1.0*	144,000	.297	11,196	.05	540	.24	14,020†
.615	53,440	.238	6,007	.042	423	.24	14,930‡
.510	39,150	.204	4,820	.035	333		
.404	25,970	.150	3,676	.025	220		
.283	15,716	.09	2,200	.024	200		
.183	10,390	.064	1,006				
.104	4.200	.05	552				
.057	2,180	.02	113				

* The cutters were parallel; the bar 3 inches wide. † With oil. ‡ Without oil.

Bolts.

Iron.				Copper.		Brass.	
Diameter.	Pressure.	Diameter.	Pressure.	Diameter.	Pressure.	Diameter.	Pressure.
In.	Lbs.	In.	Lbs.	In.	Lbs.	In.	Lbs.
1.142	35,410	.697	13,979	.943	18,460	1.110	29,790
1.040	30,707	.585	10,593	.906	13,872	.905	22,386
.945	24,057	.447	5,543	.775	11,310	.779	17,976
.812	19,688	.320	3,093	.635	8,218	.648	11,648

PUNCHING.

Diameter of punch.	Pressures.			Thickness of sheet.	Pressures. Circ. hole 1 in. diam.		Iron.	
	Brass, .05 inch thick.	Copper, .15 inch thick.	Iron, .105 inch thick.		Copper.	Brass.	Thickness.	Pressure. Circ'r hole 1 in. diam.
In.	Lbs.	Lbs.	Lbs.	In.	Lbs.	Lbs.	In.	Lbs.
1.5	8,475	15,996	23,273	.3	21,248	....	.615	82,871
1.375	7,723	14,570	21,445	.205	15,542	....	.565	76,962
1.25	6,980	13,275	19,682	.160	11,088	....	.510	69,984
1.0	5,450	11,073	16,535	.100	7,461	....	.445	62,591
.9	5,092	9,788	14,778	......	....	....	.404	57,623
.8	4,332	8,580	12,602	.050	3,646	....	.358	51,382
.7	3,772	7,827	11,468	.045	3,362	5,448	.283	40,486
.6	3,267	6,706	9,772	.041	....	4,997	.245	35,712
.5	2,635	5,507	7,916	.034	2,538	3,730	.183	27,978
.4	2,183	4,585	6,660	.032	2,212	3,540	.145	22.213
.3	1,673	3,435	4,970	.028	....	2,964	.104	16,533
.2	1,110	2,240	3,333	.022	1,544	2,448	.057	9,452

Iron-Wire Rope and Hempen Cable.

(Wire rope by J. E. Roebling.)

Trade-Number.	Circumference of Wire Rope.	Breaking-weight in tons of two thousand pounds.	Circumference of Hemp Rope of equal strength.
	Inches.	Tons.	Inches.
1	6.62	74.	15.5
2	6.20	65.	14,5
3	5.44	54.	13.
4	4.90	43.6	12.
5	4.50	35.	10.75
6	3.91	27.2	9.5
7	3.36	20.2	8.
8	2.98	16.	7.
9	2.56	11.4	6.
10	2.45	8.64	5.
11	4.45	36.	10.75
12	4.00	30.	10.
13	3.63	25.	9.5
14	3.26	20.	8.25
15	2.98	16.	7.25
16	2.68	12.3	6.25
17	2.40	8.8	5.5
18	2.12	7.6	5.
19	1.9	5.8	4.75
20	1.63	4.09	4.
21	1.53	2.83	3.3
22	1.31	2.13	2.80
23	1.23	1.65	2.46
24	1.11	1.38	2.2
25	0.94	1.03	2.04
26	0.88	0.81	1.75
27	0.78	0.56	1.50

Thickness for Cast-Iron Water-Pipes.

Let $P =$ the pressure in pounds per square inch on the inner surface of pipe;

$D =$ the interior diameter;

$T =$ the thickness of pipe, in inches;

$a =$ the thickness necessary to insure good casting:

$$\text{Then } T = a + \frac{DP}{10{,}000}.$$

The values of a are as follow:

For pipes less than 12 inches in diameter,			$a = 0.375$ inch;
"	from 12 to 30 "	"	$a = 0.5$ "
"	" 30 to 48 "	"	$a = 0.625$ "
"	" 48 to 70 "	"	$a = 0.75$ "
"	" 70 to 100 "	"	$a = 0.875$ "

Thickness to give to Water and Steam Pipes.

Iron	$e = 0.00086\,n\,d + 0.0030$	d, interior diameter in inches;
Cast iron..........	$e = 0.00238\,n\,d + 0.33465$	e, thickness of the pipe;
Wrought copper.	$e = 0.00148\,n\,d + 0.15748$	n, number of atmospheres corresponding to the interior pressure per square inch.
Lead	$e = 0.00242\,n\,d + 0.19685$	
Zinc	$e = 0.00620\,n\,d + 0.15748$	
Wood...............	$e = 0.03230\,n\,d + 1.06301$	

Strength of Columns.

When the length of the column is from 30 to 90 times its diameter, and it yields wholly by bending, Mr. Hodgkinson deduces the following formulæ:

W = the breaking-weight, in tons of 2,000 pounds;
L = the length of the column, in feet;
D = the diameter of the exterior, in inches;
d = " " interior, "

Nature of column.	Both ends being rounded, the length of the column exceeding 15 times its diameter.	Both ends being flat, the length of the column exceeding 30 times its diam.
Solid cylindrical column of cast iron....	$W = 16.6\,\frac{D^{3.76}}{L^{1.7}}$	$W = 49.4\,\frac{D^{3.55}}{L^{1.7}}$
Hollow cylindrical column of cast iron....	$W = 14.5\,\frac{D^{3.76} - d^{3.76}}{L^{1.7}}$	$W = 49.6\,\frac{D^{3.55} - d^{3.55}}{L^{1.7}}$
Solid cylindrical column of wrought iron	$W = 47.9\,\frac{D^{3.76}}{L^2}$	$W = 149.7\,\frac{D^{3.55}}{L^2}$
Solid square pillar of Dantzic oak (dry)...	....	$W = 12.2\,\frac{D^4}{L^2}$
Solid square pillar of red cedar (dry)......	....	$W = 8.7\,\frac{D^4}{L}$

When the columns are shorter than those given in the tables, the strength may be determined by the following:

Let b = the breaking-weight, as computed by the formula above; c = the crushing-weight of the material:

$$\text{Then, } W = \frac{bc}{b + \frac{3}{4}c}.$$

The strength of similar columns is nearly as the area of the cross-section.

Transverse Strength.

S = the weight, in pounds, required to break a beam 1 inch square and 1 inch long, fixed at one end and loaded at the other; b = the breadth; d = the depth; l = the length, in inches, of any other beam of the same material; and W = the weight which will cause it to break, neglecting the weight of the beam itself.

1. *If the beam be supported at one end and loaded at the other:*

$$W = S\frac{b\,d^2}{l}.$$

2. *If the beam be supported at one end and the load distributed over its whole length:*

$$W = 2\,S\frac{b\,d^2}{l}.$$

3. *If the beam be supported at both ends and loaded in the middle:*

$$W = 4\,S\frac{b\,d^2}{l}.$$

4. *If the beam be supported at both ends and loaded uniformly over its whole length:*

$$W = 8\,S\frac{b\,d^2}{l}.$$

5. *If the beam be supported at both ends and loaded at the distance* m *from one end:*

$$W = S\frac{l\,b\,d^2}{m\,(l - m)}.$$

6. *If the beam be fixed at both ends and loaded uniformly over its whole length:*

$$W = 12\,S\frac{b\,d^2}{L}.$$

In practice, about one-half of these values should be used in computing the strain to which a beam should be subjected.

Deflection of Rectangular Beams.

Let b = the breadth, d = the depth, and e = the deflection, in inches.
W = the weight, in pounds; L = the length of span, in feet.
C = a coefficient, different for different materials.

1. *For a beam fixed at one end and loaded at the other:*

$$e = C\frac{W\,L^3}{b\,d^3}.$$

2. *Beam fixed at one end and uniformly loaded:*

$$e = \tfrac{3}{8}\, C \frac{W L^3}{b\, d^3}.$$

3. *Beam supported at both ends and loaded in the centre:*

$$e = \tfrac{1}{16}\, C \frac{W L^3}{b\, d^3}.$$

4. *Beam supported at both ends and uniformly loaded:*

$$e = \tfrac{5}{8} \times \tfrac{1}{16}\, C \frac{W L^3}{b\, d^3}.$$

For wrought iron, the value of $C = .0002$ to $.0003$
" cast iron, " $C = .00037$ to $.000$
" white pine or beech, " $C = .0048$.
" ash, " $C = .004$.

9-inch beam, I-shape, (Cooper & Hewitt,) 18 feet between bearings, weight per running foot 34 pounds, with a weight of 16,864 pounds at centre, deflected, after 14 hours, 1.285 inch.

9-inch beam, I-shape, (Phœnix Iron Co.,) 21 feet between bearings, weight per running foot 32.84 pounds, with a weight of 4,865 pounds at centre, deflected 0.505 inch; with a weight of 10,916 pounds, deflected 1.184 inch.

Resistance to Torsion.

S = the weight, in pounds, required to break, by twisting, a solid cylinder 1 inch diameter, the weight acting at the distance of 1 inch from the axis of the cylinder; d = the diameter, in inches, of any other cylinder of the same material; r = the distance from its axis to the point where the breaking-weight, W, is applied: then,

$$W = S \frac{d^3}{r}.$$

For hollow cylinders:

$$W = S \frac{D^4 - d^4}{D\, r}.$$

Theoretical formula of Lieut. (now Captain) Rodman, verified by Major Wade's experiments.

D = the exterior, and d = the interior, diameter of the cylinder in inches.

Values of S.

	Begins to set.		Begins to set.
Wrought iron...	3,600 7,700	Bronze...	2,300 5,500

Relative torsional strength of cast-iron shafts of different forms, having equal areas of cross-sections.

(From Major Wade's experiments on shafts whose cross-sections were 1, 2, and 3 square inches.)

Solid cylinder.	Solid square.	Hollow cylinders, whose interior and exterior diameters are in the proportion of				
		4 to 10.	5 to 10.	6 to 10.	7 to 10.	8 to 10.
1.0000	0.8750	1.2656	1.4433	1.7000	2.0864	2.7377

Specific Gravities of Fluids.

Liquids.	Specific gravity.	Elastic Fluids.	Specific gravity.
Acid, nitric	1.217	Air, atmospheric	1.000
" sulphuric	1.841	Ammoniacal gas	.597
" acetic	1.062	Nitrogen	.972
" hydrochloric	1.200	Carbonic acid	1.524
Alcohol, absolute	.792	Carburetted hydrogen	.555
Ether, sulphuric	.715	Chlorine	2.470
Oil, linseed	.940	Chloro-carbonic	3.389
" olive	.915	Hydrogen	.070
" essential, of turpentine	.870	Oxygen	1.104
" whale	.923	Phosphuretted hydrogen	.870
" proof spirit	.925	Sulphuretted hydrogen	1.777
Turpentine, liquid	.991	Sulphurous acid	2.120
Vinegar	1.080	Vapor of alcohol	1.613
Water, distilled	1.000	" spts. of turpentine	5.013
" sea	1.026	" sulphuric ether	2.586
" Dead Sea	1.240	" water	.623
Wine	.992	Steam at 212°	.488

The weight of dry atmospheric air at the temperature of 32°, the barometer being at 30 inches, is $\frac{1}{770}$ of that of distilled water.

The weight of a cubic foot of distilled water *at the maximum density* being nearly 1,000 ounces avoirdupois, the specific gravity of a solid or liquid body expresses the weight of a cubic foot, in ounces; therefore the weight of such a body in ounces will be found by multiplying its contents in cubic feet by its specific gravity.

According to Mr. Hassler's comparisons, the weight of a cubic foot of water at its maximum density, the barometer being at 30 inches, is 998.068 ounces.

According to the British imperial standards, the weight of a cubic foot of water at 62°, the barometer being at 30 inches, is 997.136 ounces; this would give for the cubic foot of water, at the maximum density, 998.224 ounces.

Hydrometer.

The hydrometer consists of a *copper bulb*, in one piece, without seam, *a solid stem* of brass, screwed into the bottom of the bulb, with a weight at its lower extremity; *a brass wire handle*, attached to the upper surface of the bulb; 1 *vertical index-stem*, steel, .071 inch diameter, inserted into the middle point of the handle; *a weight-pan*, with a conical socket on its under side, rests on the upper end of the stem; 4 *silver wires*, two attached to the handle and two to the stem, their points turned toward each other. The whole electro-gilded. *Weights* of different sizes, from $\frac{1}{10}$ of a grain to 5,000 grains.

Dimensions.—Bulb, 8 inches high, 7.5 inches diameter; .03 inch thick. Distance from the bottom of the bulb to the weighing-pan, 21 inches.

Weights.—Of bulb, about 15,850 grains; of lower stem and ball, 20,320 grains; pan, 660 grains; whole hydrometer, 36,830 grains.

The maximum buoyancy of the hydrometer is 14,600 grains, and may be reduced one-half by placing the adjusting-weights over the ball at the bottom of the stem. This is found convenient in weighing small samples, to avoid placing numerous weights on the pan. One inch of the index-stem displaces one grain of water. The points of the silver wires are placed .1 and .3 inch apart, respectively, and are sloped to .1 inch from the point. For more full details of its construction, see Reports of Experiments on Metals for Cannon, by Ordnance Officers.

The instrument is at its zero when one of the points of the set of wires nearest each other is above and the other below the surface of the water: when either touches the water, the load is $\frac{1}{10}$ of a grain too light or heavy. If either of the two points which are more distant from the zero touch the surface of the water, the load is too heavy or too light by $\frac{3}{10}$ of a grain; if the heel of either of these parts touch the surface, the error is $\frac{4}{10}$ of a grain.

The water for the hydrometer is contained in a glass jar 25 inches deep and not less than 12 inches in diameter. The height of the water in the jar should be such that when the bottom of the hydrometer descends to the bottom of the jar the weight-pan shall be one-quarter of an inch above the surface of the water.

A thermometer divided into degrees and quarters of a degree is suspended in the water while weighing samples, and the temperature is noted at each weighing.

To Use the Hydrometer.—Load the pan with the grain-weights until the instrument rest at its zero: note the weight required. Place the sample on the pan; add weights until the hydrometer sink to its zero; the difference between this and the first weight is the weight of the sample in the air. Place the sample on the bulb of the instrument; immerse both until the hydrometer again rest at zero; note the weight on the pan. Subtract this weight from the weight of the sample in the air, and the difference will be equal to the weight of water displaced by the sample.

Divide this last weight by the number in the table, page 495, corresponding to the temperature of the water at the time of weighing, and the quotient will give the corrected displacement for the temperature of 60°. The weight of the sample in the air divided by the corrected displacement, gives the density of the sample.

Rain or river water may be used instead of distilled water, if its relative density first be determined accurately and the proper correction be made.

The density of the same water at different degrees of temperature may be determined in like manner. The weight of water which the hydrometer displaces at any other temperature than 60°, divided by its displacement in the same water at 60°, gives the proportionate weights of water displaced by the same instrument at other temperatures.

The table on page 495 does not give the absolute density of water at different temperatures, but only the proportionate weights displaced by the same glass bulb. The varying bulk of the latter in different temperatures is not taken into account, as it compensates very nearly for the varying bulk of the metals weighed in corresponding temperatures.

Beaumé's Areometer.

Beaumé.	Specific gravity.*	Beaumé.	Specific gravity.*	Beaumé.	Specific gravity.*
46	.796	28	.876	18	.942
40	.815	26	.889	17	.951
36	.833	24	.901	16	.958
33	.848	21	.923	15	.964
31	.863	19	.933	14	.970

* At the temperature of 60°.

Weight and Strength of Iron Chains.

Diam'r of iron for the links.	Weight of 1 foot of chain.	Breaking-weight.	Proof-weight.	Diam'r of iron for the links.	Weight of 1 foot of chain.	Breaking-weight.	Proof-weight.
In.	Lbs.	Lbs.	Lbs.	In.	Lbs.	Lbs.	Lbs.
0.1875	0.325	2,240	948	0.625	4.217	26,880	10,304
0.25	0.65	4,256	1,680	0.6875	4.833	32,704	12,544
0.3125	0.967	6,720	2,464	0.75	5.75	38,752	15,232
0.375	1.383	9,634	3,584	0.8125	6.667	45,696	17,696
0.4375	1.767	13,216	5,152	0.875	7.5	51,744	20,384
0.5	2.633	17,248	6,720	0.9375	9.333	58,464	23.520
0.5625	3.333	21,728	8,512	1.	10.817	65,632	26,880

*Weight of One Foot in length of Flat and Square Bar-Iron.**

Width.	Thickness.	Weight.	Width.	Thickness.	Weight.	Width.	Thickness.	Weight.
In.	In.	Lbs.	In.	In.	Lbs.	In.	In.	Lbs.
0.25	0.25	0.21	1.375	0.625	2.88	2.	0.375	2.52
0.3	0.3	0.30	"	0.75	3.46	"	0.5	3.36
0.375	0.375	0.47	"	0.875	4.04	"	0.625	4.20
0.5	0.125	0.21	"	1.	4.62	"	0.75	5.04
"	0.1875	0.31	"	1.125	5.19	"	0.875	5.88
"	0.25	0.42	"	1.25	5.77	"	1.	6.72
"	0.375	0.63	"	1.375	6.35	"	1.125	7.56
"	0.5	0.84	1.5	0.125	0.63	"	1.25	8.40
0.625	0.625	1.34	"	0.1875	0.94	"	1.375	9.24
0.75	0.125	0.31	"	0.25	1.26	"	1.5	10.08
"	0.1875	0.47	"	0.375	1.89	"	1.75	11.76
"	0.25	0.63	"	0.5	2.52	"	2.	13.44
"	0.375	0.94	"	0.625	3.15	2.25	0.125	0.94
"	0.5	1.26	"	0.75	3.78	"	0.1875	1.41
"	0.625	1.57	"	0.875	4.41	"	0.25	1.89
"	0.75	1.89	"	1.	5.04	"	0.375	2.83
0.875	0.875	2.57	"	1.125	5.67	"	0.5	3.78
1.	0.125	0.42	"	1.25	6.30	"	0.625	4.72
"	0.1875	0.63	"	1.5	7.56	"	0.75	5.66
"	0.25	0.84	1.625	0.125	0.68	"	0.875	6.61
"	0.375	1.26	"	0.25	1.36	"	1.	7.56
"	0.5	1.68	"	0.5	2.73	"	1.125	8.50
"	0.625	2.10	"	0.75	4.20	"	1.25	9.45
"	0.75	2.52	"	1.	5.46	"	1.375	10.39
"	0.875	2.94	"	1.625	8.87	"	1.5	11.34
"	1.	3.36	1.75	0.125	0.73	"	1.75	13.22
1.125	1.125	4.25	"	0.1875	1.10	"	2.	15.12
1.25	0.125	0.52	"	0.25	1.47	"	2.25	17.01
"	0.1875	0.78	"	0.375	2.20	2.5	0.125	1.05
"	0.25	1.05	"	0.5	2.94	"	0.1875	1.57
"	0.375	1.57	"	0.625	3.67	"	0.25	2.10
"	0.5	2.10	"	0.75	4.41	"	0.375	3.15
"	0.625	2.62	"	0.875	5.14	"	0.5	4.20
"	0.75	3.15	"	1.	5.87	"	0.625	5.25
"	0.875	3.67	"	1.125	6.60	"	0.75	6.30
"	1.	4.20	"	1.25	7.35	"	0.875	7.35
"	1.125	4.72	"	1.375	8.07	"	1.	8.40
"	1.25	5.25	"	1.5	8.80	"	1.125	9.55
1.375	0.125	0.57	"	1.75	10.29	"	1.25	10.50
"	0.1875	0.86	1.875	1.875	11.81	"	1.5	12.60
"	0.25	1.15	2.	0.125	0.84	"	1.75	14.70
"	0.375	1.73	"	0.1875	1.26	"	2.	16.80
"	0.5	2.31	"	0.25	1.68	"	2.5	21.00

* The above tables are computed for a specific gravity of 7.741, weight of 1 cubic inch = .28 lb.; they are about 1 per cent. too low for ordinary American iron: this is accounted for by the fact that our iron is rolled generally to *full* dimensions.

Weight of One Foot of Flat and Square Bar-Iron.—Continued.

Width.	Thickness.	Weight.	Width.	Thickness.	Weight.	Width.	Thickness.	Weight.
In.	In.	Lbs.	In.	In.	Lbs.	In.	In.	Lbs.
2.75	0.125	1.15	3.25	2.5	27.39	4.	1.5	20.18
"	0.1875	1.73	"	3.	32.76	"	2.	26.88
"	0.25	2.31	"	3.25	35.50	"	2.5	33.65
"	0.375	3.46	3.5	0.125	1.47	"	3.	40.32
"	0.5	4.62	"	0.1875	2.20	"	3.5	47.04
"	0.625	5.77	"	0.25	2.94	"	4.	53.76
"	0.75	6.93	"	0.375	4.41	4.25	0.125	1.78
"	0.875	8.08	"	0.5	5.88	"	0.25	3.57
"	1.	9.24	"	0.625	7.35	"	0.375	5.35
"	1.125	10.39	"	0.75	8.82	"	0.5	7.14
"	1.25	11.55	"	0.875	10.29	"	1.	14.28
"	1.5	13.86	"	1.	11.76	"	4.25	60.69
"	2.	18.48	"	1.25	14.70	4.5	0.125	1.89
"	2.5	23.10	"	1.5	17.64	"	0.25	3.78
"	2.75	25.41	"	2.	23.52	"	0.375	5.66
3.	0.125	1.26	"	2.5	29.40	"	0.5	7.56
"	0.1875	1.89	"	3.	35.28	"	1.	15.12
"	0.25	2.52	"	3.5	41.16	"	4.5	68.04
"	0.375	3.78	3.75	0.125	1.57	4.75	0.125	2.00
"	0.5	5.04	"	0.1875	2.36	"	0.25	4.00
"	0.625	6.30	"	0.25	3.15	"	0.375	6.00
"	0.75	7.56	"	0.375	4.72	"	0.5	7.98
"	0.875	8.82	"	0.5	6.30	"	1.	15.96
"	1.	10.08	"	0.625	7.87	"	4.75	75.81
"	1.125	11.34	"	0.75	9.45	5.	0.125	2.10
"	1.25	12.60	"	0.875	11.02	"	0.25	4.20
"	1.5	15.12	"	1.	12.60	"	0.375	6.30
"	2.	20.16	"	1.25	15.75	"	0.5	8.40
"	2.5	25.20	"	1.5	18.90	"	1.	16.80
"	3.	30.24	"	2.	25.20	"	5.	84.00
3.25	0.125	1.36	"	2.5	31.50	5.25	0.25	4.41
"	0.1875	2.04	"	3.	37.80	"	1.	17.64
"	0.25	2.73	"	3.75	47.25	5.5	0.25	4.62
"	0.375	4.09	4.	0.125	1.68	"	1.	18.48
"	0.5	5.46	"	0.1875	2.52	5.75	0.25	4.83
"	0.625	6.82	"	0.25	3.36	"	1.	19.32
"	0.75	8.19	"	0.375	5.04	6.	0.25	5.04
"	0.875	9.55	"	0.5	6.72	"	1.	20.16
"	1.	10.92	"	0.625	8.40	"	6.	120.96
"	1.125	12.28	"	0.75	10.08	6.5	0.25	5.46
"	1.25	13.65	"	0.875	11.76	"	1.	21.84
"	1.5	16.38	"	1.	13.44	"	6.5	142.00
"	2.	21.84	"	1.25	16.80	7.	7.	164.64

Weight of One Foot in length of Round Bar-Iron.

Diameter.	Weight.	Diameter.	Weight.	Diameter.	Weight.	Diameter.	Weight.
In.	Lbs.	In.	Lbs.	In.	Lbs.	In.	Lbs.
0.15	0.059	1.625	6.91	3.25	27.65	4.75	59.06
0.2	0.105	1.75	8.01	3.375	29.82	4.875	62.21
0.25	0.163	1.875	9.2	3.5	32.07	5.	65.45
0.375	0.368	2.	10.47	3.625	34.4	5.125	68.76
0.5	0.654	2.125	11.82	3.75	36.81	5.25	72.16
0.625	1.02	2.25	13.25	3.875	39.31	5.375	75.63
0.75	1.47	2.375	14.76	4.	41.89	5.5	79.19
0.875	2.	2.5	16.36	4.125	44.54	5.625	82.83
1.	2.61	2.625	18.03	4.25	47.28	5.75	86.56
1.125	3.31	2.75	19.79	4.375	50.11	5.875	90.36
1.25	4.09	2.875	21.63	4.5	53.01	6.	94.25
1.375	4.94	3.	23.56	4.625	56.	6.185	100.
1.5	5.89	3.125	25.56				

Weight of One Square Foot of various Metals.

Thickness.	Weight.				
	Wrought Iron.	Cast Iron.	Copper.	Brass.	Lead.
In.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
0.0625	2.535	2.345	2.860	2.738	3.693
0.125	5.070	4.690	5.720	5.476	7.386
0.1875	7.605	7.035	8.580	8.214	11.079
0.25	10.140	9.380	11.440	10.952	14.772
0.3125	12.675	11.725	14.300	13.690	18.465
0.375	15.216	14.670	17.160	16.428	22.158
0.4375	17.851	16.415	20.020	19.166	25.851
0.5	20.280	18.760	22.880	21.904	29.544
0.5625	22.815	21.105	25.740	24.642	33.237
0.625	25.350	23.450	28.600	27.380	36.930
0.6875	27.885	25.795	31.640	30.118	40.623
0.75	30.410	28.140	34.320	32.856	44.316
0.8125	32.945	30.485	37.180	35.594	48.009
0.875	35.480	32.880	40.040	38.332	51.702
0.9375	38.015	35.225	42.900	41.170	55.405
1.	40.550	37.570	45.760	43.908	59.098

Weight of 1 Foot in length of Cast-Iron Pipes of different thickness.

Diameter of Bore.	¼-inch.	⅜-inch.	½-inch.	⅝-inch.	¾-inch.	⅞-inch.	1-inch.
In.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
1	3.06	5.06	7.36	9.97	12.89	16.11	19.63
1¼	3.68	5.98	8.59	11.51	14.73	18.25	22.09
1½	4.29	6.9	9.82	13.04	16.56	20.4	24.54
1¾	4.91	7.83	11.05	14.57	18.41	22.55	27.
2	5.53	8.75	12.27	16.11	20.25	24.7	29.45
2¼	6.14	9.66	13.5	17.64	22.09	26.84	31.85
2½	6.74	10.58	14.72	19.17	23.92	28.93	34.36
2¾	7.36	11.5	15.95	20.7	25.71	31.14	36.81
3	7.98	12.43	17.18	22.19	27.62	33.29	39.28
3¼	8.59	13.34	18.35	23.78	29.45	35.44	41.72
3½	9.2	14.21	19.64	25.31	31.3	37.58	44.18
3¾	9.76	15.19	20.86	26.85	33.13	39.73	46.63
4	10.44	16.11	22.1	28.38	34.98	41.88	49.1
4¼	11.1	17.08	23.37	29.97	36.87	44.08	51.6
4½	11.66	17.94	24.54	31.44	38.65	46.17	54.
4¾	12.27	18.87	25.77	32.98	40.5	48.32	56.45
5	12.80	19.78	26.99	34.51	42.33	50.46	59.
5¼	13.5	20.71	28.23	36.05	44.18	52.62	61.36
5½	14.11	21.63	29.45	37.58	46.02	54.76	63.81
5¾	14.73	22.55	30.68	39.12	47.86	56.91	66.27
6	15.34	23.47	31.91	40.65	49.7	59.06	68.73
6¼	15.95	24.39	33.13	42.18	51.54	61.21	72.
6½	16.57	25.31	34.36	43.72	53.39	63.36	73.41
6¾	17.18	26.23	35.59	45.26	55.23	65.28	76.1
7	17.79	27.15	36.82	46.79	56.84	67.65	78.53
7¼	18.41	28.08	38.05	48.1	58.91	69.79	81.
7½	19.03	29.	39.05	49.86	60.74	71.95	83.45
7¾	19.64	29.69	40.5	51.38	62.59	74.09	86.
8	20.02	30.83	41.71	52.92	64.42	76.23	88.35
8¼	20.86	31.74	42.95	54.45	66.26	78.38	90.81
8½	21.69	32.9	44.4	56.21	68.33	80.76	93.49
8¾	22.09	33.59	45.4	57.52	69.95	82.68	95.72
9	22.71	34.52	46.64	59.07	71.8	84.84	98.18
9¼	23.31	35.43	47.86	60.59	73.63	86.97	100.63
9½	23.93	36.36	49.09	62.13	75.47	89.13	103.1
9¾	24.55	37.28	50.32	63.66	77.32	91.28	105.54
10	25.16	38.2	51.54	65.2	79.16	93.42	108.
10¼	25.77	39.11	52.77	66.73	80.99	95.57	110.44
10½	26.38	40.04	54.	68.26	82.84	97.71	113.
10¾	27.	40.96	55.22	69.8	84.67	99.86	115.35
11	27.62	41.88	56.46	71.33	86.52	102.01	117.81
11¼	28.22	42.8	57.67	72.86	88.35	104.15	120.26
11½	28.84	43.71	58.9	74.39	90.19	106.3	122.71
11¾	29.45	44.64	60.13	75.93	92.04	108.45	125.18
12	30.06	45.55	61.35	77.46	93.6	110.6	127.6

CHAPTER FIFTEENTH.

MISCELLANEOUS INFORMATION.

WEIGHTS AND MEASURES.

Measures of Length.

The *yard* is the unit, and is the same as the British yard.

Inches.	Feet.	Yards.	Rods or Poles.	Furlongs.	Mile.
12	1				
36	3	1			
198	$16\frac{1}{2}$	$5\frac{1}{2}$	1		
7,920	660	220	40	1	
63,360	5,280	1,760	320	8	1

For Surveying Land.—7.92 Inches = 1 link, } Gunter's
100 Links = 4 poles, or 22 yards, or 66 feet, } chain.

For Map-Making.—Chains are often made of 50 links, each 1 foot in length.

For Measuring Ropes and Soundings.—1 Fathom = 6 feet.
1 Cable's length = 120 fathoms.

For Measuring Cloth.—1 Nail = $2\frac{1}{4}$ inches = 1-16th of a yard.
1 Quarter = 4 nails.
1 Yard = 4 quarters.
1 Ell English = 5 quarters.

For Measuring Horses.—1 Hand = 4 inches.

Geographical Measure.—1 Degree of a great circle of the earth = 69.77 miles.
1 Geographical or nautical mile = 1-60th of a degree of the earth = 2,025 yards.
1 Nautical league = 3 miles.

Nautical Measure.—1 Mile or Knot = 1.1507 mile.

The inch was formerly divided into three parts, called *barley-corns*, and also into twelve parts, called *lines*, neither of which denominations is now in common use. Scales and measuring-rules are generally divided into *inches, quarters, eighths*, and *sixteenths;* or into *inches* and *decimal parts:* the latter of these divisions is used in the Ordnance Department.

Copies of the *standard yard* have been distributed to various parts of the country, for the purpose of establishing uniformity.

Measures of Surface.

Square Measure.—144 Square inches = 1 square foot.
9 Square feet = 1 square yard.

Land Measure.—$30\frac{1}{4}$ Square yards = 1 square perch or pole.
40 Perches = 1 rood.
160 Perches = 4 roods = 1 acre = 10 square chains (Gunter's) = 4,840 square yards = 70 yards square, nearly.
640 Acres = 1 square mile.

Architect's and Builder's Measure.—1 Square = 100 square feet.

Board Measure.

The unit of board measure is a superficial foot of a board 1 inch thick To find the number of feet, *board measure,* in any piece of timber, multiply the number of superficial feet by the thickness in inches.

Planks of less thickness than one inch are estimated at *one inch.*

Measures of Solidity.

Cubic or Solid Measure.—1 Cubic foot = 1,728 cubic inches.
1 Cubic yard = 46,656 " " = 27 cubic feet.

Measuring Stone.—1 Perch is usually $24\frac{3}{4}$ cubic feet.
This varies in different parts of the United States.

Measuring Wood.—1 Cord is a prism 4 feet square and 8 feet long = 128 cubic feet.

Measures of Capacity.

Liquid Measure.

The standard gallon of the United States is the old wine gallon, which measures 231 cubic inches, and contains (as determined by Mr. Hassler) 58373 Troy grains, or 8.3388822 avoirdupois pounds, of distilled water at the maximum density, (39°.83 Fahr.;) the barometer being at 30 inches.

Gills.	Pints.	Quarts.	Gallons.
4	1		
8	2	1	
32	8	4	1

A cubic foot contains 7.48 gallons.

A box $6 \times 6 \times 6.42$ inches contains 1 gallon.

A box $4 \times 4 \times 3.61$ inches contains 1 quart.

Dry Measure.

The standard bushel of the United States is the Winchester bushel, which measures 2150.4 cubic inches, and contains 543391.89 Troy grains, or 77.627413 lbs. avoirdupois, of distilled water, under the circumstances above stated.

Pints.	Quarts.	Gallons.	Pecks.	Bushels.
2	1			
8	4	1		
16	8	2	1	
64	32	8	4	1

A cubic yard contains 21.69 bushels.

A cylinder 14 in. diam. × 14 in. deep } contains 1 bushel.
Or a box 16 × 16.8 × 8 inches }

A box 12 × 11.2 × 8 inches contains ½ bushel.

A box 8 × 8.4 × 8 inches contains 1 peck.

N.B.—It will be observed that the pint, quart, and gallon of dry measure are not the same as for liquid measure.

Measures of Weight.

Avoirdupois Weight.

The standard avoirdupois pound of the United States, as determined by Mr. Hassler, is the weight of 27.7015 cubic inches of distilled water weighed in air at the temperature of the maximum density, (39°.83;) the barometer being at 30 inches.

Drams.	Ounces.	Pounds.	Quarters.	Cwt.	Ton.
16	1				
256	16	1			
7,168	448	28	1		
28,672	1,792	112	4	1	
573,440	35,840	2,240	80	20	1

Troy Weight.

Grains.	Dwt.	Ounces.	Pound.
24	1		
480	20	1	
5,760	240	12	1

The pound, ounce, and grain are the same in Apothecaries' and Troy weight; in the former, the ounce is divided into 8 drachms, the drachm into 3 scruples, and the scruple into 20 grains.

7,000 Troy grains = 1 lb. avoirdupois.
175 Troy pounds = 144 lbs. avoirdupois.
175 Troy ounces = 192 oz. avoirdupois.
437½ Troy grains = 1 oz. avoirdupois.

Measures of Value.

GOLD.		Double Eagle.	Eagle.	Half-Eagle.	Three-Dollars.	Quarter-Eagle.	Dollar.
Weight	grains	516	258	129	77.4	64.5	25.8
Deviation allowed	"	0.5	0.5	0.5	0.75	0.25	0.25
Diameter	inches	1.320	1.05	.85	.80	.70	.60
Thickness	"	.076	.059	.045	.033	.033	.019

SILVER.		Dollar.	Half-Dollar.	Quarter-Dollar.	Dime.	Half-Dime.	Three-Cent.	Copper Cent.
Weight	grains	412.5	192.	96.	38.4	19.2	11.52	72.
Deviation allowed	"	1.5	1.5	0.5	0.5	0.5	0.5	4.0
Diameter	inches	1.5	1.2	.95	.7	.6	.55	.75
Thickness	"	.084	.060	.050	.032	.024	.018	.065

The standard of gold and silver is 900 parts of pure metal and 100 of alloy in 1,000 parts of coin. The alloy of gold coin is 25 silver and 75 copper; the alloy of silver is copper. The cent is 88 parts copper and 12 parts nickel in 100 parts.

Dimensions of Drawing-Paper.

Cap	1 ft.	1	in.	× 1	foot	4	inches.
Demy	1 "	7½	"	× 1	"	3½	"
Medium	1 "	10	"	× 1	"	6	"
Royal	2 "	0	"	× 1	"	7	"
Super royal	2 "	3	"	× 1	"	7	"
Imperial	2 "	5	"	× 1	"	9¼	"
Elephant	2 "	3¾	"	× 1	"	10¼	"
Columbier	2 "	9¾	"	× 1	"	11	"
Atlas	2 "	9	"	× 2	"	2	"
Theorem	2 "	10	"	× 2	"	4	"
Double elephant	3 "	4	"	× 2	"	2	"
Antiquarian	4 "	4	"	× 2	"	7	"

A *ream* of paper is 20 *quires* of 24 *sheets* each.

FOREIGN MEASURES AND WEIGHTS.

Measures of Length.

GREAT BRITAIN.—The same as those of the United States. (See page 445.)

The Imperial standard yard of Great Britain, adopted in 1825, is referred to a natural standard, which is the distance between the axis of suspension and the centre of oscillation of a pendulum which shall vibrate seconds in vacuo, in London, at the level of the sea: that distance, measured on a brass rod, at the temperature of 62° Fahr., is declared to be 39.1393 *imperial inches.*

FRANCE.—*New System:* The metre is the unit, and is the ten-millionth part of a quadrant of a meridian of the earth, measured at the temperature of 32°. The multiples and divisions of it are decimal, viz.:

1 Metre = 10 decimetres = 100 centimetres = 1,000 millimetres.

1 Metre = $\frac{1}{10}$ decametre = $\frac{1}{100}$ hectametre = $\frac{1}{1000}$ kilometre = $\frac{1}{10000}$ myriametre.

1 Metre = 1.093633 yard = 3.280899 feet = 39.37079 inches.

1 Metre = 0.51317 toise.

1 Kilometre = 0.621383 mile.

For table for reducing metres to inches, see page 493.

Old System:

1 Point		= 0.0074	Eng. inch.	
1 Line	= 12 points	= 0.08884	"	
1 Inch	= 12 lines	= 1.06577	"	
1 Foot	= 12 inches	= 12.7892	"	
1 Ell	= 43 in. 10 lines	= 46.716	"	= 1.298 yd.
1 Toise	= 6 feet	= 76.735	"	= 2.132 "

1 Perch (Paris) = 18 feet.

1 Perch (royal) = 22 "

1 League, (common,) 25 to a degree = 4,861 yds. = 2.76 miles.

1 League (post) = 2,000 toises = 4,264 yds. = 2.42 miles.

1 Fathom (*brasse*) = 63.946 inches, or $5\frac{1}{3}$ feet Eng., nearly.

1 Cable length = 120 fathoms French = $106\frac{2}{3}$ fathoms English.

1 Pace (*pas*) = $\frac{2}{3}$ metre = 26.5 inches nearly.

AUSTRIA.
- 1 Foot (*fuss*) = 12 zoll = 1.0371 ft. = 12.4452 inches.
- 1 Inch (*zoll*) = 12 linie = 144 punkt = 1.0371 inch.
- 1 Mile (*meile*) = 4.7141 miles.

PRUSSIA.
- 1 Rhineland ft. (*Rhein-fuss*) = 12 zoll = 1.0297 ft. = 12.3564 in.
- 1 Inch (*zoll*) = 12 linie = 144 scrupel = 1.0297 inch.
- 1 Mile (*post-meile*) = 2,000 ruthe = 24,000 Rhein-fuss = 4.68045 miles.

RUSSIA.
- The foot is the same as the English foot.
- 1 Foot = 12 inches = 120 lines = 1,200 points.
- 1 Archine = 28 inches = 2.3333 feet = 1 foot.
- 1 Sagène = 3 archines = 7 feet.
- 1 Verst = 500 sagènes = 1,500 archines = 3,500 ft. = .6629 mile.

SPAIN.
- 1 Foot = 0.91319 foot = 10.95828 inches.
- 1 Vara = 3 feet = 0.91319 yard = 2.73957 feet.
- 1 League = 24,000 feet = 4.1508 miles.
- 1 Common league, or 19,800 feet = 3.4245 miles.

SARDINIA	1 Ft. (Turin) = 12 oncia = 144 punto = 1.12374 ft. = 13.485 in.
	1 Foot (Liprando) = 1.68561 ft.
	1 Mile = 1,300 tesa = 1.5744 mile.
SWEDEN.	1 Foot = 0.97144 foot = 11.6573 inches.
	1 Mile = 6.6235 miles.
TURKEY.	1 Pic = 0.73173 yard = 2.19519 feet.
	1 Berri = 1.0358 mile.
CHINA.	1 Chik mathematical = 13.125 inches = 1.093 foot.
	1 Chik commercial = 14.7625 inches = 1.2302 foot.
	1 Li = 608.608 yards = .3458 mile.
	1 To = 69.1797 miles.
HAVANA.	1 Foot = 0.92741 foot = 11.129 inches.
	1 Vara = 0.92741 yard = 2.78223 feet.
MEXICO.	1 Foot = .91578 foot = 10.989 inches.
	1 Vara = 0.91578 yard = 2.74735 feet = 32.9682 inches.
	1 League (common) = 2.594 miles.

Measures of Surface.

GREAT BRITAIN.—The same as those used in the United States.

FRANCE.—*Old System*	1 Square inch = 1.13587 square inch.
	1 Arpent (Paris) = 4.089 square yds. = .8449 acre.
	1 Arpent (ordinary) = 1.0457 acre.
New System	1 are = 100 square metres = 119.603 square yards.
	1 hectare = 10 decares = 100 ares = 2.4711 acres.

AUSTRIA.—1 Joch or Jochart = 1.4223 acre.

PRUSSIA.—1 Morgen = 0.6309 acre.

SPAIN.—1 Fanigada = 1.5871 acre.

Measures of Solidity.

GREAT BRITAIN.—The same as those used in the United States.

FRANCE.—*Old System*	1 cubic inch = 1.2106 cubic inch.
	1 cubic foot = 2091.85 inches = 1.2105 foot.
New System	1 cubic decimetre = 61.0271 cubic inches.
	1 stere = 1 cubic metre = 35.3166 cubic ft. = 1.308 cubic yard.

Measures of Capacity.

GREAT BRITAIN.—The British imperial gallon measures 277.274 cubic inches, containing 10 pounds avoirdupois of distilled water weighed in air at the temperature of 62°, the barometer being at 30 inches. The same measure is used for liquids as for dry goods which are not measured by heaped measure; for the latter, the bushel is to be heaped in the form of a cone not less than 6 inches high, the base being 19½ inches. The old distinctions of wine measure, ale and beer measure, and dry measure, are discontinued.

1 Gallon = 1.2006 gallon = 277.274 cubic inches.

For grain. { 1 Bushel = 1.0318 bushel = 1.2836 cubic ft.
1 Load = 5 quarters = 40 bushels = 51.347 cubic feet.

For coal. { 1 Sack = 3 bushels = 3.0944 bushels.
1 Chaldron = 12 sacks = 36 bushels = 58.68 cubic feet.

For timber.—1 Load = 40 cubic feet.

FRANCE. { 1 Litre = 1.057 quart = 61.0271 cubic inches.
1 Hectolitre = 10 decalitres = 100 litres = 26.418 gallons.
1 Kilolitre = 10 hectolitres = 28.3782 bushels.
1 Pinte (old) = .98383 quart.

SPAIN. { 1 Wine arroba = 4.26304 gallons.
1 Fanega = 1.59914 bushel.

MEXICO.—1 Fanega = 1.60307 bushel.

HAVANA.—1 Fanega = 3.11023 bushels.

Measures of Weight.

GREAT BRITAIN.—The same as those used in the United States.

The imperial avoirdupois pound is the weight of 27.7274 cubic inches of distilled water weighed in air at the temperature of 62° Fahr.; barometer, 30 inches.

Horseman's weight.—1 Stone = 14 lbs.

FRANCE.—*Old System:*

1 Livre = 16 onces	= 1.0780 lb. avoirdupois.
1 Once = 8 gros	= 1.0780 oz. avoirdupois.
1 Gros = 72 grains	= 58.9548 grains Troy.
1 Grain................	= 0.8188 "	

New System: The basis of the system of weights is the weight, in vacuo, of a litre, or a cubic decimetre, of distilled water, at the temperature of 39°.2 Fahr.; $\frac{1}{1000}$ part of this weight is a *gramme,* the multiples of which are: 1 decagramme = 10 grammes; 1 hectogramme = 100 grammes; 1 kilogramme = 1,000 grammes. The divisions are: 1 decigramme = $\frac{1}{10}$ gramme; 1 centigramme = $\frac{1}{100}$ gramme; 1 milligramme = $\frac{1}{1000}$ gramme.

1 Quintal = 100 kilogrammes.

1 Millier = 1,000 kilogrammes = 1 ton sea-weight, (French.)

1 Kilogramme = 2.204737 pounds avoirdupois.

1 Gramme = 15.433159 grains Troy = 0.03528 oz. avoirdupois.

For table for converting kilogrammes into pounds, see page 494.

AUSTRIA. { 1 Pound = 16 unze = 32 loth = 128 quent = 512 pfennig = 1.234677 pound.
1 Karch = 4 centner = 20 stein = 493.87084 lbs.

PRUSSIA.
1 Pound = 2 mark = 16 unze = 32 loth = 128 quentchen = 1.03118 lb.
1 Centner = 110 pfund = 113.44 lbs.

RUSSIA.
1 Pound = 12 lana = 32 loth = 96 solotniks = 9,216 doli = .901691 lb.
1 Pood = 40 pounds.
1 Berkowitz = 360.6764 lbs.
1 Pound is the weight of 25 cubic inches of water.

SPAIN.
1 Pound = 16 onza = 128 ochava = 256 adarme = 768 tomine = 9,216 grano = 1.016097 lb.
1 Ton = 20 quintal = 80 arroba = 2,000 lbs. = 2,032.2 lbs.

SARDINIA.
1 Pound = 12 oncia = 96 ottavo = 6125 grano = .896286 lb.
1 Pound of Turin = .813332 lb.
1 Rubbio = 25 pounds = 20.3333 lb.

SWEDEN.
1 Pound = 16 untz = 128 qwintin = 8,848 as = .937284 lb.
1 Skeppund (for iron) = 299.93088 lbs.

TURKEY.—1 Oka = 2.828571 lb.

CHINA.
1 Pound = 16 leung = 364 chu = 3,840 lui = 38,400 shu = 1.3333 lb.
1 Shik = 4 kwan = 60 yin = 120 kan = 160 lbs.

JAPAN.—1 Pecul = 100 catty = 1,600 tael = 16,000 mas = 160,000 condorine = 130 lbs.

Equivalents of Ounces in Decimal Fractions of a Pound.

Ounces.		Pounds.
1	=	.0625
2	=	.125
3	=	.1875
4	=	.25
5	=	.3125
6	=	.375
7	=	.4375
8	=	.5
9	=	.5625
10	=	.625
11	=	.6875
12	=	.75
13	=	.8125
14	=	.875
15	=	.9375
16	=	1.0

Pounds.		Ounces.
.1	=	1.6
.2	=	3.2
.3	=	4.8
.4	=	6.4
.5	=	8.0
.6	=	9.6
.7	=	11.2
.8	=	12.8
.9	=	14.4
1.0	=	16.0

Measures of Value.

FOREIGN MONEY.—ITS MINT VALUE.

			Dollars.	Subdivisions.
GREAT BRITAIN.	*Gold...*	1 Guinea = 21 shillings	5.059	½, ⅓, ¼ of guinea.
		1 Sovereign or Pound = 20 shillings............	4.848	
	Silver..	1 Crown = 5 shillings..	1.08	
		1 Shilling = 12 pence ..	0.222	
	Copper...	1 Penny	0.018	
FRANCE.....	*Gold...*	100 Francs...............	19.225	50 francs, 40 frs.
		20 Francs.................	3.845	10 francs, 5 frs.
	Silver...	5 Francs	0.968	1 franc = 20 sous.
	Copper.	1 Sou.......................	0.00968	
AUSTRIA ...	*Gold....*	1 Imperial souverain = 13 florins 20 kreutzers	6.77	Half, quarter souverains.
		1 Imperial ducat = 4 florins 36 kreutzers..	2.28	
	Silver..	1 Rix-dollar = 2 florins	1.013	Half, or florin.
		1 Crown = 2 florins 12 kreutzers	1.1138	
		1 Zwanziger = 20 kreutzers......................	0.168	Or 20 kreutzers.
		1 Silver Groschen = 3 kreutzers	0.025	
PRUSSIA....	*Gold...*	1 Double Frederick = 11 thalers 10 silver groschen......	8.00	Single, half.
	Silver..	1 Thaler = 30 silver groschen................................	0.717	$\frac{1}{3}$, $\frac{1}{6}$, $\frac{1}{12}$, $\frac{1}{24}$, $\frac{1}{30}$.
RUSSIA......	*Gold...*	1 Imperial = 10 roubles..	7.952	Half imperial.
	Silver..	1 Rouble.....................	0.784	Half rouble.
SARDINIA...	*Gold...*	80 Lires	15.488	40, 20 lires.
	Silver..	5 Lires........................	0.968	2, 1, ½, ¼ lire.
SPAIN	*Gold...*	1 Doubloon or Ounce...	15.731	
		100 Reals..................	4.963	
	Silver..	1 Piastre.....................	1.005	Pistareen, (⅕ of piastre.)
SWEDEN.....	*Gold...*	1 Ducat......................	2.267	½, ¼ ducat.
	Silver..	1 Specie rix-daler..........	1.101	½, ¼, ⅛, $\frac{1}{16}$.
ROME........	*Gold...*	2½ Scudi.....................	2.60	
	Silver..	1 Scudo.......................	1.047	
MEXICO.....	*Gold...*	1 Doubloon	15.534	
	Silver..	1 Piastre of 8 reals........	1.049	
TURKEY.....	*Gold...*	100 Piastres.................	4.374	
	Silver..	20 Piastres = 800 paras..	0.865	Pieces of 10 and 5 piastres.
JAPAN	*Silver..*	1 Itzebu......................	0.37	
HINDUSTAN	*Gold...*	1 Mohur......................	7.08	
	Silver..	1 Rupee.......................	0.46	

Comparative Table of French and United States Measures.

	No.	Logarithm.	Logarithm.	No.	
Grains in a gramme	15.433159	1.1884549	$\bar{2}.8125451$	0.064945	Gramme in a grain.
Pounds avoirdupois in a kilogramme	2.204737	0.3433567	$\bar{1}.6566433$	0.453569	Kilogramme in a pound avoirdupois.
Ton in a millier or tonneau	0.9842575	1.9931087	0.0068913	1.015994	Millier or tonneau in a ton.
Inch in a millimetre	0.03937079	$\bar{2}.5951741$	1.4048259	25.39954	Millimetres in an inch.
Feet in a metre	3.280899	0.5159929	$\bar{1}.4840071$	0.30479449	Metre in a foot.
Yard in a metre	1.093633	0.0388716	$\bar{1}.9611284$	0.914384	Metre in a yard.
Mile in a kilometre	0.621382	$\bar{1}.7933590$	0.2066410	1.609315	Kilometre in a mile.
Square inch in a square millimetre	0.00155006	$\bar{3}.1903482$	2.8096518	645.137	Square millimetres in a square inch.
Square inch in a square centimetre	0.155006	$\bar{1}.1903482$	0.8096518	6.45137	Square centimetres in a square inch.
Square feet in a square metre	10.7643	1.0319858	$\bar{2}.9680142$	0.0928997	Square metre in a square foot.
Square yard in a square metre	1.196033	0.0777432	$\bar{1}.9222568$	0.8360973	Square metre in a square yard.
Acre in an are	0.0247114	$\bar{2}.3928977$	1.6071023	40.46713	Ares in an acre.
Cubic inch in a cubic centimetre	0.061027	$\bar{2}.7855223$	1.2144777	16.38618	Cubic centimetres in a cubic inch.
Cubic feet in a cubic metre	35.3166	1.5479787	$\bar{2}.4520213$	0.0283153	Cubic metre in a cubic foot.
Cubic yard in a cubic metre	1.308021	0.1166148	$\bar{1}.8833852$	0.7645135	Cubic metre in a cubic yard.
Quart in a litre	1.05672	0.0239599	1.9760401	0.9463248	Litre in a quart.
Bushel in a litre	0.0283794	$\bar{2}.4530034$	1.5469966	35.2368	Litres in a bushel.
Foot-pounds in a kilogrammetre	7.23352	0.8593496	$\bar{1}.1406504$	0.138245	Kilogrammetre in a foot-pound.
Pounds-to-the-foot in a kilogram.-to-the-metre	0.671957	1.8273411	0.1726589	1.48819	Kilogram.-to-the-metre in a pound-to-the-foot.
Pounds-to-the-sq. inch in a kilogram.-to-the-square-millimetre.	1422.28	3.1529858	$\bar{4}.8470142$	0.000703095	Kilogram.-to-the-sq're-millimetre in a pound-to-the-square-inch.
Pounds-to-the-square foot in a kilogram.-to-the-square-metre	0.2048098	$\bar{1}.3113482$	0.6886518	4.88261	Kilogram.-to-the-square-metre in a pound-to-the-square-foot.
Pounds-to-the-cubic-foot in a kilogram.-to-the-cubic-metre	0.062425	$\bar{2}.7953553$	1.2046447	16.019	Kilogram.-to-the-cubic-metre in a pound-to-the-cubic-foot.
Units of heat in a calorie	3.96853	0.5986292	$\bar{1}.4013708$	0.251983	Calorie in a unit of heat.
Fahrenheit degree in a centigrade degree	1.8	0.2552725	$\bar{1}.7447275$	0.55555	Centigrade degree in a Fahrenheit degree.

PHYSICAL DATA.

Working-Power of Men and Horses.

MEN.—*A foot soldier* travels in 1 minute,

in common time,	90 steps	=	70	yards.
in quick time,	110 "	=	86	"
in double quick,	140 "	=	109	"

He occupies in the ranks a front of 20 in., and a depth of 13 in., without the knapsack; the interval between the ranks is 13 in. 5 men can stand in a space of 1 square yard. Average weight of men, 150 lbs. each.

A *man* travels, without a load, on level ground, during $8\frac{1}{2}$ hours a day, at the rate of 3.7 miles an hour, or $31\frac{1}{4}$ miles a day. He can carry 111 lbs. 11 miles in a day. A porter going short distances and returning unloaded carries 135 lbs. 7 miles a day. He can carry in a wheelbarrow 150 lbs. 10 miles a day.

The maximum power of a strong man, exerted for $2\frac{1}{2}$ minutes, may be stated at 18,000 lbs. raised 1 foot in a minute.—*Mr. Field's experiments,* 1838.

A man of ordinary strength exerts a force of 30 lbs. for 10 hours a day, with a velocity of $2\frac{1}{2}$ feet in a second = 4,500 lbs. raised 1 foot in a minute = *one-fifth* the work of a horse.

Daily allowance of water for a man, 1 gallon, for all purposes.

HORSES.—*A horse* travels the distance of 400 yards, at a walk, in $4\frac{1}{2}$ minutes; at a trot, in 2 minutes; at a gallop, in 1 minute.

He occupies in the ranks a front of 40 in., a depth of 10 feet; in a stall, from $3\frac{1}{2}$ to $4\frac{1}{2}$ feet front; at picket, 3 feet by 9. Average weight of horses, 1,000 lbs. each.

A horse carrying a soldier and his equipments (say 225 lbs.) travels 25 miles in a day, (8 hours.)

A *pack-horse* can carry 250 to 300 lbs. 20 miles a day.

A *draught-horse* can draw 1,600 lbs. 23 miles a day,—weight of carriage included.

Artillery-horses should not be made to draw more than 700 lbs. each, the weight of the carriage included.

The ordinary work of a horse for 8 hours a day may be stated at 22,500 lbs. raised 1 foot in a minute.

In a horse-mill, the horse moves at the rate of 3 feet in a second. The diameter of the path should not be less than 25 or 30 feet.

Daily allowance of water for a horse, 4 gallons.

VENTILATION.—A man exhales about $\frac{5}{8}$ of a cubic foot of carbonic acid in an hour, or 15 cubic feet in a day. He produces from the lungs and skin about 600 grains of vapor in an hour.

Air is no longer fit for combustion or respiration when it contains 4 per cent. of its volume of carbonic acid.

A ventilation of 8 to 9 cubic yards per hour for each person is in all cases sufficient. For barracks a capacity of 13 to 20 cubic yards per man is sufficient; the air being renewed in part by the cracks about the windows and by the opening of the doors.

In dormitories the volume of carbonic acid does not exceed three or four thousandths of the whole space, and the air is not more than $\frac{3}{4}$ saturated with moisture.

Table showing the Weight and Bulk of 1,000 *Rations.*

1,000 rations.	Net weight in pounds.	Gross weight in pounds.	Bulk in barrels.
Pork	750.	1218.75	3.75
Bacon	750.	903.1861	4.9019
Flour	1125.	1234.0561	5.7397
Pilot bread	750.	921.6867	9.031
"	1000.	1228.9156	12.048
Beans	155.	177.3187	0.7142
Rice	100.	114.5	0.4629
Coffee	100.	118.1683	0.5813
Sugar	150.	169.5312	0.625
Vinegar	92.5	107.5	0.333
Candles	15.	17.5	0.0925
Soap	40.	46.8965	0.1877
Salt	33.75	38.6328	0.1562

Forage.—Hay, pressed in bundles; 11 lbs. to the cubic foot. Average weight of bundles, 300 lbs.

Oats: 32 lbs. to the bushel, or 25.71 lbs. to the cubic foot.

Wheat: 60 lbs. to the bushel, or 48.21 lbs. to the cubic foot.

Corn: 56 lbs. to the bushel, or 45.02 lbs. to the cubic foot.

Fresh grass weighs about 84 lbs. to the cubic yard.

3 beeves or 15 sheep consume the forage of 2 horses.

Weight of the Atmosphere.

Pressure of the atmosphere, on one square inch, the barometer being at 30 in., is 14.736 lbs.; at 29.922 in. the pressure is 14.7 lbs.

Velocity of Sound.

At the temperature of 33° the mean velocity of sound is 1092.5 feet in a second. It is increased or diminished *half a foot* for each degree of temperature above or below 33°.

Velocity and Force of the Wind.

VELOCITY.		Pressure on 1 square foot.	Common designations of the force of the winds.
In 1 hour.	In 1 second.		
Miles.	Feet.	Lbs.	
1	1.47	0.005	Hardly perceptible.
2	2.93	.020	Just perceptible.
3	4.40	.044	
4	5.87	.079	Gentle, pleasant wind.
5	7.33	.123	
10	14.67	.492	Pleasant, brisk breeze.
15	22.00	1.107	
20	29.34	1.968	Very brisk.
25	36.67	3.075	
30	44.01	4.429	High wind.
35	51.34	6.027	
40	58.68	7.873	Very high.
45	66.01	9.963	
50	73.35	12.300	A storm or tempest.
60	88.02	17.715	A great storm.
80	117.36	31.490	A hurricane.
100	146.70	49.200	A hurricane that tears up trees, carries buildings before it, &c.

Malleability of Metals.

1. Gold.
2. Silver.
3. Copper.
4. Tin.
5. Platinum.
6. Lead.
7. Zinc.
8. Iron.

Ductility of Metals.

1. Gold.
2. Silver.
3. Platinum.
4. Iron.
5. Nickel.
6. Copper.
7. Zinc.
8. Tin.

Electricity.

RELATIVE CONDUCTING-POWER OF METALS.

Copper	10,000	Iron	1,580
Gold	9,360	Tin	1,550
Silver	7,360	Lead	830
Zinc	2,850	Mercury	345
Platinum	1,880	Potassium	133

The conducting-power of rods of the same metal, of equal diameter, is inversely as their lengths.

The conducting-power is increased by lowering the temperature, and diminished, and finally destroyed, by raising the temperature.

The metals are infinitely better conductors than any other substances. Charcoal which has been exposed to a strong heat is one of the best conductors, but greatly inferior in this respect to iron and platinum.

Heat.

THERMOMETERS.

Fixed Points.	Fahrenheit.	Reaumur.	Centigrade.
Freezing-point of water..............	32°	0°	0°
Boiling-point " "	212°	80°	100°

For converting degrees of one scale into those of another we have—

$$F^\circ = \frac{C^\circ \times 9}{5} + 32^\circ = \frac{R^\circ \times 9}{4} + 32^\circ.$$

The zero of Wedgewood's pyrometer corresponds with 1077° Fahr., and 1° Wedgewood is equal to 130° Fahr. Hence $F^\circ = W^\circ \times 130^\circ + 1077^\circ$.

NOTE.—The indications of Wedgewood's pyrometer are no longer relied on for high temperatures.

Melting-Points of Solids.

3280° is the highest heat attained with an air-furnace. Platinum does not *melt* at this temperature.

Platinum, palladium, rhodium, lime, silex, fine porcelain, can he melted, in small quantities, by means of strong lenses, or hy the hydro-oxygen blow-pipe.

Iron *red hot*, in daylight, 1077° Fahr.; in the dark, 752°.

Wrought iron	3,280°
Cast iron	2,786
Gold	2,016
Silver	1,873
Copper	2,204
Brass	1,869
Flint-glass	2,377
Antimony	955.5
Zinc	775.5
Saltpetre	600
Lead	644
Zinc	500
Tin	445°
Lead 2, tin 1 (common solder)	475
Lead 1, tin 1	393
Lead 1, tin 2 (soft solder)	360
Lead 1, tin 1, bismuth 1	272
Lead 2, tin 3, bismuth 5	212
Lead 1, tin 1, bismuth 2	200
Sulphur	228
Gutta-percha softens	145
Beeswax	150
Tallow	127

Boiling-Points of Liquids. (*The Barometer at* 30 *in.*)

Hydrochloric ether	52°
Sulphuric ether	96
Sulphuret of carbon	118
Ammonia	140
Alcohol of 0.825	175
Water, and essential oils	212
Water, saturated with salt	224
Nitric acid	248
Spirits of turpentine	314°
Naphtha	320
Phosphorus	554
Sulphur	570
Sulphuric acid, sp. gr. 1.843	620
Linseed-oil	600
Whale-oil	630
Mercury	662

Liquids boil at a much lower temperature in vacuo, or under diminished pressure of the atmosphere. At the altitude of about 17,500 feet above the sea, where the barometer stands at 15.35 in., water boils at 180°.

Expansion by Heat.

Linear Expansion of Solids, from 32° *to* 212°.

Zinc	0.0029416	Roman cement	0.00144
Lead	0.0028483	Marble, Sicilian	0.00141
Tin, refined	0.0021729	" Carrara	0.00119
Silver, fine	0.0019097	Sandstone	0.00117
Brass	0.0018750	Slate	0.00104
Copper	0.0017122	Granite	0.00080
Gold	0.0015000	Glass, flint	0.00082
Steel, tempered	0.0012395	Brick, stock	0.00055
Iron, soft, hammered	0.0012583	" fire	0.00049
" cast	0.0011111	Marble, black Galway	0.00045
Steel, not tempered	0.0010788	Oak, dry	0.00006
Platinum	0.0008842		
Antimony	0.0010833		

The expansion in surface is expressed by numbers *double* of the above, and the expansion in volume by *triple* numbers.

Expansion of Fluids in bulk, from 32° *to* 212°.

Mercury	0.01808	Sulphuric acid	0.05882
Water, distilled	0.04330	Oil (olive and linseed)	0.08333
Water, saturated with salt	0.05000	Spirits turpentine	0.07143
Alcohol	0.11000	Gases, and air	0.37500

The rate of expansion of solids and liquids increases with the temperature; that of the gases is uniform for all temperatures.

Density of Water.

(From a report of Prof. R. S. McCulloch to Prof. A. D. Bache.)

Temp.	Density.	Temp.	Density.	Temp.	Density.
20°	.99901	50°	.99975	80°	.99666
25	.99944	55	.99947	85	.99581
30	.99984	60	.99910	90	.99487
35	.99999	65	.99863	95	.99383
40	1.00000	70	.99807	100	.99270
45	.99993	75	.99741	Max. density at 39°.6.	

Conduction of Heat.

$q = \dfrac{T - T'}{g\,x}$. When q, the rate of conduction, is expressed in thermal units per hour, per square foot of area, and $x =$ the thickness of the layer in inches, T and T' being the temperatures at the two faces, the value of g, which is equal to 1 divided by the coefficient of conductivity, is as follows:

Gold, Platinum, Silver	0.0036	Lead	0.0198
Copper	0.0040	Marble	0.1578
Iron	0.0096	Brick	0.3306
Zinc	0.0099		

Specific Heat between 32° and 80°.

The number of units of heat required to raise the temperature of 1 lb. of each of the following substances one degree is as follows:

Antimony	.5077	Lead	.0293	Water	1.000
Bismuth	.3084	Mercury	.0333	Air	0.238
Charcoal	.2415	Platinum	.0314	Carbonic acid	0.217
Copper	.0951	Silver	.0557	Hydrogen	3.405
Glass	.1980	Sulphur	.20259	Nitrogen	0.244
Gold	.0298	Spts. turp'tine.	.4672	Oxygen	0.218
Ice	.504	Tin	.0514	Steam	0.475
Iron, wrought	.1138	Zinc	.0927		

The *unit of heat* is the quantity of heat necessary to raise the temperature of 1 lb. of water at its maximum density 1°.

Specific heats of substances are in the inverse ratio of their atomic weight.

The specific heat of a substance is called its capacity for heat. The capacity for heat increases with the temperature and diminishes as the density of the body increases. Air reduced rapidly to one-fifth of its volume evolves heat enough to set fire to tinder.

Latent Heat.

In thermal units for one pound: the vapors under a pressure of one atmosphere of 14.7 lbs. per square inch.

Of Fusion.		Of Evaporation.	
Ice	142.65	Water	966.1
Spermaceti	148.	Alcohol	364.3
Beeswax	175.	Ether	162.8
Phosphorus	9.06	Bisulphuret of carbon	156.0
Sulphur	16.86		
Tin	500.0		

Total Heat of Combustion of different Combustibles;

Or, the heat produced by burning one pound of each substance.

SUBSTANCES.	Weight of carbon to produce the same heat.	Lbs. of water evaporated at 212°.	Units of heat.
Hydrogen gas	....	64.2	62.032
Carbon imperfectly burned, so as to make C O	....	4.55	4.400
Carbon completely burned, so as to make CO^2	1.0	15.0	14.500
Various liquids, hydro-carbons ...... from..	1.33	20.	19.000
Various liquids, hydro-carbons ...... to	1.46	22.	21.000
Charcoal from wood	0.93	14.	13.500
" from peat	0.80	12.	11.600
Coke, good	0.94	14.	13.620
" middling	0.88	13.2	12.760
" bad	0.82	12.3	11.890
Coal, anthracite	1.05	15.75	15.225
" dry bituminous	1.06	15.9	15.370
" "	1.025	15.4	14.860
" "	1.02	15.3	14.790
" "	0.95	14.25	13.775
" caking	1.075	16.	15.837
" "	1.01	15.15	14.645
" cannel	1.04	15.6	15.080
Dry long flaming	0.91	13.65	13.195
Lignite	0.81	12.15	11.745
Peat, dry	0.66	10.0	9.660
" containing 25 per cent. of moisture	....	7.25	7.000
Wood, dry	0.50	7.5	7.245
" containing 20 per cent. of moisture	....	5.8	5.600

The heating-power of different kinds of wood (taking equal weights of wood equally dry) does not vary more than in the proportion of 13 to 14, for the extremes.

Nearly six times as much heat is required to evaporate a given quantity of water as is required to raise its temperature to the boiling-point: multiplying the above numbers by 6, we have, therefore, the quantity of water which each kind of fuel will raise from 32° to 212°.

In even the best apparatus, not more than *half* the heat produced by the combustion of fuel is economized.

Dry wood makes a hotter fire than equal weights or volumes of green wood.

Freezing-Points of Liquids.

Olive-oil	36° Fahr.	Strong wines	20° Fahr.
Water	32 "	Sulphuric acid	1 "
Milk	30 "	Brandy	—7 "
Vinegar	28 "	Mercury	—39 "
Spirits of turpentine	16 "	Nitric acid	—55 "

Strength of Ice.

Ice 2 inches thick will bear infantry.
" 4 " " " cavalry or light guns.
" 6 " " " heavy field-guns.
" 8 " " " 24-pdr. guns on sledges: weight not more than 1,000 lbs. to a square foot.

Frigorific Mixtures.

MATERIALS.	Parts.	The thermometer falls
Hydrochlorate of ammonia	5	From 50° to 10°.
Nitrate of potassa	5	
Water	16	
Hydrochlorate of ammonia	5	From 50° to 4°.
Water	16	
Nitrate of ammonia	1	From 50° to 4°.
Water	1	
Sulphate of soda	3	From 50° to 3°.
Dilute nitric acid	2	
Sulphate of soda	8	From 50° to 0°.
Hydrochloric acid	5	
Snow	1	From 32° to 0°.
Common salt	1	
Snow	1	From 30° to —15°.
Caustic potash, crystallized	1	
Snow	1	From 20° to —60°.
Sulphuric acid, dilute	1	
Snow	2	From —4° to —67°.
Chloride of calcium	3	
Sulphuric acid, dilute	10	From —67° to —90°.
Snow	8	

Measurement of Heights by Means of the Barometer.

1. $$X = 60345.51 \text{ ft.} \times \frac{1 + .00102\,(t + t' - 64°)}{1 - 0.002695 \cos. 2\,L} \times \log. \frac{h}{h'[1 + 0.0001\,(T - T')]}$$

X is the required difference of height, in feet,

T, the temperature of the air, in degrees of Fahrenheit, t, the temperature of mercury, H, the height of mercury — at the lower station.

T', the temperature of the air, t', the temperature of mercury, H', the height of mercury — at the upper station.

L, the latitude of the place.

2. Neglecting the corrections for the latitude of the place and for the difference between the temperature of the air and that of the mercury in

the barometers at the two stations, the difference of height, in feet, may be expressed approximately by $X = 67.0505\ (T + T' + 836) \times \log. \frac{H}{H'}$.

3. *Approximate Rule.*—For a mean temperature of 55° the difference of height in feet is, $X = 55{,}000 \times \frac{H - H'}{H + H'}$. Add $\frac{1}{440}$ of this result for each degree which the mean temperature of the air at the two stations exceeds 55°, and deduct as much for each degree below 55°.

Altitudes may be determined without the aid of a barometer by observing accurately the boiling-point of water at the different stations. h, the altitude, is equal to $517\ T + T^2$; or, for altitudes under 10,000 ft., $h = 540\ T$; T being the difference in degrees between the boiling-points of water at the two stations.

The *altitude* of Washington City is 50 to 90 feet; that of St. Louis, 450 feet; of Santa Fé, 6,846 feet; of San Antonio, 600 feet.

The *average quantity of water* which falls in rain and snow at Washington City is 41.2 inches; at San Francisco, 23.59 inches; at Santa Fé, 19.83 inches.

Latitude of the Washington Observatory, 38° 53′ 39″.25.

The mean temperature of Washington City is 36°.05 in winter, 76°.33 in summer; 56°.14 for the year: of San Francisco, 50°.86 in winter, 57°.53 in the summer, and 54°.88 for the year.

Declination of the Magnetic Needle for 1860.

Washington City	2° 36′	West.	Savannah	3° 5′	East.
New York	7 01	"	Mobile	6 8	"
Albany	8 3	"	San Diego	12 6	"
Charleston	1 7	East.	San Francisco	15 8	"

The annual increase at Washington is 3 minutes.

Dip of the needle at Washington, 1861, 71° 24′.

Sun-Dials.

The most common dial is that in which the plane of the dial is horizontal, and the *style*, placed in the meridian, is inclined to the plane of the dial at an angle equal to the latitude of the place.

Hour-lines are drawn from the centre, or point where the style intersects the plane, to the circumference: their positions are calculated from the formula $\tan. x = \tan. h \sin. L$, in which $x =$ the hour-angle on the horizontal plane, $h = 15°, 30°, 45°$, etc., the hour-angle on the equatorial plane, and $L =$ the latitude of the place.

To determine these lines geometrically, draw in the meridian-plane from some point a, on the style, a line perpendicular to the style, and note the point b where it intersects the plane of the dial. Draw through this point a line, in the plane of the dial, perpendicular to the meridian-plane. This will be the equatorial line.

Measure off from b, on the prolongation of the meridian, the distance $b\,c$ equal to $a\,b$, and with c as a centre, describe a semicircle, and divide it into 12 equal parts, 6 on each side of the meridian: through these points of division draw radii, and prolong them till they meet the equatorial line. Join these points of intersection with the foot of the style, and these lines will mark the hours before and after 12 o'clock M.

To determine the meridian-line without the use of astronomical instruments.—Take a point in the plane of the dial through which it is intended the meridian-plane shall pass. With this point as a centre describe several concentric circles. Fix a straight pin in the centre, perpendicular to the plane of the dial, of such a length that the extremity of the shadow cast by it shall fall within the circles at 12 M. Mark the points where the extremity of the shadow passes over these circles in the forenoon, and again the same in the afternoon. The line drawn from the middle of these arcs contained between the points of passage, to the centre of the circles, will be the meridian.

Or the meridian may be determined by two plumb-lines made to cover each other, and also the North Star at the time of its passage across the meridian.

The time given by the dial is true solar time: to reduce it to mean, or clock time, the equation of time must be added or subtracted.

Equation of Time.

January	1	+ 3′ 46″	July	1	+ 3′ 27″
	16	+10 1		16	+ 5 42
February	1	+13 53	August	1	+ 6 1
	16	+14 23		16	+ 3 59
March	1	+12 35	September	1	— 0 9
	16	+ 8 49		16	— 5 13
April	1	+ 3 57	October	1	—10 18
	16	— 0 13		16	—14 22
May	1	— 3 3	November	1	—16 17
	16	— 3 53		16	—15 2
June	1	— 2 30	December	1	—10 44
	16	+ 0 18		16	— 3 59

FORMULÆ IN MECHANICS.

Forces acting on machines are compared to weights, and are expressed in pounds.

The velocity of a body, the space which it passes over in a second of time when it is moving with a uniform motion, or the space that it would pass over in a second of time when it has a varied motion, if its motion should become uniform at the time it is considered, is expressed in feet.

UNIFORM MOTION.—Is expressed by $S = V\,T$.

S being the space passed over, V the velocity, and T the duration of the motion.

UNIFORMLY ACCELERATED MOTION STARTING FROM A STATE OF REST.— $S = \frac{1}{2} V_1 T^2$: $V^2 = 2 V_1 S$: V_1, the velocity after the 1st second.

UNIFORMLY RETARDED MOTION.—$S = V' T - \frac{1}{2} V_1 T^2$.

$V = V' - V_1 T$: V' the velocity at the moment the retarding force begins to act; V the velocity remaining at the end of the time T.

MOTION OF FALLING BODIES.—The force of gravity is uniform and constant for the same place on the surface of the earth. Let g be the velocity acquired by a body falling freely in vacuo at the end of the first second; v the velocity at the time t; t the time in seconds; h the space passed over in the time t; then $h = \frac{1}{2} g t^2$: $v = g t = \sqrt{2 g h}$.

The velocity g, which is the measure of the force of gravity, varies with the latitude of the place, and with its altitude above the level of the sea.

The force of gravity at the latitude of 45° = 32.1803 feet; at any other latitude L; $g = 32.1803$ feet $- 0.0821 \cos. 2 L$. If g' represent the force of gravity at the height h above the sea, and r the radius of the earth, the force of gravity at the level of the sea will be $g = g' \left(1 + \frac{5h}{4r}\right)$.

$$g' = g\ 45° \times \frac{1 - 0.002588 \cos. 2L}{1 + \frac{5h}{4r}}.$$

In the latitude of London, at the level of the sea, $g = 32.1908$ feet.
" Washington, " " $g = 32.155$ feet.

QUANTITY OF WORK.—It is the product of the intensity of a force by the distance passed over by its point of application in the direction of the force. The unit of work done corresponds to the elevation of 1 pound through a height of 1 foot, and is called a *foot-pound* (*ft.-lb.*)

A HORSE-POWER.—This force is estimated at 550 lbs. raised 1 foot in a second, or 33,000 lbs. raised 1 foot in 1 minute.

THE MASS OF A BODY is expressed by the weight divided by the force of gravity, thus: $M = \frac{P}{g}$.

MOVING FORCE, AND FORCE OF INERTIA.—We have $F = M \frac{v}{t}$ for the force F capable of communicating or taking away from the body of a mass M an element of velocity v in an element of time t.

QUANTITY OF MOTION.—The product of the mass of a body by the velocity which it has at the time considered; that is, $M V$.

IMPACT OF ELASTIC AND UNELASTIC BODIES.—A body of a mass M moving with a velocity V impinges against another M' moving with a velocity V' in the same line and in the same direction. A diminution of velocity v is developed in the element of time t, at the point of contact in the first body, and an increase of velocity v' in the second body, so that we have

$M v = M' v'$: the sum of the quantity of motion is the same before and after impact.

For unelastic bodies, if they remain together after impact, moving with a common velocity U, we have $U = \frac{M V + M' V'}{M + M'}$; if they meet, going in opposite directions, $U = \frac{M V - M' V'}{M + M'}$.

For elastic bodies, the velocity of the body M after impact is $2\,U - V$; that of M' is $2\,U - V'$. $2\,U = \frac{2(M V + M' V')}{M + M'}$. If M' were in a state of rest, its velocity after impact would be $2\,U = \frac{2\,M\,V}{M + M'}$, double that which would have been communicated to an unelastic body under the same circumstances.

Living Force of a Body is the product of its mass by the square of its velocity at the time considered.

Principle of Living Forces.—$T = \frac{1}{2}(M\,V^2 - M'\,V'^2)$. T is the work of a force which accelerates or retards the motion of a body which is moving in its own direction.

Centrifugal Force.—$F = \frac{M\,V^2}{r}$. r is the radius described by the centre of gravity of the mass.

Simple Pendulum.—The time of vibration of a simple pendulum $T = \pi\sqrt{\frac{l}{g}}$, l being the length of the pendulum.

The relation between the times T and T' of vibration of simple pendulums of lengths l and l' in different places for which the force of gravity is g and g' is $\frac{T}{T'} = \sqrt{\frac{g' l}{g\, l'}}$. If l be the length of a pendulum vibrating seconds, and l' the length of any other simple pendulum vibrating in the time t at the same place, then $l' = l\,t^2$.

The length of the seconds-pendulum is in a constant ratio to the force of gravity: $\frac{g}{l} = 9.8696044$.

Length of a Pendulum vibrating Seconds at the Level of the Sea, in various Latitudes.

At the Equator		39.027144 inches
Washington,	Lat. 38° 53′ 23″	39.10583 "
New York,	Lat. 40° 42′ 43″	39.11256 "
London,	Lat. 51° 31′	39.13908 "
	Lat. 45°	39.12696 "
	Lat. L	39.12696 in. — 0.099816 cos. 2 L.

The time of oscillation of a compound pendulum is $T = \pi\sqrt{\frac{I}{M d g}}$. I being the moment of inertia of the oscillating body in reference to the axis of oscillation; d the distance of the centre of gravity of the pendulum from the axis.

T being known, we have $I = \frac{T^2}{\pi^2} Mdg$.

The moment of inertia, in reference to an axis passing through the centre of gravity and parallel to the axis of suspension, is $I_1 = I - Md^2$.

REVOLVING PENDULUM.—The time of revolution is $T = 2\pi\sqrt{\frac{h}{g}}$; h is the projection of the stem on a vertical plane.

For Washington, $h = \frac{9.77388}{T^2}$ inches; T being the number of revolutions per second.

THE DISCHARGE OF WATER UNDER A CONSTANT HEAD.—The theoretical discharge of water through an orifice in a thin plate is $Q = S\sqrt{2gH}$; Q, the quantity of water; S, the area of the orifice, and H, the depth of the orifice below the surface of the water.

To get the actual discharge, multiply the theoretical discharge by one of the following coefficients, according to the height of the surface above the middle of the orifice.

	Feet.	Feet.	Feet.	Inches.	Inches.
$H =$	33.75	5.	1.	8.	4.
Coefficient for orifice 1 inch in diam.	0.6	0.62	0.632	0.634	0.637
" " " 4 " "	0.6	0.612	0.617	0.613	0.608

If the *contraction* of the vein be not complete, if one or more of the sides of the orifice be in the prolongation of the sides of the vessel, multiply the preceding coefficients by .1035 when there is no contraction on *one* side; by 1.072 when there is none on *two* sides; by 1.125 when the contraction is only on *one* side.

THROUGH PIPES HAVING NO SUDDEN CHANGES OF DIRECTION.—$V = 26.79\sqrt{DI} - .082$ feet; $Q = \frac{D^2V}{1.273}$; D, diameter of the pipe; $I = \frac{H}{L}$, the slope per running foot; H, the difference of level between the two reservoirs; L, the whole length of the pipe.

To find the size of pipe for a given volume of water, we have $Q = 21.045\sqrt{D^5I} - 0.0196\,D^2$; or $D = 0.2956\sqrt[5]{\frac{Q^2}{I}}$, with sufficient accuracy for a mean velocity not exceeding $1\frac{1}{2}$ feet.

HYDRAULIC RAMS.—The following proportions have been found to answer in practice:

h, the height above the reservoir to which the water is to be thrown.

H, the height of the reservoir above the outlet of the waste-valve.

L, the length of the supply-pipe from the reservoir to the waste-valve.

D, its interior diameter.

Q, the whole supply of water in cubic feet per second.

q, the quantity raised to the height h.

$H = \frac{h}{20}$; $L = 2.8\,H = 0.14\,h$; $D = \frac{H}{10} = \frac{h}{200}$; $\frac{qh}{QH} = \frac{2}{3}$ nearly.

MECHANICAL POWERS.

Conditions of Equilibrium of Simple Machines.

LEVER.—The *effective arm* of a lever is the perpendicular distance from the fulcrum to the line of direction of the power or weight.

The power is to the weight inversely as the effective arms of the lever:

$$P D = w d.$$

The pressure on the fulcrum is the resultant of the power and weight.

FIXED PULLEY.—The power is equal to the weight. The pressure Q on the axis is to the power or weight as the chord c of the arc enveloped by the rope is to the radius r of the pulley:

$$P = w = \frac{Q r}{c}.$$

MOVABLE PULLEY.—The power is to the weight as the radius of the pulley is to the chord of the arc enveloped by the rope.

The tension on the fixed end of the rope is equal to the power:

$$P = Q = \frac{w r}{c}.$$

In a system of n movable pulleys, the power is to the weight as the product of the radii of the pulleys is to the product of the chords of the arcs enveloped by the rope:

$$P = w \frac{r\, r'\, r'' \, .\,.\, n}{c\, c'\, c'' \, .\,.\, n}.$$

If the ropes be parallel, $c = 2r$ and $P = \frac{w}{2^n}$.

BLOCK AND TACKLE.—The power is equal to the weig t divided by the number of ropes attached to the lower block, or by twice the number of rising pulleys.

WHEEL AND AXLE.—The power is to the weight as the radius r, of the axle, is to the radius R, of the wheel.

$$P = \frac{w r}{R}.$$

SYSTEM OF WHEELS AND PINIONS.—The power is to the weight as the product of the radii (or number of teeth) r, r', r'', etc., of the pinions is to the product of the radii (or number of teeth) R, R', R'', etc., of the wheels:

$$P = w \frac{r\, r'\, r'' \ldots .}{R\, R'\, R'' \ldots .}.$$

INCLINED PLANE.—If the direction of the power be horizontal, the power is to the weight as the height of the plane h is to its base b.

$$P = \frac{w h}{b}.$$

The pressure on the plane, $Q = \frac{P l}{h} = \frac{w l}{b}$; l being the length of the plane.

If the direction of the power be parallel to the plane, the power is to the weight as the height of the plane to its length.

$$P = \frac{w\,h}{l}.$$

The pressure on the plane, $Q = \frac{P\,b}{h} = \frac{w\,b}{l}$.

SCREW.—The power, applied perpendicular to the axis, is to the weight as the *pitch* of the screw s, or the distance between two threads, is to the circumference described by the point to which the power is applied. Thus, if the power be applied by means of a lever l,

$$P = \frac{w\,s}{2\,\pi\,l}.$$

WEDGE.—The power is to the resistance, acting perpendicularly *on each side* of the wedge, as the thickness of the back of the wedge is to the length of the side.

BALANCE.—The common balance is a simple lever, the arms of which are equal. If the balance be not accurate, the true weight of a body may be found by taking the square root of the product of the weights which counterpoise it successively in each scale. A better and more convenient method of eliminating the error of a balance is to place the body in one scale and counterpoise it by any weights in the opposite scale; then remove the body and replace it by known weights until the equilibrium be again restored. The sum of the latter weights will be that of the body required.

Friction.

In the foregoing conditions of equilibrium of machines, no account is taken of the resistance caused by friction, and by the stiffness of ropes, chains, &c.

Numerous experiments on friction have been made in France by M. Morin, from which the following general results are obtained:

1. The friction of any two bodies in motion is proportional to the pressure, whether the surfaces be dry or covered with an unguent. The ratio between the pressure and the friction is called the *coefficient of friction.*

2. The amount of friction is independent of the surface of contact and of the velocity of the motion. It depends only on the pressure, the nature of the surfaces in contact, and the kind of unguent interposed.

3. In general, friction is less between bodies of different kinds than between those of the same kind.

4. When two surfaces have been long in contact at rest, an adhesion takes place between them, the force of which is proportional to the extent of the surface of contact, and independent of the pressure.

5. When a continuous stratum of an unguent is constantly interposed

between the surfaces of contact, the amount of friction depends on the nature of the unguent, and not on that of the surfaces.

6. With the unguents hog's lard and olive-oil, the coefficient of friction is nearly the same for surfaces of wood moving on metals, wood on wood, metal on wood, and metal on metal.

The coefficient for the unguent tallow is the same, except in the case of metal on metal, for which it appears to be less suited than the others, giving a coefficient of about 0.10.

7. The friction of axles is generally a little less than that of plane surfaces under similar circumstances. The amount of friction is here also proportional to the pressure, and independent of the velocity of the motion

Friction of Plane Surfaces, in Motion, upon Each Other.

Surfaces in Contact.	Angle of Repose.	Coefficient of Friction.
Wood on wood, dry	14° to 26½	.25 to .5
" " soaped	11½° to 2°	.2 to .04
Metals on oak, dry	26½° to 31°	.5 to .6
" " wet	13½° to 14½°	.24 to .26
" " soaped	11½°	.2
Metals on elm, dry	11½° to 14°	.2 to .25
Hemp on oak, dry	28°	.53
" " wet	18½°	.33
Leather on oak, dry	15° to 19½°	.27 to .38
Leather on metals, dry	29½°	.55
" " wet	20°	.36
" " greasy	13°	.23
" " oily	8½°	.15
Metals on metals, dry	8½° to 11½°	.15 to .2
" " wet	16½°	.3
Smooth surfaces occasionally greased	4° to 4½°	.07 to .08
" " continually "	3°	.05
" " best results	1¾° to 2°	.03 to .036

The Quantity of Work that may be done by Men and Horses.

(From the French Aide-Mémoire, 1856.)

KIND OF WORK.	Weight raised, or mean effort exerted.	Velocity or distance per second.	Work per second.	Number of working-hours each day.	Quantity of work per day.
Raising Weights vertically.	Lbs.	Feet.	Ft.-Lbs.	Hours	Ft.-Lbs.
1 man going up a gentle slope or a ladder, without a load, raising the weight of his own body	150.	.5	75.	8	2,160,000
1 man raising weights with a cord and pulley, the cord coming down unloaded	40.	.66	26.4	6	570,240
1 man raising weights with the hands	45.	.56	25.2	6	544,320
1 man raising weights or carrying them on his back up a gentle slope or up a ladder, returning unloaded	150.	.13	19.5	6	421,200
1 man wheeling a load up a slope of 1–12th in a wheelbarrow, and returning with the empty barrow	135.	.07	9.45	10	340,200
1 man throwing earth to a mean height of 5 feet with a shovel	6.	1.31	7.86	10	282,960
Action on Machines.					
1 man on the spokes of a wheel or drum:					
1. On a level with the axis	135.	.5	67.5	8	1,944,000
2. Toward the bottom or at 24°	27.	2.3	62.1	8	1,788,480
1 man walking and pushing or pulling horizontally	27.	1.97	53.19	8	1,531,870
1 man working at a crank	18.	2.46	44.28	8	1,275,260
1 man pulling and pushing alternately in a vertical direction	12.	3.61	43.22	8	1,244,750
1 horse harnessed to an ordinary carriage, going at a walk	155.	2.95	457.25	10	16,461,000
1 horse harnessed to a pumping-engine, going at a walk	100.	2.95	295.0	8	8,496,000
1 horse harnessed to a pumping-engine, going at a trot	67.	6.56	439.52	4.5	7,120,220
1 ox harnessed to a pumping-engine, going at a walk	145.	1.97	285.65	8	8,226,720
1 mule harnessed to a pumping-engine, going at a walk	67.	2.95	197.65	8	5,692,320
Carrying Loads horizontally.					
1 man, on a level road, without a load, carrying the weight of his own body	145.	4.92	713.4	10	25,682.400
1 man with a hand-cart, returning without a load	220.	1.64	360.8	10	12,988,800
1 man with a wheelbarrow, returning without a load	135.	1.64	221.4	10	7,970,400
1 man carrying a load on his back	90.	2.46	221.4	7	5,579,280
1 man carrying a load on his back, returning without a load	145	1.64	237.8	6	5,136,480
1 man with a hand-barrow, returning without a load	110.	1.08	118.8	10	4,267.800
1 horse in a cart, at a walk	1550.	3.6	5580.	10	200,880 000
1 horse in a wagon, at a trot	770.	7.2	5544.	4.5	89,812,800
1 horse in a cart, returning without a load, at a walk	1550.	2.0	3100.	10	111,600,000
1 horse under the saddle, at a walk	265.	3.6	954.	10	34.344,000
1 horse under the saddle, at a trot	180.	7.2	1296.	7	32,659,200

The Quantity of Work done by Men and Horses.—Continued.

Kind of Work.	Weight raised, or mean effort exerted.	Velocity or distance per second.	Work per second.	Number of working-hours each day.	Quantity of work per day.
	Lbs.	Feet.	Ft.-Lbs.	Hours	Ft.-Lbs.
1 man raising his own weight up a stair or ladder	143.	0.5	72.5	8	2,088,000
1 man raising weights with cord and pulley, cord returning unloaded	40.	0.75	30.	6	648,000
1 man lifting weights with his hands	44.	0.55	24.2	6	522,720
1 man carrying weights up a ladder, returning unloaded	143.	0.13	18.5	6	399,600
1 man throwing earth with a shovel to a height of 5.25 feet	6.	1.3	7.8	10	280,800
1 man wheeling earth in a barrow up a slope of 1–12th, returning unloaded	132.	0.075	9.9	10	356,400
1 man working at the spokes of a drum, on a level with the axis	132.	0.5	66.	8	1,900,800
1 man working at the spokes of a drum, toward the bottom or at 24°	26.5	2.3	60.95	8	1,755,360
1 man pushing or pulling horizontally (capstan or oar)	26.5	2.0	53.	8	1,526,400
1 man turning a crank	18.	2.5	45.	8	1,296,000
1 man working a pump	13.2	2.5	33.	10	1,188,000
1 man walking on a level road, unloaded	143.	5.	715.	10	25,740,000
1 man wheeling load in hand-cart, returning unloaded	224.	1.666	373.	10	13,428,000
1 man wheeling a load in wheelbarrow, returning unloaded	132.	1.666	220.	10	7,920,000
1 man carrying a load on his back	90.	2.5	225.	7	5,670,000
1 man carrying a load on his back, returning unloaded	140.	1.666	233.	6	5 032,800
1 horse cantering and trotting, drawing a light railway-carriage	30.5	14.666	447.5	4	6,444,000
1 horse drawing cart or boat, walking	120.	3.6	432.	8	12,441,600
1 horse drawing gin or mill, walking	100.	3.0	300.	8	8,640,000
1 horse drawing gin or mill, trotting	66.	6.5	429.	4.5	6,950,000
1 horse drawing cart always loaded, walking	1,500.	3.6	5,400.	10	194,400,000
1 horse drawing cart always loaded, trotting	750.	7.2	5,400.	4.5	87,480,000
1 horse drawing cart, going loaded, returning unloaded	1,500.	2.0	3,000.	10	108,000,000
1 horse carrying burden, walking	270.	3.6	972.	10	34,992,000
1 horse carrying burden, trotting	180.	7.2	1,296.	7	32,659,200
1 ox drawing a cart always loaded	1,500.	2.4	3.600.	10	129,600,000
1 mule drawing a cart always loaded	750.	2.4	1,800.	10	64,800,000
1 ass drawing a cart always loaded	375.	2.4	900.	10	32,400,000

A horse-power in steam-engines is estimated at 550 foot-pounds per second, or 33,000 foot-pounds per minute, or 1,980,000 foot-pounds per hour. The average power of a draught-horse as given above is 432 foot-pounds per second = 0.785 of the *conventional horse-power.*

The French horse-power is equal to 542½ foot-pounds per second, being about $\frac{1}{70}$ less than our horse-power.

The number of horse-powers in a single-stroke engine is expressed by

.0000238 $d^2\,n\,p\,l$; d being the diameter of the piston in inches, n the number of strokes in a minute, l the length of stroke in feet, and p the pressure of steam on a square inch, (diminished usually by $\frac{1}{5}$ for friction and inertia.) In a double-stroke engine the power is double the above.

Elastic Force of Steam at different Temperatures.

(From experiments of Committee of Franklin Institute.)

The unit is the atmospheric pressure, or 1 atmosphere = 30 inches of mercury.

Temp.	Press.	Temp.	Press.	Temp.	Press.	Temp.	Press.	Temp.	Press.
212	1	275	3	304½	5	326	7	345	9
235	1½	284	3½	310	5½	331	7½	349	9½
250	2	291½	4	315½	6	336	8	352½	10
264	2½	298½	4½	321	6½	340½	8½		

Pressure of Gunpowder per square inch.

(From Captain Rodman's experiments.)

The pressure on a 42-pounder gun, at the bottom of the bore, when fired with 10 pounds of powder and a solid shot weighing 43 pounds, is 44,535 lbs.

8 lbs. of powder of a grain .1 inch diameter, with the same gun and shot, gave a pressure of 51,800 lbs.

8 lbs. of powder of a grain .4 inch diameter, with the same gun and shot, gave a pressure of 31,900 lbs.

12.67 lbs. of powder of a grain .6 inch diameter, and a solid shot, weighing 186.3 lbs., fired from an 11-inch gun, gave a pressure of 21,370 lbs.

The same weight, of .3 inch diameter, gave a pressure of 35,330 lbs.

The same weight, of .3 inch diameter, of different powder, gave a pressure of 65,920 lbs.

Half the weight of powder, of the ordinary charge, with double the weight of shot, gave the same pressure as the ordinary charge.

1 lb. of powder, burned in a space equal to twice that occupied by the powder, gave a pressure of 42,500 lbs.

2 lbs., burned in the space occupied by it, gave a pressure of 133,590 lbs.

1 lb., burned in the space occupied by it, .1 inch grain, gave a pressure of 185,000 lbs.

The actual pressures are probably greater than those above given

MATHEMATICAL FORMULÆ AND DATA.

Mensuration.

LINES.

Circle.—Ratio of circumference to diameter, $\pi = 3.1415926536 = \frac{355}{113}$ nearly.

Circumference of a circle $= 2\,\pi\,r$.

Length of an arc $= \frac{a\,\pi\,r}{180}$; r being the radius of the circle and a the number of degrees in the arc; or nearly $= \frac{8\,c' - c}{3}$; c being the chord of the arc, and c' the chord of half the arc, which is $= \sqrt{\frac{1}{4}\,c^2 + \text{versine}^2}$.

Length of 1 *degree* $= 0.0174533$; radius being 1.

Length of 1 *minute* $= 0.0002909$.

Length of 1 *second* $= 0.0000048$.

Ellipse.—Circumference $= \frac{199}{200}\,\pi\,\sqrt{\frac{1}{2}\,(a^2 + b^2)}$, nearly; a and b being the axes.

Parabola.—Length of an arc, commencing at the vertex, $= \sqrt{\left(\frac{4\,a^2}{3} + \sqrt{b}\right)}$, nearly; a being the abscissa, and b the ordinate.

SURFACES.

Triangle.—Half the base $\times$ the height; or half the product of two sides $\times$ the sine of the included angle, $(\frac{1}{2}\,a\,b\frac{\sin.\ C}{R})$; or, $\sqrt{s\,(s-a)\,(s-b)\,(s-c)}$; or, $\frac{1}{4}\sqrt{[(b+a)^2 - c^2]\,[c^2 - (b - a^2)]}$; a, b, c being the sides, and $s = \frac{a+b+c}{2}$.

Parallelogram.—The base $\times$ the height.

Trapezoid.—Half the sum of the parallel sides $\times$ the height.

Any Quadrilateral.—Half the product of the diagonals $\times$ the sine of their angle.

Any irregular plane figure bounded by curves.—Divide the figure into any *even* number of parts by parallel equidistant ordinates; let a be the sum of the first and last ordinates; b the sum of the *even* ordinates; c that of the *odd* ones, except the first and last; d the common distance between them: then will the area $= \frac{1}{3}\,d\,(a + 4\,b + 2\,c)$. *Five* ordinates will generally be found sufficient.

Circle.—$\pi\,r^2$; or diam.$^2 \times .7854$; or circum.$^2 \times .07958$.

Circular sector.—$\frac{r\,a}{2} = \pi\,r^2\,\frac{a}{360}$; a being the length of the arc in linear measure; a the number of degrees in the arc.

Circular segment.—The difference between the sector and the triangle formed by the chord and the radii; or $\frac{r\,a - r^2 \sin. A}{2}$; or nearly $= .4\, v\, (c + \frac{4}{3}\sqrt{\frac{1}{4} c^2 + v^2})$; c being the chord, and v the versed sine.

Ellipse.—$\pi\, a\, b$ sin. a; $2\,a$, $2\,b$ being any two conjugate diameters; a the angle formed by them. When $a = 90$ degrees, these two diameters are the axes, and then we have $s = \pi\, a\, b$.

Parabola.—$\frac{2}{3}\, a\, b$; a being the abscissa, and b the double ordinate.

Right prism or *cylinder.*—Curved surface = height $\times$ perimeter of base.

Right pyramid or *cone.*—Half the slant height $\times$ perimeter of base.

Frustum of a right prism or *cylinder.*—The perimeter of the base multiplied by the distance from the centre of gravity of the upper section to the base. If the prism or cylinder be oblique, multiply this product by the sine of the angle of inclination.

Frustum of a right pyramid or *cone.*—The slant height $\times$ half the sum of the perimeters of the two ends.

Sphere.—$4\,\pi\, r^2$; or diam. $\times$ circum.; or diam.$^2 \times 3.1416$.

Spherical zone or *segment.*—$2\,\pi\, r\, h$, or the height of the zone or segment multiplied by the circumference of the sphere.

Circular spindle.—$2\,\pi\,(r\, c - a\sqrt{r^2 - \frac{1}{4} c^2})$; a being the length of the arc, and c its chord, or the length of the spindle.

Spherical triangle.—$\pi\, r^2 \frac{s - 180°}{180°}$; s being the sum of the three angles

Any surface of revolution.—$2\,\pi\, r\, l$; or the length of the generating element multiplied by the circumference described by its centre of gravity.

Table of Regular Polygons.

No. of sides.	Name.	Area.	Radius of circumscribing circle.	Side of inscribed polygon.
3	Triangle............	0.4330127	0.5773503	1.732051
4	Square..............	1.0000000	0.7071068	1.414214
5	Pentagon...........	1.7204774	0.8506508	1.175570
6	Hexagon...........	2.5980762	1.0000000	1.000000
7	Heptagon...........	3.6339124	1.1523824	0.867767
8	Octagon.............	4.8284271	1.3065628	0.765367
9	Nonagon	6.1818242	1.4619022	0.684040
10	Decagon.............	7.6942088	1.6180340	0.618034
11	Undecagon	9.3656399	1.7747324	0.563465
12	Dodecagon..........	11.1961524	1.9318517	0.517638

The column of *areas* in the foregoing table gives the number by which the *square of the side* is to be multiplied to find the area of the polygon.

The next column gives the multiplier for the *side of a polygon*, to find the radius of the circumscribing circle.

The last column gives the multiplier for the *radius of a circle*, to find the side of the inscribed polygon.

SOLIDS.

Prism or *cylinder*.—Area of base multiplied by the height.

Pyramid or *cone*.—Area of base multiplied by one-third of the height.

Frustum of a pyramid or *cone*.—$\frac{1}{3} h (B + b + \sqrt{B b})$; h being the height; B and b the areas of the two ends. Or, for a conic frustum, $\frac{1}{3} h \times .7854 \times \left(\frac{D^3 - d^3}{D - d}\right)$; D and d being the diameters of the two ends.

Frustum of a right triangular prism.—The base $\times \frac{1}{3} (H + H' + H'')$.

Frustum of any right prism.—The base multiplied by its distance from the centre of gravity of the section.

Cylindrical segment, contained between the base and an oblique plane passing through a diameter of the base; two-thirds of the height multiplied by the area of the great triangular section; or $\frac{2}{3} r h^2$; r being the radius of the base, and h the height.

Sphere.—$\frac{4 \pi r^3}{3}$; or $.5236\, d^3$; r being the radius, and d the diameter.

Spherical segment.—$\frac{1}{3} \pi h^2 (3 r - h) = \frac{\pi h}{6} (3 b^2 + h^2)$; b being the radius of the base, h the height of the segment, and r the radius of the sphere.

Spherical zone.—$\frac{\pi h}{6} (3 B^2 + 3 b^2 + h^2)$; B, b being the radii of the bases.

Spherical sector.—$\frac{1}{3} r \times$ the surface of the segment or zone; or $\frac{2}{3} \pi r^2 h$.

Ellipsoid.—$\frac{\pi a^2 b}{6}$; a being the revolving diameter, and b the axis of revolution.

Paraboloid.—Half the area of the base multiplied by the height.

Circular spindle.—$\pi (\frac{1}{6} c^3 - 2 s \sqrt{r^2 - \frac{1}{4} c^2})$; s being the area of the revolving segment, and c its chord.

Any solid of revolution.—$2 \pi r s$; or the area of the generating surface multiplied by the circumference described by its centre of gravity.

Any irregular solid bounded by a curved surface.—Use the rule for finding the area of an irregular plane figure, substituting *sections* for *ordinates*.

Cask-gauging.—1. By the preceding rule:

The content of a cask $= \frac{\pi}{24} l (d^2 + D^2 + 4 M^2)$; l being the length, d, D the head and bung diameters, and M a diameter midway between them — all measured in the clear, inside; $\frac{\pi}{24} = 0.1309$.

The same formula may be thus stated: $\frac{1}{6} l (A + B + C)$; l being the length, A and B the areas of the head and bung sections, and C that of the section midway between them.

2. Contents of a cask, nearly $= \frac{\pi}{12} l (2 D^2 + d^2)$; or $l \times$ the area of a circle whose diameter is $\frac{2 D + d}{3}$.

Centres of Gravity.

LINES.

Circular arc.—At a distance from the centre $= \frac{r c}{l}$; r being the radius, c the chord, and l the length of the arc.

AREAS.

Triangle.—On a line drawn from any angle to the middle of the opposite side, at two-thirds of the distance from the angle to the side.

Trapezoid.—On a line, a, joining the middle points of the two parallel sides, B, b; distance from $B = \frac{a}{3}\left(\frac{B + 2 b}{B + b}\right)$.

Semicircle.—Distance from the centre $= \frac{4 r}{3 \pi}$.

Circular segment.—Distance from the centre $= \frac{c^3}{12 A}$; c being the chord of the segment, and A its area.

Circular sector.—Distance from the centre $= \frac{2 r c}{3 l}$; c being the chord, and l the length of the arc.

Parabolic segment.—Distance from the vertex = three-fifths of the abscissa.

Surface of a right cylinder, cone, or *frustum of a cone.*—The centre of gravity is at the same distance from the base as that of the parallelogram, triangle, or trapezoid, which is a right section of the same.

Surface of a spherical zone or *segment.*—At the middle of the height.

SOLIDS.

Prism or *cylinder.*—At the middle of the line joining the centres of gravity of the two ends.

Pyramid or *cone.*—The distance from the base is one-fourth of the line joining the vertex with the centre of gravity of the base.

Frustum of a cone.—Distance from the centre of the smaller end $=$ $\frac{1}{4} h \times \frac{(R + r)^2 + 2 R^2}{(R + r)^2 - R r}$; or $\frac{1}{4} h \times \frac{3 R^2 + 2 R r + r^2}{R^2 + R r + r^2}$; h being the height, R and r the radii of the greater and less ends. Distance from the large end $= \frac{1}{4} h \, \frac{3 r^2 + 2 R r + R^2}{R^2 + R r + r^2}$.

Spherical segment.—Distance from the centre $= \dfrac{3\,(r - \frac{1}{2}h)^2}{3\,r - h} = \dfrac{\pi\, h^2\,(r - \frac{1}{2}\,h)^2}{S}$; r being the radius of the sphere, h the height of the segment, and S its solid contents. Distance from the vertex $= h\,\dfrac{8\,r - 3\,h}{12\,r - 4\,h}$.

Spherical sector.—Distance from the centre $= \frac{3}{4}\,(r - \frac{1}{2}\,h)$.

Distance from the vertex $= \dfrac{2\,r + 3\,h}{8}$.

Hemisphere.—Distance from the centre $= \frac{3}{8}\,r$.

Semi-ellipsoid.—Distance from the centre $= \frac{3}{8}$ of semi-axis of revolution.

Paraboloid.—Distance from the vertex $= \frac{2}{3}\,h$.

Any system of bodies.—Distance of the common centre of gravity from a given plane $= \dfrac{B\,D + B'\,D' + B''\,D'' + \text{etc.}}{B + B' + B'' + \text{etc.}}$; B, B', B'' being the masses or solid contents of the bodies, and D, D', D'' the distances of their respective centres of gravity from the given plane.

Arithmetical Progression.

a, the first term; d, the common difference; n, the number of terms; l, the n^{th} term; s, the sum of n terms.

$$l = a + d\,(n - 1);\ s = \frac{n}{2}\,(a + l).$$

Geometrical Progression.

r, the common ratio; the rest as above.

$$l = a\,r^{n-1};\ s = \frac{l\,r - a}{r - 1} = a\,\frac{(r^n - 1)}{r - 1}.$$

Logarithms.

x, the common logarithm of the number a; e, the base of the hyperbolic logarithms $= 2.7182818$; x', the hyperbolic logarithm of a.

$$a = 10^x = e^{x'};\ x = x'\,\log.\,e;\ \log.\,e = 0.4342945.$$

PLANE TRIGONOMETRY.

The radius is taken equal to unity. To restore it, replace such expressions as tang. a, sin. a, $1 -$ sin. a, etc., by $\dfrac{\text{tang. } a}{R}$, $\dfrac{\text{sin. } a}{R}$, $\dfrac{R - \text{sin. } a}{R}$, etc.

FORMULÆ. (a and b are the angles.)

$$\text{sin. } a = \sqrt{1 - \text{cos.}^2\,a};\ \text{tang. } a = \frac{\text{sin. } a}{\text{cos. } a};\ \text{sec. } a = \frac{1}{\text{cos. } a};$$

$$\text{cot. } a = \frac{\text{cos. } a}{\text{sin. } a}; \text{ cosec. } a = \frac{1}{\text{sin. } a}; \text{ ver-sin. } a = 1 - \text{cos. } a;$$

$$\text{sin. } (a \pm b) = \text{sin. } a \text{ cos. } b \pm \text{sin. } b \text{ cos. } a;$$

$$\text{cos. } (a \pm b) = \text{cos. } a \text{ cos. } b \mp \text{sin. } a \text{ sin. } b;$$

$$\text{tang. } (a \pm b) = \frac{\text{tang. } a \pm \text{tang. } b}{1 \mp \text{tang. } a \text{ tang. } b};$$

$$\text{tang. } \tfrac{1}{2} a = \frac{1 - \text{cos. } a}{\text{sin. } a} = \frac{\text{sin. } a}{1 + \text{cos. } a};$$

$$\text{sin. } \tfrac{1}{2} a = \sqrt{\frac{1 - \text{cos. } a}{2}}; \text{ cos. } \tfrac{1}{2} a = \sqrt{\frac{1 + \text{cos. } a}{2}};$$

Solution of Triangles.

A, B, C, are the 3 angles: a, b, c, are the 3 sides opposite them, respectively.

RIGHT-ANGLED TRIANGLES—(A being the right angle.)

Given.	*Formulæ.*
1. a, B,	$b = a \text{ sin. } B$: $c = a \text{ cos. } B$: $C = 90° - B$.
2. B, c,	$a = \dfrac{c}{\text{cos. } B}$: $b = c \text{ tang. } B$: $C = 90° - B$.
3. a, b,	$\text{sin. } B = \dfrac{b}{a}$: $c = \sqrt{(a + b)\ (a - b)}$: $c = 90° - B$.
4. b, c.	$\text{tang. } B = \dfrac{b}{c}$: $a = \dfrac{c}{\text{cos. } B}$: $C = 90° - B$.

OBLIQUE-ANGLED TRIANGLES. (S, the area of the triangle; $p = \dfrac{a + b + c}{2}$)

Given.	*Formulæ.*
1. A B, a,	$b = \dfrac{a \text{ sin. } B}{\text{sin. } A}$: $c = \dfrac{a \text{ sin. } C}{\text{sin. } A}$: $S = \tfrac{1}{2} b c \text{ sin. } A = \dfrac{a^2 \text{ sin. } B \text{ sin. } C}{2 \text{ sin. } A}$.
2. a, b, A,	$\text{sin. } B = \dfrac{b \text{ sin. } A}{a}$: $C = 180° - (A + B)$: $c = \dfrac{a \text{ sin. } C}{\text{sin. } A}$.
3. b, c, A,	$\tfrac{1}{2}(B + C) = \tfrac{1}{2}(180° - A)$: $\text{tang. } \tfrac{1}{2}(B - C) = \dfrac{b - c}{b + c} \text{cot. } \tfrac{1}{2} A$.
	$B = \tfrac{1}{2}(B + C) + \tfrac{1}{2}(B - C)$.
	$C = \tfrac{1}{2}(B + C) - \tfrac{1}{2}(B - C)$. $c = \dfrac{a \text{ sin. } C}{\text{sin. } A}$.
4. a, b, c.	$\text{sin. } \tfrac{1}{2} A = \sqrt{\dfrac{(p - b)\ (p - c)}{b\ c}}$: or $\text{tang. } \tfrac{1}{2} A = \sqrt{\dfrac{(p - b)\ (p - c)}{p\ (p - a)}}$.
	$\text{cos. } \tfrac{1}{2} A = \sqrt{\dfrac{p\ (p - a)}{b\ c}}$.
	$S = \sqrt{p\ (p - a)\ (p - b)\ (p - c)}$.

BALLISTICS.

Motion of a Body projected vertically upward, in Vacuo.

Let t represent any time of ascent, in seconds.

h, the height } at the end of the time t.
v, the velocity }

g, the velocity acquired by a falling body in 1 second.

V, the initial velocity of projection.

H, the whole height of ascent.

T, the whole time of ascent.

Then,

$$h = Vt - \tfrac{1}{2} g t^2. \qquad v = V - g t.$$

$$H = \frac{V^2}{2g}. \qquad T = \frac{V}{g}.$$

Motion of a Projectile in Vacuo.

The trajectory of a body projected obliquely, in vacuo, is a parabola, the axis of which is vertical.

Let V represent the initial velocity $= \sqrt{2gH}$.

ϕ, the angle of projection above the horizontal plane.

x, y, the horizontal and vertical co-ordinates of any point m in the trajectory, from the point of departure as the original.

v, the velocity of the projectile at the point m.

t, the time of flight, to the same point.

θ, the inclination of the tangent at that point.

X, the whole horizontal range.

Y, the greatest height of ascent.

T, the whole time of flight, for the range X.

a, b, the horizontal and vertical co-ordinates of the object aimed at.

ε, its angle of elevation, making tang. $\varepsilon = \frac{b}{a}$.

Equation of the trajectory.

$$y = x \text{ tang. } \phi - \frac{x^2}{4H \cos.^2 \phi}.$$

$$y = Vt \sin. \phi - \tfrac{1}{2} g t^2. \quad x = Vt \cos. \phi. \quad v = \sqrt{2g(H-y)}.$$

$$X = 2H \sin. 2\phi = \frac{V^2 \sin. 2\phi}{g}. \qquad Y = H \sin.^2 \phi = \frac{V^2 \sin.^2 \phi}{2g}.$$

$$t = \frac{x}{V \cos. \phi}; \quad T = \frac{V \sin. \phi}{\frac{1}{2} g} = 2 \sin. \phi \sqrt{\frac{2H}{g}};$$

$$\text{tang. } \theta = \text{tang. } \phi - \frac{x}{2H \cos.^2 \phi}.$$

From which it follows: the angle of greatest range is $\phi = 45°$. Then

$$X = 2H = 4Y: \quad Y = \tfrac{1}{2}H: \quad V = \sqrt{gX}: \quad T = \sqrt{\frac{2x}{g}} = \tfrac{1}{4}\sqrt{x \text{ ft.}} \text{ nearly}:$$

$$t = 1.4142\,\frac{x}{V}.$$

The ranges are equal at angles equidistant from 45°.

Under a given angle of projection the initial velocities are as the square roots of the ranges.

When the initial velocities are equal, the ranges are proportional to the sines of double the angles of elevation.

The velocities are equal in the two branches of the trajectory, at the same height.

The least velocity is at the summit, and is $= V \cos.\,\phi$.

On horizontal ground, the angle of descent is equal to the angle of projection, and the final velocity is equal to the initial velocity.

To find the initial velocity, or the angle of projection, necessary for striking a given point.

$$H = \frac{a}{4 \sin.\,(\phi - \varepsilon)}\,\frac{\cos.\,\varepsilon}{\cos.\,\phi}; \qquad V = \sqrt{\frac{a\,g}{2 \sin.\,(\phi - \varepsilon)}\,\frac{\cos.\,\varepsilon}{\cos.\,\phi}};$$

$$\text{tang.}\,\phi = \frac{2}{a}\left(H \pm \sqrt{H(H - b) - \tfrac{1}{4}a^2}\right) = \frac{2H}{a} \pm \sqrt{\frac{4H(H - b)}{a^2} - 1}.$$

If the trajectory be required to pass through two points whose co-ordinates are a and b, a' and b', or to pass through the first point and have a certain inclination θ with the horizontal plane at that point, as in firing over the crest of a parapet to ricochet on the terre-plein, we have in the first case,

$$\text{tang.}\,\phi = \frac{a'\dfrac{b}{a} - a\,\dfrac{b}{a'}}{a' - a}; \text{ and } V = \frac{1}{\cos.\,\phi}\sqrt{\frac{g}{2}\,\frac{a' - a}{\dfrac{b}{a} - \dfrac{b'}{a'}}};$$

and in the second,

$$\text{tang.}\,\phi = 2\,\text{tang.}\,\varepsilon - \text{tang.}\,\theta; \text{ and } V = \frac{1}{\cos.\,\phi}\sqrt{\frac{g}{2}\,\frac{a}{\text{tang.}\,\varepsilon - \text{tang.}\,\theta}}.$$

When the point is in the descending branch of the curve, θ and tang. θ are negative.

The trajectory described by a heavy projectile thrown with a low velocity, as in the case of an eprouvette ball, approaches very near to a parabola. If the projectile be light for its volume,—as is the case with shells,—the trajectory described is not so near; and when higher velocities are employed the trajectory is very different, and it is necessary to take into consideration the resistance of the atmosphere.

Resistance of the Air.

When a body moves in the air with a low velocity, of 25 to 30 feet per second, it meets with a resistance which is sensibly proportional to the density of the air, to the area of the projection of the body on a plane perpendicular to the direction of the motion, and to the square of the velocity of the body.

The resistance of the air in pounds $= \frac{k \delta S V^2}{2g} = k \delta S h$,

δ being the weight of a cubic foot of air, and k a coefficient, constant for similar solids, but varying with different forms.

When the body moves with a high velocity, the resistance of the air increases in a more rapid ratio than the square of the velocity, and the law may be expressed by adding a term proportional to the cube of the velocity.

For spherical projectiles the resistance is in proportion to the area of a great circle: calling the radius R, the velocity v, the resistance of the air, in pounds, ρ, it has been found that

$\rho = A \pi R^2 v^2 \left(1 + \frac{v}{r}\right)$, in which A is the resistance per square foot of cross-section for a velocity of 1 foot per second, and r is the velocity for which the resistance due to the second term is equal to that due to the first.

Experiments in France with guns and solid shot have shown that for a mean density of the atmosphere of $\frac{1}{823}$ part of water, and for ordinary velocities, with spherical projectiles, $A = .000514$ and $r = 1427$ ft.: for shells with low velocities, as from mortars, $r = 2735$ feet.

Motion of a Projectile in the Air.

The normal trajectory in the air is a continuous plane curve, which can be cut by a right line in not more than two points; it has two asymptotes, one vertical, the other inclined.

The actual trajectory of a ball is generally a curve of double curvature. It differs from the normal trajectory in consequence of the deviations, both lateral and vertical, produced by the eccentricity of the ball, its position in the gun, the motion of the air, and other circumstances, which cause the ball to revolve about an uncertain and variable axis and to depart from the vertical plane of projection.

The equation of the trajectory is a complicated one and difficult of computation. General Didion has reduced it to the simplest form.

Adopting the same notation as in the motion of a projectile in vacuo, and designating by $V_1 = V \cos. \phi$, the horizontal component of the initial velocity, a the relation of the length of an arc of the trajectory to its horizontal projection, so that $a x$ is the length of the arc passed over, B, I, D, U,

certain multipliers, each functions of $\frac{a\,x}{c}$ and of $\frac{a\,V_1}{r}$, c and r being coefficients of the formula for the resistance of the air, he gets $y = x$ tang. $\phi - \frac{g}{2}\frac{x^2}{V^2 \cos.^2 \phi} B$: tang. $\theta =$ tang. $\phi - g\frac{x}{V^2 \cos.^2 \phi} I$:
$t = \frac{x}{V \cos.\ \phi} D$: $v = \frac{V \cos.\ \phi}{U \cos.\ \theta}$; which are the equations of the trajectory in vacuo multiplied by these constants B, I, D, U. He has calculated the values of these multipliers for the different circumstances of firing, and tabulated them for ready use.

The loss of velocity by the resistance of the air in any *small* distance x will be expressed by

$$V = v = x\,\frac{3\,A\,g}{4\,R\,D}\left(1 + \frac{v}{r}\right)v.$$

This formula may be used in experiments with the Ballistic Pendulum, for computing the velocity lost by the ball in passing from the gun to the pendulum-block.

Velocities of Spherical Case Shot at x Distance from the Gun.

The velocity remaining at any distance x is found, according to the experiments at Metz, by the equation, $v' = \frac{V}{\left(1 + \frac{V}{r}\right) e^{cx} - \frac{V}{r}}$: for high velocities, $c = \frac{3\,A\,g}{4\,R\,D}$; $D =$ density of the ball; water $= 1,000$.

$A = .008\left(.74 + \frac{.1542}{.16404 + 2\,R}\right)$.

$e = 2.7182818$; $g = 32.155$ feet; log. $g = 1.5072485$; log. $e = 0.4342945$; log. $e = 1.6377892$.

All the dimensions are expressed in *feet:*

Weight of shell, loaded...lbs.	12-pdr. 11.82	24-pdr. 24.	32-pdr. 32.
	In. Ft.	Ft.	Ft.
$2\,R$..................	4.52 = 0.3767	0.4742	0.521
D..................	6752.6	6877.7	6914.4
log. D..................	3.8294754	3.8374471	6.8397573
A..................	0.00816	0.00785	0.00772
c..................	0.00015473	0.000116	0.00010336
log. c..................	$\bar{4}$.1895633	$\bar{4}$.0648008	$\bar{4}$.0143649

Velocities of Spherical Case Shot at x Distance from the Gun.

Distance, x yards.			100.	500.	600.	700.	800.	900.	1000.	1100.	1200.	1300.	1400.	1500.	1600.
12-pounder field-gun, 12-pounder mountain-howitzer, 12-pounder howitzer	log. e^{ax}		.0201592.	.1007960.	.1209550.	.1411145.	.1612740.	.1814330.	.2015922.	.2217515.	.2419110.	.2620700.	.2822290.	.3023880.	
	Charge.	V.	Remaining Velocities.												
	Lbs.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	
12-pounder field-gun	2.	1375	1258	909	844	784	730	682	637	596	558	524	492	462	
	2.5	1485	1349	969	897	832	774	722	673	629	589	552	518	486	
	3.	1600	1453	1030	952	882	819	762	710	663	620	580	544	511	
12-pounder mountain-howitzer	.5	640	598	464	437	411	388	365	345						
12-pounder howitzer	1.0	900	835	631	591	553	519	486	458	430	406				
	1.25	1000	925	694	647	605	567	532	500	469	441				
24-pounder howitzer	log. e^{ax}		.0151134.		.0906807.		.1209076.		.1511345.		.1813612.		.2115881.		.2418152.
	Charge.	V.													
	Lbs. 2.5	Feet. 1000	Feet. 948		Feet. 717		Feet. 647		Feet. 586		Feet. 532		Feet. 484		Feet. 441
32-pounder howitzer	log. e^{ax}		.0134666.		.0807996.		.1077328.		.1346660.		.1615992.		.1885324.		.2154656.
	Charge.	V.													
	Lbs. 3.25	Feet. 1000	Feet. 949		Feet. 742		Feet. 676		Feet. 622		Feet. 566		Feet. 520		Feet. 478

Final Velocity of Descent in the Air.

The velocity of a projectile diminishes from the commencement of its flight to a point a little beyond the summit of the trajectory; it then increases to a certain limit, dependent on the diameter and density of the ball. The final velocity is given by the equation

$$v^2\left(1+\frac{v}{r}\right)=\frac{4\,R\,D}{3\,A}.$$

Calibre	Shot. 42.	24.	18.	12.	6.	Shells. 13-inch.	10-inch.	8-inch.	24-pdr.	Musket-ball, round.
Final velocity of descent in feet....per sec.	485	455	425	410	360	585	505	445	375	213

Penetration of Spherical Projectiles.

The penetration of a cannon-ball in a solid mass of oak timber, such as the sides of a vessel, according to the French experiments at Gâvre, is expressed, in inches, by the following formula:

$$z=\frac{2.306\;D\;2\;R}{1200}\left(1+\frac{.0929\;v'^2}{10^5}\right).$$

The same notation being used as at page 483.

The penetration in other substances is obtained by multiplying those given by the above formula by the following coefficients:

1.64 for compact earth, half sand and half clay.
1.03 for sand mixed with gravel.
3.21 for fresh earth.
1.3 for elm.
1.8 for beech and white pine.
2. for poplar.
0.19 for limestone rock.
0.41 for masonry of good quality.

General Formula for Computing the Initial Velocity of a Ball.

$$V=\gamma\sqrt{\frac{\mu}{m+\frac{1}{3}\mu}\log.\frac{M}{\mu}-\Lambda\frac{C^2-R^2}{C^2}}.$$

In which V is the initial velocity of the ball.
C, the radius of the bore.
R, the radius of the ball.
m, the weight of the ball, with the sabot, etc., used in loading.
μ, the weight of the charge of powder.

M, the weight of powder (loose) which would fill the bore of the gun.

Log. the common logarithms.

γ and Δ, coefficients, depending on the nature of ordnance and the quality of the powder used; to be determined experimentally by means of some known velocity, and given difference of windage.

Δ may probably, without sensible error, be regarded as constant for the same quality of powder, though used in different kinds of ordnance; but the value of γ should be computed from the known velocity in a case approaching nearest to that to which the formula is to be applied.

In ordinary cases of windage (W) we may consider

$$\frac{C^2 - R^2}{C^2} = \frac{2(C - R)}{C} = \frac{W}{C}.$$

According to the experiments made with the Ballistic Pendulum at Washington Arsenal, the mean values of the coefficients γ and Δ, for Dupont's powder, in guns of various calibres, (from 6-pounder to 32-pounder,) are: $\gamma = 3{,}500$ feet; $\Delta = 3{,}200$ feet.

The above formulæ, for the resistance of the air and for the initial velocity, are obtained from the "Traité de Balistique, par le Général Didion, 1860;" a work which may be consulted for a full discussion of the theory of the motion of projectiles, and the deviations produced by their eccentricity and other causes.

Small Arms of Foreign Countries.

Country.	Kind of Arm.	Weight of: Arm without bayonet.	Weight of: Arm with bayonet.	Barrel: Calibre.	Barrel: Length.	Grooves: No.	Grooves: Width.	Grooves: Depth at Muzzle.	Grooves: Depth at Breech.	Grooves: Twist.	Ball: Diam.	Ball: Weight.	Powder: Wt.
		Lbs.	Lbs.	In.	In.		In.	In.	In.	In.	In.	Grs.	Grs.
England...	Musket, 1851	9.	10.5	.702	39.	4	0.25	0.01	0.02	78.	0.69	680.	68
	Enfield musket, 1853.	8.7	9.2	.577	39.	3	.262	.004	.014	78.	.568	525.	68
	Artillery carbine	6.5	8.25	.577	24.	3	.262	.004	.014	78.	.568	525.	55
France	Musket à tige	9.34	10.	.70	42.64	4	.27	.004	.02	78.75	.677	720.	70
	Carabine à tige.........	9.	10.7	.70	34.2	4	.27	.012	.02	78.75	.677	720.	70
	" des cent-gardes*	7.	....	.36	31.5	5	......	......	......	31.5	....	180.	30
	Double-barrel musket	10.23	11.04	.689	31.23	..	......	......	......	......	.657	416.6	104
Russia......	Rifle	9.56	11.5	.70	30.	2	.31	.02	.02	31.9	.629	366.	97
	Cavalry carbine........	5.83	....	.677	13.	8	.1	.031	.031	23.2	.629	366.	97
Prussia.....	Needle-gun*	10.75	....	.62	36.	4	.23	.03	.03	29.	.63	440.	56
	Rifle à tige	10.0	....	.577	27.6	8	.11	.025	.025	36.8	.56	366.	56
	Wall piece	9.53	10.33	.708	41.	4	.27	.017	.017	60.	.68	483.	100
Austria....	Rifle-musket...........	9.5	10.25	.55	37.5	4	.21	.02	.025	75.	.545	450.	62
	Rifle (Jäger)............	9.	10.5	.55	28.	4	.21	.02	.025	75.	.545	450.	62
	" with tige	9.	10.5	.55	28.	4	.21	.02	.025	75.	.545	450.	62
Sardinia	Rifle......................	9.25	11.04	.661	27.7	8	.079	.019	.019	51.5	.645	517.	43
Belgium......	Rifle......................	11.07	12.03	.669	34.48	6	.098	.02	.02	....	.629	406.	65
Saxony........	Rifle à tige	....	....	.577	40.4	4	.2	.025	.025	64.5	.57	418.	85
Switzerland	Rifle......................	9.	9.51	.414	32.	8	.08	.015	.015	36.	.41	240.	62
Norway	Rifle*.....................	....	....	.65	36.5	..	......	......	......	58.	....	....	.....
Sweden	Rifle......................	13.7	....	.748	31.5	8	.157	.019	.019	41.	.74	601.	.....

* Breech-loading.

ORDNANCE OF FOREIGN COUNTRIES.

In *Austria* and *Prussia*, howitzers and mortars take their denominations from the weight of a stone ball of the calibre of the bore; in *Russia*, from the true weight of the shell; in other countries, the same as with us.

The column of *exterior length* shows the length from the rear of the base-ring to the face of the piece, and the *length of bore* includes the chamber, when not otherwise mentioned.

Designation.		Diameter of Bore.	Windage.	Brass.		Iron.	
				Exterior Length.	Weight.	Exterior Length.	Weight.
ENGLAND.		In.	In.	In.	Lbs.	In.	Lbs.
Guns:	*10-inch	10.	.16	......	......	112	10,632
	*10-inch	10.	.16	......	......	112	9,400
	68-pdr	8.12	.2	......	......	130	12,544
	*68-pdr	8.12	.2	......	......	120	10,640
	*68-pdr	8.12	.2	......	......	114	9,856
	8-inch	8.05	.125	......	......	108	7,280
	*8-inch	8.05	.125	......	......	106	6,720
	*8-inch	8.05	.125	......	......	96	5,824
	8-inch	8.05	.125	......	......	80.5	5,600
	56-pdr	7.65	.175	......	......	132	10,976
	56-pdr	7.65	.175	......	......	120	9,744
	42-pdr	6.84	....	......	......	120	9,408
	42-pdr	6.84	....	......	......	120	8,400
	42-pdr	6.97	.2	......	......	114	7,504
	32-pdr	6.32	.175	......	......	115	7,168
	*32-pdr	6.32	.176	......	......	114	6,500
	32-pdr	6.35	.173	......	......	114	6,272
	32-pdr	6.35	.173	......	......	96	5,600
	*32-pdr	6.375	.198	......	......	108	5,600
	*32-pdr	6.35	.173	......	......	102	5,040
	*32-pdr	6.35	.173	......	......	96	4,700
	*32-pdr	6.41	.223	......	......	96	4,600
	*32-pdr	6.35	.173	......	......	90	4,480
	*32-pdr	6.35	.173	......	......	90	4,368
	32-pdr	6.3	.123	......	......	78	3,684
	*32-pdr	6.3	.123	......	......	72	3,800
	32-pdr	6.3	.123	......	......	64	3,800
	24-pdr	5.823	.211	......	......	114	5,600
	24-pdr	5.823	.211	......	......	108	5,376
	24-pdr	5.75	.138	......	......	78	3,696
	18-pdr	5.29	.193	......	......	108	4,700
	18-pdr	5.17	.071	......	......	108	4,700
	18-pdr	5.17	.071	......	......	72	2,240
	12-pdr	4.623	0.1	78.	2,000	108	3,800
	9-pdr	4.2	0.1	72.	1,500	66	1,900
	6-pdr	3.668	0.1	60.	672	72	1,900
	6-pdr	3.668	0.1	......	......	78	2,016
	3-pdr	2.913	0.09	48.	336	......	......
Howitzers:	10-inch	10.	.16	......	......	60	4.592
	8-inch	8.	.14	......	......	48	2,350
	32-pdr	6.3	.125	63.	......	......	......
	24-pdr	5.72	.125	56.5	1,456	......	......
	5½-inch	6.62	.025	40.75	......	40.75	1,680
	12-pdr	4.58	.122	45.25	728	......	......
	4⅖-inch	4.52	.066	22.5	280	......	......
Mortars:	*13-inch	13.	.16	......	......	63.	11,300
	13-inch	13.	.16	......	......	36.75	4,000
	*10-inch	10.	.16	......	......	45.6	5,824
	10-inch	10.	.16	27.	1,428	31.6	1,848
	8-inch	8.	.14	21.5	728	25.25	924
Armstrong Gun†		4.0	none.	......	......	......	2,600‡
" "		3.	none.	......	......	......	896§

* Navy guns. † The largest Armstrong gun is an 80-pdr.; weight, 7,280 lbs.

‡ 50 grooves; they make one turn in 10 feet. § 34 grooves.

Foreign Ordnance.—Continued.

Designation.	Diameter of Bore.	Diameter of Ball.		Brass.			Iron.		
		High gauge.	Low gauge.	Length.		Weight.	Length.		Weight.
				Exterior.	Bore.		Exterior.	Bore.	
FRANCE.	In.	In.	In.	In.	In.	Lbs.	In.	In.	Lbs.
Guns: Siege and garrison. 30-pdr...	6.458	6.307	6.263	....	....	....	110.91	104.01	6,684
Siege and garrison. 24-pdr...	6.011	5.878	5.804	127.33	121.53	6,067	114.17	108.27	6,229
Siege and garrison. 16-pdr...	5.264	5.130	5.056	122.34	117.26	4,432	110.24	105.12	4,773
Siege and garrison. 12-pdr...	4.775	4.686	4.620	115.48	110.87	3,482			
Field.. 12-pdr.........	4.775	4.686	4.620	83.15	78.86	1,959			
Field.. 12-pdr.........	4.763	4.685	4.637	75.20	71.56	1,366			
Field.. 12-pdr., light	4.763	4.685	4.637	72.49	68.74	1,190			
Howitzers:									
Sea-coast...22 centimetres	8.791	8.703	8.640	....	....	....	98.08	92.21	8,000
Siege........22 "	8.782	8.703	8.640	52.00	39.38	2,646			
Garrison...22 "	8.819	8.703	8.640	....	....	....	102.36	96.45	6.093
" ...16 "	6.518	6.439	6.392	90.29	74.29	1,951			
Mountain..12 "	4.745	4.686	4.639	33.87	31.90	221			
Mortars: 32 centimetres	12.799	12.661	12.590	35.27	27.45	2,922			
32 "	12.788	12.658	12.587	*	....	....	48.98	37.95	9,615
27 "	10.790	10.712	10.641	30.29	22.83	2,296			
22 "	8.782	8.703	8.640	21.72	17.46	607			
Mountain...15 "	5.958	5.879	5.832	16.70	14.10	154			
Eprouvette.19 "	7.460								
Naval guns:	....	....	....	....	....	....	....	9.28	344
60-pdr...	7.637	7.473	7.410	....	....	....	128.	121.81	10,191
36-pdr...	6.885	6.685	6.641	....	....	....	115.13	107.32	7,734
Long 30-pdr...	6.485	6.307	6.263	....	....	....	110.91	104.01	6,684
30-pdr...	6.485	6.307	6.263	....	....	....	102.00	96.81	5,476
30-pdr...	6.457	6.284	6.263	....	....	....	92.97	88.58	4,718
30-pdr...	6.441	6.304	6.263	....	....	....	79.77	85.04	4,100
12-pdr...	4.775	4.641	4.597	....	....	....	95.94	90.35	3,230
12-pdr...	4.742	4.641	4.597	....	....	....	87.23	83.15	2,585
Howitzers: 27 centimetres	10.803	10.709	10.638	....	....	....	102.92	97.64	11,464
22 "	8.791	8.701	8.677	....	....	....	109.61	104.41	7,967
22 "	8.791	8.701	8.677	....	....	....	97.21	92.12	6,000
Boat... 12 "	4.745	4.685	4.638	....	....	661			
Boat... 12 "	4.745	4.685	4.639	33.87	31.90	221			
Carronades: 30-pdr...	6.419	6.307	6.263	....	....	....	53.33	45.85	2,227
24-pdr...	5.937	5.826	5.782	....	....	....	45.71	38.36	1,663
18-pdr...	5.419	5.308	5.264	....	....	....	41.71	34.65	1,272
12-pdr...	4.753	4.642	4.597	....	....	....	35.33	29.37	840
Mortars: 32 centimetres	12.788	*	....	....	....	....	48.98	37.95	9,615
Rifled field gun†...............	3.31	....	....	61.8	54.3	670			
BELGIUM.									
Guns: 48-pdr...	7.480	7.323	7.238	....	....	....	139.84	131.10	11,685
36-pdr...	6.882	6.724	6.638	....	....	....	115.12	107.28	7,827
24-pdr...	5.973	5.854	5.755	....	....	....	113.50	106.57	6,217
18-pdr...	5.410	5.291	5.221	121.41	116.26	4,916	108.15	101.65	5,049
12-pdr...	4.721	4.642	4.578	117.80	112.31	3,660	103.86	98.23	3,637

* Cast with a bed-plate. † 6 grooves, .118 inch depth; projectile, 8 pounds.

Rifled 36 and 30 pounders are used in the armament of ships. They have 2 grooves, making 1 turn in 30 feet. A rifle-gun has been arranged for siege-purposes also.

Foreign Ordnance.—Continued.

DESIGNATION.	DIAMETER OF BORE.	DIAMETER OF BALL.		BRASS.			IRON.		
		High gauge.	Low gauge.	Length.		Weight.	Length.		Weight.
				Exterior.	Bore.		Exterior.	Bore.	
BELGIUM—*Continued.*									
GUNS—*continued:*	In.	In.	In.	In.	In.	Lbs.	In.	In.	Lbs.
Field ....12-pdr...	4.721	4.642	4.578	75.28	70.83	1,962			
6-pdr...	3.760	3.681	3.626	101.30	97.76	1,962	90.16	85.83	1,940
Field .... 6-pdr...	3.760	3.681	3.626	63.70	60.16	1,047			
HOWITZERS: 27 centimetres	10.787	10.709	10.638	....	....	....	106.57	100.20	11,024
22 "	8.780	8.701	8.638	....	....	....	96.97	91.10	8,047
GUN HOWITZER: 22 "	8.780	8.701	8.638	....	....	....	108.27	101.97	7,165
20 "	7.930	7.849	7.795	38.11	25.43	1,323			
15 "	6.972	5.894	5.846	29.72	20.08	750			
15 "	5.972	5.894	5.846	65.71	60.35	1,113			
MORTARS: 29 "	11.473	11.394	11.315	33.15	26.10	1,323			
20 "	7.930	7.849	7.795	22.95	18.19	551			
13 "	5.165	5.106	5.067	11.14	9.09	77			
Stone mortar...........	15.355	....	....	....	....	....	32.17	25.87	1,377
Grenade mortar........	15.355	....	....	....	....	....	40.75	30.47	3,330
Eprouvette.............	7.520	....	....	....	....	....	....	11.97	435
SPAIN.									
GUNS: 24-pdr...	6.105	....	....	....	123.63	6,532			
16-pdr...	5.255	....	....	....	111.44	4,416			
Long........ 12-pdr...	4.843	....	....	....	111.90	3,654			
Long........ 8-pdr...	4.237	....	....	....	99.06	2.640			
Long........ 4-pdr...	3.362	....	....	....	86.78	1,431			
Short........ 12-pdr...	4.843	....	....	....	79 91	2,131			
Short........ 8-pdr...	4.237	....	....	....	69.74	1,403			
Short........ 4-pdr...	3.362	....	....	....	55.33	690			
Mountain......4-pdr...	2.267	....	....	....	28.11	178			
HOWITZERS: 9-inch..	8.650	....	....	....	41.07	1,796			
7-inch..	6.666	....	....	....	27.57	744			
MORTARS: 14-inch..	12.977	....	....	....	29.19	2,288	*		
14-inch..	12.977	....	....	....	27.87	2,806	†		
12-inch..	10.948	....	....	....	23.10	1,908	†		
7-inch..	6.646	....	....	....	13.31	203	†		
Eprouvette....7-inch..	7.638	....	....	....	12.17	193			
PRUSSIA.									
GUNS: 24-pdr., long.	5.849	....	....	119.03	113.27	5,496	119.03	112.34	5,571
24-pdr., short	6.849	....	....	71.87	67.13	2,649	72.80	64.22	2,737.8
12-pdr...	4.675	....	....	105.55	102.46	2,876	107.10	101.74	2,939
6-pdr...	3.707	....	....	....	....	....	59.72	55.60	968
Field........ 6-pdr...	3.707	....	....	63.84	60.96				
Field........ 12-pdr...	4.675	....	....	80.32	76.56				
HOWITZERS: 7-pdr...	5.838	....	....	39.13	35.01				
10-pdr...	6.69	....	....	42.26	38.40	1,200			
25-pdr...	8.897	....	....	54.80	53.66	5,416	54.80	53.66	3,426
MORTARS: Hand.	3.092	....	....	‡	5.21	15½			
Hand.	4.618	4.573	4.460	§	7.63	39			
7-pdr...	5.793	5.752	5.639	15.86	13.02	166			

* Cylindrical chambers.
† Conical chambers.
‡ Attached to a stock
§ Cast with a bed-plate.

Foreign Ordnance.—Continued.

Designation.	Diameter of bore.	Diameter of ball.		Brass.			Iron.		
		High gauge.	Low gauge.	Length. Exterior.	Length. Bore.	Weight.	Length. Exterior.	Length. Bore.	Weight.
PRUSSIA—*Continued.*									
MORTARS—*continued:*	In.	In.	In.	In.	In.	Lbs.	In.	In.	Lbs.
10-pdr...	6.690	6.633	6.520	20.61	15.97	393	21.64	15.97	627
25-pdr...	8.906	8.834	8.710	26.29	21.65	909	27.83	21.65	1,129
50-pdr...	11.184	11.102	10.978	36.69	29.89	1,775	37.87	29.89	2,165
Stone.....................	15.454	....	....	....	....	....	33.00	25.77	1,553
BOMB-CANNON: 50-pdr...	11.120	11.102	10.978	....	....	....	111.00	....	12,400
RUSSIA.									
GUNS: Field........ 6-pdr...	3.762	3.646	3.609	....	51.13	802			
Field........ 12-pdr...	4.739	4.610	4.560	....	74.64	1,783			
Siege and garrison and sea-coast..... 3-pdr...	2.996	2.920	2.880	....	....	....	51.00	48.00	681
6-pdr...	3.762	3.646	3.609	....	....	....	82.70	79.00	1,665
12-pdr...	4.739	4.610	4.560	....	100.00	3,492	104.00	99.00	3,300
18-pdr...	5.426	5.300	5.210	....	108.75	4,814	114.00	106.50	5,680
24-pdr...	5.972	5.860	5.784	....	119.70	6,485	126.00	118.00	7,600
30-pdr...	6.443	6.320	6.240	....	....	....	129.00	121.15	9,080
36-pdr...	6.837	6.750	6.650	....	....	....	136.00	127.70	10,500
HOWITZERS (Likorna):									
56-pdr...	7.5	....	....	....	....	....	124.	....	13,500
Field.......... 3-pdr...	3.242	3.140	3.100	Exclusive of chamber.	28.37	240			
10-pdr...	4.843	4.700	4.650		37.53	707			
10-pdr...	4.843	4.700	4.650		42.38	780			
20-pdr...	6.102	5.990	5.915		50.34	1,509		50.34	1,675
Siege and garrison. 40-pdr...	7.688	7.575	7.476		63.90	3,170		63.43	3,476
MORTARS:									
6-pdr...	4.084	3.920	3.890		7.00	26			
80-pdr...	9.650	9.570	9.490		14.50	1,311		16.00	1,927
200-pdr...	13.150	13.050	12.950		18.81	3,243		21.83	4,900
BOMB-CANNON:									
20-pdr...	6.000	5.990	5.915	....	....	....	92.00	87.00	3,300
40-pdr...	7.700	7.575	7.476	....	....	....	116.00	110.00	5,600
96-pdr...	9.000	8.900	8.820						
120-pdr...	10.750	10.680	10.580						
SWEDEN.									
GUNS: 3-pdr...	3.015	2.922	2.887						
Field........ 6-pdr...	3.786	3.687	3.652	....	....	....	65.60	62.50	816
Field........ 12-pdr...	4.791	4.674	4.628	....	....	....	81.70	77.75	1,565
18-pdr...	5.551	5.446	5.388						
24-pdr...	6.112	5.994	5.924						
Ship.......... 30-pdr...	6.560	6.455	6.385	....	....	....	74.00	70.00	3,636
Ship.......... 30-pdr...	6.560	6.455	6.385	....	....	....	....	....	6,276
HOWITZERS: Field*. 12-pdr...	4.791	4.674	4.628	....	....	....	53.77	50.62	830
Field*. 24-pdr...	6.112	5.994	5.924	....	....	....	68.39	64.53	1,550
MORTARS: 7-inch	8.905	8.765	8.695	....	....	....	33.78	29.23	1,050
Light 9-inch	11.254	11.114	11.021	....	....	....	39.04	33.30	2,100
Heavy 9-inch	11.254	11.114	11.021	....	....	....	52.84	44.66	4,800
11-inch	12.855	12.715	12.598						

* Not chambered.

Foreign Ordnance.—Continued.

Designation.		Diameter of bore.	Diameter of ball. High gauge.	Diameter of ball. Low gauge.	Brass. Length. Exterior.	Brass. Length. Bore.	Brass. Weight.	Iron. Length. Exterior.	Iron. Length. Bore.	Iron. Weight.
SAXONY.		In.	In.	In.	In.	In.	Lbs.	In.	In.	Lbs.
Guns:	6-pdr...	3.684	3.573	....	63.868	60.74	881			
	12-pdr...	4.613	4.502	....	77.09	72.03	1,697			
New gun-howitzer:	12-pdr...	4.613	4.502	....	57.40	54.02	995			
	7½-pdr...	5.986	5.864	....	42.61	36.40	721			
AUSTRIA.										
Guns: Mountain..	1-pdr...	2.075	1.981	1.959	31.37	29.41	180			
	3-pdr...	2.957	2.849	2.827	31.64	29.16	296			
Field.........	3-pdr...	2.957	2.849	2.827	45.25	42.42	508			
	6-pdr...	3.724	3.594	3.562	57.00	53.43	842			
	12-pdr...	4.660	4.524	4.488	71.82	67.33	1.700			
	18-pdr...	5.311	5.173	5.137	82.22	77.71	2,514			
Siege and garrison.	6-pdr...	3.724	3.594	3.562	....	....	....	92.47	88.90	1,666
	12-pdr...	4.660	4.524	4.488	112.22	108.01	3,276	111.85	106.61	3,445
	18-pdr...	5.311	5.173	5.137	123.32	118.50	4,735	117.86	111.76	4,789
	24-pdr...	5.827	5.691	5.655	130.08	124.78	6,130			
Bomb-cannon:	30-pdr...	9.473	9.350	9.256	....	....	....	98.31	92.39	8,558
Howitzers:	7-pdr...	5.870	5.755	5.698	34.55	31.70	598	34.55	31.70	498
	10-pdr...	6.634	6.512	6.418	35.71	31.68	913			
Mortars: Coehorn......	6-pdr...	3.724	3.594	3.562	....	....	....	10.91	9.35	68
	10-pdr...	6.634	6.512	6.418	22.47	18.91	421			
	30-pdr...	9.494	9.350	9.256	27.77	22.63	1,141			
	30-pdr...	9.422	9.350	9.256	28.35	23.58	1,294			
	60-pdr...	11.922	11.763	11.663	32.44	25.97	2,167			
Stone mortar......	60-pdr...	12.390	....	....	....	....	....	38.45	32.44	2,180

Ordnance of the Navy of the United States.

Designation.		Diameter of bore.	Length. Bore.	Length. Exterior.	Weight.	Charge. Powder.	Charge. Shot or shell.
		In.			Lbs.	Lbs.	Lbs.
Guns:	64-pdr......	8.	124.2	140.95	11,872	12.	65.
	32-pdr......	6.4	....	....	6,832	8.	32.
	32-pdr......	6.4	107.9	125.34	6,384	8.	32.
	32-pdr......	6.4	104.	121.08	5,712	7.	32.
	32-pdr......	6.4	97.2	115.69	5,152	7.	32.
	32-pdr......	6.4	90.5	105.	4,704	6.	32.
	32-pdr......	6.4	75.04	91.83	3,696	4.5	32.
	32-pdr......	6.4	70.	81.6	3,024	4.	32.
							Shell.
Shell-Guns:	11-inch.....	11.	....	....	15,700	15.	130.
	10-inch.....	10.	....	....	12,000	12.5	97.
	9-inch.....	9.	....	....	9,000	10.	69.75
	8-inch.....	8.	100.3	119.31	7,056	8.	51.
	8-inch.....	8.	95.4	114.15	6,160	7.	51.
							Shell.
Boat-Howitzers:	24-pdr......	5.82	58.2	67.	1,310	2.	17.
	12-pdr......	4.62	55.23	63.5	760	1.	8.4
	12-pdr......	4.62	44.0	51.75	430	0.625	8.4
	Rifle-gun...	3.4	55.23	63.5	780		

Table for Reducing Metres to Inches.

Metres.	Inches.	Metres.	Inches.	Metres.	Inches.	Metres.	Inches.
0.001	0.039371	0.051	2.007910	0.101	3.976450	0.151	5.944989
2	0.078742	52	2.047281	102	4.015821	152	5.984360
3	0.118112	53	2.086652	103	4.055191	153	6.023731
4	0.157483	54	2.126023	104	4.094562	154	6.063102
5	0.196854	55	2.165393	105	4.133933	155	6.102472
6	0.236225	56	2.204764	106	4.173304	156	6.141843
7	0.275596	57	2.244135	107	4.212675	157	6.181214
8	0.314966	58	2.283506	108	4.252045	158	6.220585
9	0.354337	59	2.322877	109	4.291416	159	6.259956
0.010	0.393708	0.060	2.362247	0.110	4.330787	0.160	6.299326
11	0.433078	61	2.401618	111	4.370158	161	6.338697
12	0.472449	62	2.440989	112	4.409528	162	6.378068
13	0.511820	63	2.480358	113	4.448899	163	6.417439
14	0.551191	64	2.519731	114	4.488270	164	6.456810
15	0.590562	65	2.559101	115	4.527641	165	6.496180
16	0.629933	66	2.598472	116	4.567011	166	6.535551
17	0.669303	67	2.637843	117	4.606382	167	6.574922
18	0.708674	68	2.677214	118	4.645753	168	6.614293
19	0.748045	69	2.716585	119	4.685124	169	6.653664
0.020	0.787416	0.070	2.755955	0.120	4.724495	0.170	6.693034
21	0.826787	71	2.795326	121	4.763866	171	6.732405
22	0.866157	72	2.834697	122	4.803236	172	6.771776
23	0.905528	73	2.874068	123	4.842607	173	6.811147
24	0.944899	74	2.913438	124	4.881978	174	6.850517
25	0.984270	75	2.952809	125	4.921349	175	6.889888
26	1.023641	76	2.992180	126	4.960720	176	6.929259
27	1.063011	77	3.031551	127	5.000090	177	6.968630
28	1.102382	78	3.070922	128	5.039461	178	7.008001
29	1.141753	79	3.110292	129	5.078832	179	7.047371
0.030	1.181124	0.080	3.149663	0.130	5.118203	0.180	7.086742
31	1.220494	81	3.189034	131	5.157573	181	7.126113
32	1.259865	82	3.228405	132	5.196944	182	7.165484
33	1.299236	83	3.267776	133	5.236315	183	7.204855
34	1.338607	84	3.307146	134	5.275686	184	7.244225
35	1.377978	85	3.346517	135	5.315057	185	7.283596
36	1.417348	86	3.385888	136	5.354427	186	7.322967
37	1.456719	87	3.425259	137	5.393798	187	7.362338
38	1.496090	88	3.464630	138	5.433109	188	7.401709
39	1.535461	89	3.504000	139	5.472540	189	7.441079
0.040	1.574832	0.090	3.543371	0.140	5.511911	0.190	7.480450
41	1.614202	91	3.582742	141	5.551281	191	7.519821
42	1.653573	92	3.622113	142	5.590652	192	7.559192
43	1.692944	93	3.661483	143	5.630023	193	7.598562
44	1.732315	94	3.700854	144	5.669394	194	7.637933
45	1.771686	95	3.740225	145	5.708765	195	7.677304
46	1.811056	96	3.779596	146	5.748135	196	7.716675
47	1.850427	97	3.818967	147	5.787506	197	7.756046
48	1.889798	98	3.858337	148	5.826877	198	7.795416
49	1.929169	99	3.897708	149	5.866248	199	7.834787
0.050	1.968540	0.100	3.937079	0.150	5.905618	0.200	7.874158

Table for reducing Kilogrammes to Pounds.

Kilog.	Pounds.	Kilog.	Pounds.	Kilog.	Pounds.	Kilog.	Pounds.
1	2.204737	31	68.346847	61	134.488957	91	200.631067
2	4.409474	32	70.551584	62	136.693694	92	202.835804
3	6.614211	33	72.756321	63	138.898431	93	205.040541
4	8.818948	34	74.961058	64	141.103168	94	207.245278
5	11.023685	35	77.165795	65	143.307905	95	209.450015
6	13.228422	36	79.370532	66	145.512642	96	211.654752
7	15.433159	37	81.575269	67	147.717379	97	213.859489
8	17.637896	38	83.780006	68	149.922116	98	216.064226
9	19.842633	39	85.984743	69	152.126853	99	218.268963
10	22.047370	40	88.189480	70	154.331590	100	220.473700
11	24.252107	41	90.394217	71	156.536327	101	222.678437
12	26.456844	42	92.598954	72	158.741064	102	224.883174
13	28.661581	43	94.803691	73	160.945801	103	227.087911
14	30.866318	44	97.008428	74	163.150538	104	229.292648
15	33.071055	45	99.213165	75	165.355275	105	231.497385
16	35.275792	46	101.417902	76	167.560012	106	233.702122
17	37.480529	47	103.622639	77	169.764749	107	235.906859
18	39.685266	48	105.827376	78	171.969486	108	238.111596
19	41.890003	49	108.032113	79	174.174223	109	240.316333
20	44.094740	50	110.236850	80	176.378960	110	242.521070
21	46.299477	51	112.441587	81	178.583697	111	244.725807
22	48.504214	52	114.646324	82	180.788434	112	246.930544
23	50.708951	53	116.851061	83	182.993171	113	249.135281
24	52.913688	54	119.055798	84	185.197908	114	251.340018
25	55.118425	55	121.260535	85	187.402645	115	253.544755
26	57.323162	56	123.465272	86	189.607382	116	255.749492
27	59.527899	57	125.670009	87	191.812119	117	257.954229
28	61.732636	58	127.874746	88	194.016856	118	260.158966
29	63.937373	59	130.079483	89	196.221593	119	262.363703
30	66.142110	60	132.284220	90	198.426330	120	264.568440

Table for Reducing Grammes to Grains.

Gram.	Grains.	Gram.	Grains.	Gram.	Grains.	Gram.	Grains.
1	15.433159	14	216.064226	27	416.695293	40	617.326360
2	30.866318	15	231.497385	28	432.128452	41	632.759519
3	46.299477	16	246.930544	29	447.561611	42	648.192678
4	61.732636	17	262.363703	30	462.994770	43	663.625837
5	77.165795	18	277.796862	31	478.427929	44	679.058996
6	92.598954	19	293.230021	32	493.861088	45	694.492155
7	108.032113	20	308.663180	33	509.294247	46	709.925314
8	123.465272	21	324.096339	34	524.727406	47	725.358473
9	138.898431	22	339.529498	35	540.160565	48	740.791632
10	154.331590	23	354.962657	36	555.593724	49	756.224791
11	169.764749	24	370.395816	37	571.026883	50	771.657950
12	185.197908	25	385.828975	38	586.460042	51	787.091109
13	200.631067	26	401.262134	39	601.893201	52	802.524268

Weight of Distilled Water, displaced by the same Glass Bulb, at different Temperatures.

Temperature.	Weight of water.	Logarithms of weight.	Temperature.	Weight of water.	Logarithms of weight.
60.00	1.000000	0.0000000	72.00	0.998942	1.9995401
60.25	0.999981	1.9999919	72.25	0.998912	1.9995274
60.50	0.999963	1.9999839	72.50	0.998884	1.9995150
60.75	0.999945	1.9999760	72.75	0.998855	1.9995027
61.00	0.999927	1.9999681	73.00	0.998825	1.9994892
61.25	0.999909	1.9999603	73.25	0.998795	1.9994765
61.50	0.999890	1.9999522	73.50	0.998766	1.9994635
61.75	0.999871	1.9999440	73.75	0.998736	1.9994506
62.00	0.999853	1.9999361	74.00	0.998705	1.9994373
62.25	0.999834	1.9999280	74.25	0.998675	1.9994241
62.50	0.999814	1.9999193	74.50	0.998645	1.9994113
62.75	0.999795	1.9999108	74.75	0.998615	1.9993979
63.00	0.999774	1.9999020	75.00	0.998584	1.9993845
63.25	0.999753	1.9998929	75.25	0.998553	1.9993710
63.50	0.999733	1.9998840	75.50	0.998521	1.9993574
63.75	0.999712	1.9998749	75.75	0.998492	1.9993446
64.00	0.999692	1.9998660	76.00	0.998461	1.9993313
64.25	0.999672	1.9998574	76.25	0.998430	1.9993175
64.50	0.999651	1.9998483	76.50	0.998399	1.9993039
64.75	0.999629	1.9998388	76.75	0.998367	1.9992904
65.00	0.999608	1.9998294	77.00	0.998337	1.9992771
65.25	0.999585	1.9998198	77.25	0.998309	1.9992649
65.50	0.999563	1.9998104	77.50	0.998278	1.9992515
65.75	0.999542	1.9998011	77.75	0.998248	1.9992382
66.00	0.999521	1.9997918	78.00	0.998216	1.9992244
66.25	0.999499	1.9997822	78.25	0.998184	1.9992104
66.50	0.999479	1.9997737	78.50	0.998152	1.9991965
66.75	0.999454	1.9997630	78.75	0.998120	1.9991826
67.00	0.999432	1.9997533	79.00	0 998080	1.9991686
67.25	0.999409	1.9997435	79.25	0.998055	1.9991545
67.50	0.999387	1.9997338	79.50	0.998022	1.9991400
67.75	0.999365	1.9997243	79.75	0.997989	1.9991258
68.00	0.999343	1.9997146	80.00	0.997956	1.9991113
68.25	0.999320	1.9997047	80.25	0.997923	1.9990970
68.50	0.999297	1.9996945	80.50	0.997889	1.9990822
68.75	0.999273	1.9996843	80.75	0.997855	1.9990673
69.00	0.999249	1.9996740	81.00	0.997821	1.9990526
69.25	0.999226	1.9996636	81.25	0.997788	1.9990383
69.50	0.999202	1.9996532	81.50	0.997754	1.9990233
69.75	0.999178	1 9996477	81.75	0.997718	1.9990079
70.00	0.999153	1.9996320	82.00	0.997681	1.9989918
70.25	0.999127	1.9996208	82.25	0.997644	1.9989756
70.50	0.999102	1.9996098	82.50	0.997607	1.9989596
70.75	0.999076	1.9995985	82.75	0.997571	1.9989438
71.00	0.999050	1.9995873	83.00	0.997536	1.9989286
71.25	0.999024	1.9995779	83.25	0.997500	1.9989138
71.50	0.998997	1.9995642	83.50	0.997468	1.9988989
71.75	0.998969	1.9995522	83.75	0.997433	1.9988837

Powers.—Roots.—Circles.

No.	Square.	Cube.	Square Root.	Cube Root.	Area.	Circum.
1	1	1	1.000	1.000	0.7854	3.1416
2	4	8	1.414	1.260	3.1416	6.2832
3	9	27	1.732	1.442	7.0686	9.4248
4	16	64	2.000	1.587	12.5664	12.5664
5	25	125	2.236	1.710	19.6350	15.7080
6	36	216	2.449	1.817	28.2743	18.8496
7	49	343	2.646	1.913	38.4846	21.9911
8	64	512	2.828	2.000	50.2655	25.1327
9	81	729	3.000	2.080	63.6173	28.2743
10	100	1000	3.162	2.154	78.5398	31.4159
11	121	1331	3.317	2.224	95.0332	34.5575
12	144	1728	3.464	2.289	113.0973	37.6991
13	169	2197	3.606	2.351	132.7323	40.8407
14	196	2744	3.742	2.410	153.9380	43.9823
15	225	3375	3.873	2.466	176.7146	47.1239
16	256	4096	4.000	2.520	201.0619	50.2655
17	289	4913	4.123	2.571	226.9801	53.4071
18	324	5832	4.243	2.621	254.4690	56.5487
19	361	6859	4.359	2.668	283.5287	59.6903
20	400	8000	4.472	2.714	314.1593	62.8319
21	441	9261	4.583	2.759	346.3606	65.9734
22	484	10648	4.690	2.802	380.1327	69.1150
23	529	12167	4.796	2.844	415.4756	72.2566
24	576	13824	4.899	2.884	452.3893	75.3982
25	625	15625	5.000	2.924	490.8739	78.5398
26	676	17576	5.099	2.962	530.9292	81.6814
27	729	19683	5.196	3.000	572.5552	84.8230
28	784	21952	5.292	3.037	615.7522	87.9646
29	841	24389	5.385	3 072	660.5199	91.1062
30	900	27000	5.477	3.107	706.8583	94.2478
31	961	29791	5.568	3.141	754.7676	97.3894
32	1024	32768	5.657	3.175	804.2477	100.5310
33	1089	35937	5.745	3.208	855.2986	103.6726
34	1156	39304	5.831	3.240	907.9203	106.8142
35	1225	42875	5.916	3.271	962.1128	109.9557
36	1296	46656	6.000	3.302	1017.8760	113.0973
37	1369	50653	6.083	3.332	1075.2101	116.2389
38	1444	54872	6.164	3.362	1134.1149	119.3805
39	1521	59319	6.245	3.391	1194.5906	122.5221
40	1600	64000	6.325	3.420	1256.6370	125.6637
41	1681	68921	6.403	3.448	1320.2543	128.8053
42	1764	74088	6.481	3.476	1385.4424	131.9469
43	1849	79507	6.557	3.503	1452.2012	135.0885
44	1936	85184	6.633	3.530	1520.5308	138.2301
45	2025	91125	6.708	3.557	1590.4313	141.3717
46	2116	97336	6.782	3.583	1661.9025	144.5133
47	2209	103823	6.856	3.609	1734.9445	147.6549
48	2304	110592	6.928	3.634	1809.5574	150.7964
49	2401	117649	7.000	3.659	1885.7410	153.9380
50	2500	125000	7.071	3.684	1963.4954	157.0796

No.	Square.	Cube.	Square Root.	Cube Root.	Area.	Circum.
51	2601	132651	7.141	3.708	2042.8206	160.2212
52	2704	140608	7.211	3.733	2123.7166	163.3628
53	2809	148877	7.280	3.756	2206.1834	166.5044
54	2916	157464	7.348	3.780	2290.2210	169.6460
55	3025	166375	7.416	3.803	2375.8294	172.7876
56	3136	175616	7.483	3.826	2463.0086	175.9292
57	3249	185193	7.550	3.849	2551.7586	179.0708
58	3364	195112	7.616	3.871	2642.0794	182.2124
59	3481	205379	7.681	3.893	2733.9710	185.3540
60	3600	216000	7.746	3.915	2827.4334	188.4956
61	3721	226981	7.810	3.936	2922.4666	191.6372
62	3844	238328	7.874	3.958	3019.0705	194.7787
63	3969	250047	7.937	3.979	3117.2453	197.9203
64	4096	262144	8.000	4.000	3216.9909	201.0619
65	4225	274625	8.062	4.021	3318.3072	204.2035
66	4356	287496	8.124	4.041	3421.1944	207.3451
67	4489	300763	8.185	4.062	3525.6524	210.4867
68	4624	314432	8.246	4.082	3631.6811	213.6283
69	4761	328509	8.307	4.102	3739.2807	216.7699
70	4900	343000	8.367	4.121	3848.4510	219.9115
71	5041	357911	8.426	4.141	3959.1921	223.0531
72	5184	373248	8.485	4.160	4071.5041	226.1947
73	5329	389017	8.544	4.179	4185.3868	229.3363
74	5476	405224	8.602	4.198	4300.8403	232.4779
75	5625	421875	8.660	4.217	4417.8647	235.6194
76	5776	438976	8.718	4.236	4536.4598	238.7610
77	5929	456533	8.775	4.254	4656.6257	241.9026
78	6084	474552	8.832	4.273	4778.3624	245.0442
79	6241	493039	8.888	4.291	4901.6699	248.1858
80	6400	512000	8.944	4.309	5026.5482	251.3274
81	6561	531441	9.000	4.327	5152.9974	254.4690
82	6724	551368	9.055	4.344	5281.0173	257.6106
83	6889	571787	9.110	4.362	5410.6079	260.7522
84	7056	592704	9.165	4.380	5541.7694	263.8938
85	7225	614125	9.220	4.397	5674.5017	267.0354
86	7396	636056	9.274	4.414	5808.8048	270.1770
87	7569	658503	9.327	4.431	5944.6787	273.3186
88	7744	681472	9.381	4.448	6082.1234	276.4602
89	7921	704969	9.434	4.465	6221.1389	279.6017
90	8100	729000	9.487	4.481	6361.7251	282.7433
91	8281	753571	9.539	4.498	6503.8822	285.8849
92	8464	778688	9.592	4.514	6647.6101	289.0265
93	8649	804357	9.644	4.531	6792.9087	292.1681
94	8836	830584	9.695	4.547	6939.7782	295.3097
95	9025	857375	9.747	4.563	7088.2184	298.4513
96	9216	884736	9.798	4.579	7238.2295	301.5929
97	9409	912673	9.849	4.595	7389.8113	304.7345
98	9604	941192	9.899	4.610	7542.9640	307.8761
99	9801	970299	9.950	4.626	7697.6874	311.0177
100	10000	1000000	10.000	4.642	7853.9816	314.1593

No.	Square.	Cube.	Square Root.	Cube Root.	Area.	Circum.
101	10201	1030301	10.050	4.657	8011.847	317.301
102	10404	1061201	10.100	4.672	8171.282	320.442
103	10609	1092727	10.149	4.688	8332.289	323.584
104	10816	1124864	10.198	4.703	8494.867	326.726
105	11025	1157625	10.247	4.718	8659.015	329.867
106	11236	1191016	10.296	4.733	8824.734	333.009
107	11449	1225043	10.344	4.747	8992.024	336.150
108	11664	1259712	10.392	4.762	9160.884	339.292
109	11881	1295029	10.440	4.777	9331.316	342.434
110	12100	1331000	10.488	4.791	9503.318	345.575
111	12321	1367631	10.536	4.806	9676.891	348.717
112	12544	1404928	10.583	4.820	9852.035	351.858
113	12769	1442897	10.630	4.835	10028.749	355.000
114	12996	1481544	10.677	4.849	10207.035	358.142
115	13225	1520875	10.724	4.863	10386.891	361.283
116	13456	1560896	10.771	4.877	10568.318	364.425
117	13689	1601613	10.817	4.891	10751.315	367.566
118	13924	1643032	10.863	4.905	10935.884	370.708
119	14161	1685159	10.909	4.919	11122.023	373.849
120	14400	1728000	10.954	4.932	11309.734	376.991
121	14641	1771561	11.000	4.946	11499.015	380.133
122	14884	1815848	11.045	4.960	11689.866	383.274
123	15129	1860867	11.091	4.973	11882.289	386.416
124	15376	1906624	11.136	4.987	12076.282	389.557
125	15625	1953125	11.180	5.000	12271.846	392.699
126	15876	2000376	11.225	5.013	12468.981	395.841
127	16129	2048383	11.269	5.027	12667.687	398.982
128	16384	2097152	11.314	5.040	12867.963	402.123
129	16641	2146689	11.358	5.053	13069.811	405.265
130	16900	2197000	11.402	5.066	13273.229	408.407
131	17161	2248091	11.446	5.079	13478.218	411.549
132	17424	2299968	11.489	5.092	13684.778	414.690
133	17689	2352637	11.533	5.104	13892.908	417.832
134	17956	2406104	11.576	5.117	14102.609	420.973
135	18225	2460375	11.619	5.130	14313.882	424.115
136	18496	2515456	11.662	5.143	14526.724	427.257
137	18769	2571353	11.705	5.155	14741.138	430.398
138	19044	2628072	11.747	5.168	14956.123	433.540
139	19321	2685619	11.790	5.180	15174.678	436.681
140	19600	2744000	11.832	5.192	15393.804	439.823
141	19881	2803221	11.874	5.205	15614.501	442.965
142	20164	2863288	11.916	5.217	15836.769	446.106
143	20449	2924207	11.958	5.229	16060.607	449.248
144	20736	2985984	12.000	5.241	16286.016	452.389
145	21025	3048625	12.042	5.254	16512.996	455.531
146	21316	3112136	12.083	5.266	16741.547	458.673
147	21609	3176523	12.124	5.278	16971.669	461.814
148	21904	3241792	12.166	5.290	17203.361	464.956
149	22201	3307949	12.207	5.301	17436.625	468.097
150	22500	3375000	12.247	5.313	17671.459	471.239

No.	Square.	Cube.	Square Root.	Cube Root.	Area.	Circum.
151	22801	3442951	12.288	5.325	17907.864	474.380
152	23104	3511808	12.329	5.337	18145.839	477.522
153	23409	3581577	12.369	5.348	18385.386	480.664
154	23716	3652264	12.410	5.360	18626.503	483.805
155	24025	3723875	12.450	5.372	18869.191	486.947
156	24336	3796416	12.490	5.383	19113.450	490.088
157	24649	3869893	12.530	5.395	19359.279	493.230
158	24964	3944312	12.570	5.406	19606.680	496.372
159	25281	4019679	12.610	5.418	19855.651	499.513
160	25600	4096000	12.650	5.429	20106.193	502.655
161	25921	4173281	12.689	5.440	20358.306	505.796
162	26244	4251528	12.728	5.451	20611.989	508.938
163	26569	4330747	12.767	5.463	20867.244	512.080
164	26896	4410944	12.806	5.474	21124.069	515.221
165	27225	4492125	12.845	5.485	21382.465	518.363
166	27556	4574296	12.884	5.496	21642.432	521.504
167	27889	4657463	12.923	5.507	21903.969	524.646
168	28224	4741632	12.961	5.518	22167.078	527.788
169	28561	4826809	13.000	5.529	22431.757	530 929
170	28900	4913000	13.038	5.540	22698.007	534.071
171	29241	5000211	13.077	5.550	22965.824	537.212
172	29584	5088448	13.115	5.561	23235.219	540.354
173	29929	5177717	13.153	5.572	23506.182	543.496
174	30276	5268024	13.191	5.583	23778.715	546.637
175	30625	5359375	13.229	5.593	24052.819	549.779
176	30976	5451776	13.266	5.604	24328.493	552.920
177	31329	5545233	13.304	5.615	24605.739	556.062
178	31684	5639752	13.342	5.625	24884.555	559.203
179	32041	5735339	13.379	5.636	25164.943	562.345
180	32400	5832000	13.416	5.646	25446.900	565.487
181	32761	5929741	13.454	5.657	25730.429	568.628
182	33124	6028568	13.491	5.667	26015.529	571.770
183	33489	6128487	13.528	5.677	26302.199	574.911
184	33856	6229504	13.565	5.688	26590.440	578.053
185	34225	6331625	13.601	5.698	26880.252	581.195
186	34596	6434856	13.638	5.708	27171.635	584.336
187	34969	6539203	13.675	5.718	27464.588	587.478
188	35344	6644672	13.711	5.729	27759.113	590.619
189	35721	6751269	13.748	5.739	28055.208	593.761
190	36100	6859000	13.784	5.749	28352.874	596.903
191	36481	6967871	13.820	5.759	28652.110	600.044
192	36864	7077888	13.856	5.769	28952.918	603.186
193	37249	7189057	13.892	5.779	29255.296	606.327
194	37636	7301384	13.928	5.789	29559.245	609.469
195	38025	7414875	13.964	5.799	29864.765	612.611
196	38416	7529536	14.000	5.809	30171.856	615.752
197	38809	7645373	14.036	5.819	30480.517	618.894
198	39204	7762392	14.071	5.828	30790.749	622.035
199	39601	7880599	14.107	5.838	31102.553	625.177
200	40000	8000000	14.142	5.848	31415.927	628.319

No.	Square.	Cube.	Square Root.	Cube Root.	Area.	Circum.
201	40401	8120601	14.177	5.858	31730.871	631.460
202	40804	8242408	14.213	5.867	32047.386	634.602
203	41209	8365427	14.248	5.877	32365.473	637.743
204	41616	8489664	14.283	5.887	32685.129	640.885
205	42025	8615125	14.318	5.896	33006.358	644.026
206	42436	8741816	14.353	5.906	33329.156	647.168
207	42849	8869743	14.387	5.915	33653.526	650.310
208	43264	8998912	14.422	5.925	33979.468	653.452
209	43681	9123329	14.457	5.934	34306.977	656.593
210	44100	9261000	14.491	5.944	34636.059	659.734
211	44521	9393931	14.526	5.953	34966.712	662.876
212	44944	9528128	14.560	5.963	35298.936	666.018
213	45369	9663597	14.595	5.972	35632.729	669.159
214	45796	9800344	14.629	5.981	35968.096	672.300
215	46225	9938375	14.663	5.991	36305.030	675.442
216	46656	10077696	14.697	6.000	36643.536	678.584
217	47089	10218313	14.731	6.009	36983.614	681.726
218	47524	10360232	14.765	6.018	37325.264	684.868
219	47961	10503459	14.799	6.028	37668.480	688.008
220	48400	10648000	14.832	6.037	38013.271	691.150
221	48841	10793861	14.866	6.046	38359.632	694.292
222	49284	10941048	14.900	6.055	38707.564	697.434
223	49729	11089567	14.933	6.064	39057.069	700.575
224	50176	11239424	14.967	6.073	39408.140	703.716
225	50625	11390625	15.000	6.082	39760.782	706.858
226	51076	11543176	15.033	6.091	40114.996	710.000
227	51529	11697083	15.067	6.100	40470.782	713.141
228	51984	11852352	15.100	6.109	40828.140	716.284
229	52441	12008989	15.133	6.118	41187.065	719.424
230	52900	12167000	15.166	6.127	41547.563	722.566
231	53361	12326391	15.199	6.136	41909.631	725.707
232	53824	12487168	15.232	6.145	42273.272	728.850
233	54289	12649337	15.264	6.153	42638.481	731.991
234	54756	12812904	15.297	6.162	43005.260	735.132
235	55225	12977875	15.330	6.171	43373.614	738.274
236	55696	13144256	15.362	6.180	43743.536	741.416
237	56169	13312053	15.395	6.188	44115.029	744.557
238	56644	13481272	15.427	6.197	44488.092	747.698
239	57121	13651919	15.460	6.206	44862.728	750.841
240	57600	13824000	15.492	6.214	45238.934	753.982
241	58081	13997521	15.524	6.223	45616.710	757.124
242	58564	14172488	15.556	6.232	45996.060	760.266
243	59049	14348907	15.588	6.240	46376.976	763.407
244	59536	14526784	15.620	6.249	46759.465	766.548
245	60025	14706125	15.652	6.257	47143.525	769.690
246	60516	14886936	15.684	6.266	47529.155	772.832
247	61009	15069223	15.716	6.274	47916.356	775.973
248	61504	15252992	15.748	6.283	48305.129	779.115
249	62001	15438249	15.780	6.291	48695.471	782.257
250	62500	15625000	15.811	6.300	49087.385	785.398

No.	Square.	Cube.	Square Root.	Cube Root.	Area.	Circum.
251	63001	15813251	15.843	6.308	49480.870	788.540
252	63504	16003008	15.875	6.316	49875.925	791.681
253	64009	16194277	15.906	6.325	50272.550	794.823
254	64516	16387064	15.937	6.333	50670.748	797.964
255	65025	16581375	15.969	6.341	51070.516	801.106
256	65536	16777216	16.000	6.350	51471.854	804.248
257	66049	16974593	16.031	6.358	51874.763	807.389
258	66564	17173512	16.062	6.366	52279.243	810.531
259	67081	17373979	16.093	6.374	52685.294	813.672
260	67600	17576000	16.125	6.383	53092.916	816.814
261	68121	17779581	16.155	6.391	53502.109	819.956
262	68644	17984728	16.186	6.399	53912.872	823.097
263	69169	18191447	16.217	6.407	54325.205	826.239
264	69696	18399744	16 248	6.415	54739.110	829.380
265	70225	18609625	16.279	6.423	55154.586	832.522
266	70756	18821096	16.310	6.431	55571.632	835.664
267	71289	19034163	16.340	6.439	55990.250	838.805
268	71824	19248832	16.371	6.447	56410.438	841.947
269	72361	19465109	16.401	6.455	56832.196	845.088
270	72900	19683000	16.432	6.463	57255.526	848.230
271	73441	19902511	16.462	6.471	57680.426	851.372
272	73984	20123648	16.492	6.479	58106.898	854.513
273	74529	20346417	16.523	6.487	58534.940	857.655
274	75076	20570824	16.553	6.495	58964.552	860.796
275	75625	20796875	16.583	6.503	59395.736	863.938
276	76176	21024576	16.613	6.511	59824.490	867.080
277	76729	21253933	16.643	6.519	60260.815	870.221
278	77284	21484952	16.673	6.527	60698.711	873.363
279	77841	21717639	16.703	6.534	61136.178	876.484
280	78400	21952000	16.733	6.542	61575.216	879.646
281	78961	22188041	16.763	6.550	62015.824	882.788
282	79524	22425768	16.793	6.558	62458.003	885.929
283	80089	22665187	16.823	6.565	62901.753	889.071
284	80656	22906304	16.852	6.573	63347.074	892.212
285	81225	23149125	16.882	6.581	63793.966	895.354
286	81796	23393656	16.912	6.589	64242.428	898.495
287	82369	23639903	16.941	6.596	64692.461	901.637
288	82944	23887872	16.971	6.604	65144.065	904.779
289	83521	24137569	17.000	6.611	65597.240	907.920
290	84100	24389000	17.029	6.619	66051.986	911.062
291	84681	24642171	17.059	6.627	66508.302	914.203
292	85264	24897088	17.088	6.634	66966.189	917.345
293	85849	25153757	17.117	6.642	67425.647	920.466
294	86436	25412184	17.146	6.649	67886.675	923.628
295	87025	25672375	17.176	6.657	68349.275	926.770
296	87616	25934336	17.205	6.664	68813.445	929.911
297	88209	26198073	17.234	6.672	69279.186	933.053
298	88804	26463592	17.263	6.679	69746.498	936.195
299	89401	26730899	17.292	6.687	70215.381	939.336
300	90000	27000000	17.321	6.694	70685.835	942.478

No.	Square.	Cube.	Square Root.	Cube Root.	Area.	Circum.
301	90601	27270901	17.349	6.702	71157.859	945.619
302	91204	27543608	17.378	6.709	71631.454	948.761
303	91809	27818127	17.407	6.717	72106.620	951.903
304	92416	28094464	17.436	6.724	72583.356	955.044
305	93025	28372625	17.464	6.731	73061.664	958.186
306	93636	28652616	17.493	6.739	73541.542	961.327
307	94249	28934443	17.521	6.746	74022.991	964.469
308	94864	29218112	17.550	6.753	74506.008	967.610
309	95481	29503629	17.578	6.761	74990.602	970.752
310	96100	29791000	17.607	6.768	75476.764	973.894
311	96721	30080231	17 635	6.775	75964.496	977.035
312	97344	30371328	17.664	6.782	76453.798	980.177
313	97969	30664297	17.692	6.790	76944.673	983.318
314	98596	30959144	17.720	6.797	77437.117	986.460
315	99225	31255875	17.748	6.804	77931.133	989.602
316	99856	31554496	17.776	6.811	78426.719	992.743
317	100489	31855013	17.804	6.818	78923.876	995.885
318	101124	32157432	17.833	6.826	79422.604	999.026
319	101761	32461759	17.861	6.833	79922.902	1002.168
320	102400	32768000	17.889	6.840	80424.772	1005.310
321	103041	33076161	17.916	6.847	80928.212	1008.451
322	103684	33386248	17.944	6.854	81433.223	1011.593
323	104329	33698267	17.972	6.861	81939.805	1014.734
324	104976	34012224	18.000	6 868	82447.958	1017.876
325	105625	34328125	18.028	6.875	82957.681	1021.018
326	106276	34645976	18.055	6.882	83468.975	1024.159
327	106929	34965783	18.083	6.889	83981.840	1027.303
328	107584	35287552	18.111	6.896	84496.276	1030.442
329	108241	35611289	18.138	6.903	85012.282	1033.584
330	108900	35937000	18.166	6.910	85529.860	1036.726
331	109561	36264691	18.193	6.917	86049.008	1039.867
332	110224	36594368	18.221	6.924	86569.727	1043.009
333	110889	36926037	18.248	6.931	87092.016	1046.150
334	111556	37259704	18.276	6.938	87615.877	1049.292
335	112225	37595375	18.303	6.945	88141.309	1052.434
336	112896	37933056	18.330	6.952	88668.311	1055.575
337	113569	38272753	18.358	6.959	89196.884	1058.717
338	114244	38614472	18.385	6.966	89727.028	1061.858
339	114921	38958219	18.412	6.973	90258.742	1065.000
340	115600	39304000	18.439	6.980	90792.028	1068.142
341	116281	39651821	18.466	6.986	91326.884	1071.283
342	116964	40001688	18.493	6.993	91863.311	1074.425
343	117649	40353607	18.520	7.000	92401.308	1077.566
344	118336	40707584	18.547	7.007	92940.877	1080.708
345	119025	41063625	18.574	7.014	93482.016	1083.849
346	119716	41421736	18.601	7.020	94024.726	1086.991
347	120409	41781923	18.628	7.027	94569.007	1090.132
348	121104	42144192	18.655	7.034	95114.859	1093.274
349	121801	42508549	18.682	7.041	95662.282	1096.418
350	122500	42875000	18.708	7.047	96211.275	1099.557

No.	Square.	Cube.	Square Root.	Cube Root.	Area.	Circum.
351	123201	43243551	18.735	7.054	96761.84	1102.699
352	123904	43614208	18.762	7.061	97313.97	1105.840
353	124609	43986977	18.788	7.067	97867.16	1108.982
354	125316	44361864	18.815	7.074	98422.96	1112.124
355	126025	44738875	18.841	7.081	98979.80	1115.265
356	126736	45118016	18.868	7.087	99538.22	1118.407
357	127449	45499293	18.894	7.094	100098.21	1121.548
358	128164	45882712	18.921	7.101	100659.37	1124.690
359	128881	46268279	18.947	7.107	101222.90	1127.832
360	129600	46656000	18.974	7.114	101787.60	1130.973
361	130321	47045881	19.000	7.120	102353.87	1134.115
362	131044	47437928	19.026	7.127	102921.72	1137.256
363	131769	47832147	19.053	7.133	103491.13	1140.398
364	132496	48228544	19.079	7.140	104062.11	1143.540
365	133225	48627125	19.105	7.147	104634.67	1146.681
366	133956	49027896	19.131	7.153	105208.79	1149.823
367	134689	49430863	19.157	7.160	105784.49	1152.964
368	135424	49836032	19.183	7.166	106361.76	1156.106
369	136161	50243409	19.209	7.173	106940.60	1159.248
370	136900	50653000	19.235	7.179	107521.01	1162.389
371	137641	51064811	19.261	7.186	108102.99	1165.531
372	138384	51478848	19.287	7.192	108686.54	1168.672
373	139129	51895117	19.313	7.198	109271.66	1171.814
374	139876	52313624	19.339	7.205	109858.35	1174.956
375	140625	52734375	19.365	7.211	110446.62	1178.097
376	141376	53157376	19.391	7.218	111036.45	1181.238
377	142129	53582633	19.416	7.224	111627.86	1184.380
378	142884	54010152	19.442	7.230	112220.83	1187.522
379	143641	54439939	19.468	7.237	112815.38	1190.663
380	144400	54872000	19.494	7.243	113411.49	1193.805
381	145161	55306341	19.519	7.250	114009.28	1196.947
382	145924	55742968	19.545	7.256	114608.44	1200.088
383	146689	56181887	19.570	7.262	115209.27	1203.230
384	147456	56623104	19.596	7.268	115811.67	1206.372
385	148225	57066625	19.621	7.275	116415.64	1209.513
386	148996	57512456	19.647	7.281	117021.18	1212.654
387	149769	57960603	19.672	7.287	117628.30	1215.796
388	150544	58411072	19.698	7.294	118236.98	1218.938
389	151321	58863869	19.723	7.300	118847.24	1222.079
390	152100	59319000	19.748	7.306	119459.06	1225.221
391	152881	59776471	19.774	7.312	120072.46	1228.363
392	153664	60236288	19.799	7.319	120687.42	1231.504
393	154449	60698457	19.824	7.325	121303.96	1234.646
394	155236	61162984	19.849	7.331	121922.07	1237.788
395	156025	61629875	19.875	7.337	122541.75	1240.929
396	156816	62099136	19.900	7.343	123163.00	1244.071
397	157609	62570773	19.925	7.350	123785.82	1247.212
398	158404	63044792	19.950	7.356	124410.21	1250.354
399	159201	63521199	19.975	7.362	125036.17	1253.495
400	160000	64000000	20.000	7.368	125663.70	1256.637

No.	Square.	Cube.	Square Root.	Cube Root.	Area.	Circum.
401	160801	64481201	20.025	7.374	126292.81	1259.778
402	161604	64964808	20.050	7.380	126923.48	1262.920
403	162409	65450827	20.075	7.386	127555.73	1266.062
404	163216	65939264	20.100	7.393	128189.54	1269.204
405	164025	66430125	20.125	7.399	128824.93	1272.345
406	164836	66923416	20.149	7.405	129461.89	1275.486
407	165649	67419143	20.174	7.411	130100.42	1278.628
408	166464	67911312	20.199	7.417	130740.52	1281.770
409	167281	68417929	20.224	7.423	131382.19	1284.911
410	168100	68921000	20.248	7.429	132025.43	1288.053
411	168921	69426531	20.273	7.435	132670.24	1291.194
412	169744	69934528	20.298	7.441	133316.62	1294.336
413	170569	70444997	20.322	7.447	133964.58	1297.478
414	171396	70951944	20.347	7.453	134614.10	1300.620
415	172225	71473375	20.372	7.459	135265.20	1303.761
416	173056	71991296	20.396	7.465	135917.87	1306.902
417	173889	72511713	20.421	7.471	136572.10	1310.043
418	174724	73034632	20.445	7.477	137227.91	1313.186
419	175561	73560059	20.469	7.483	137885.29	1316.327
420	176400	74088000	20.494	7.489	138544.24	1319.469
421	177241	74618461	20.518	7.495	139204.76	1322.610
422	178084	75151448	20.543	7.501	139866.85	1325.752
423	178929	75686967	20.567	7.507	140530.51	1328.895
424	179776	76225024	20.591	7.513	141195.74	1332.036
425	180625	76765625	20.616	7.518	141862.54	1335.177
426	181476	77308776	20.640	7.524	142530.91	1338.318
427	182329	77854483	20.664	7.530	143200.86	1341.459
428	183184	78402752	20.688	7.536	143872.38	1344.600
429	184041	78953589	20.712	7.542	144545.46	1347.744
430	184900	79507000	20.736	7.548	145220.12	1350.885
431	185761	80062991	20.761	7.554	145896.35	1354.027
432	186624	80621568	20.785	7.560	146574.14	1357.168
433	187489	81182737	20.809	7.565	147253.51	1360.310
434	188356	81746504	20.833	7.571	147934.46	1363.452
435	189225	82312875	20.857	7.577	148616.97	1366.593
436	190096	82881856	20.881	7.583	149301.06	1369.736
437	190969	83453453	20.905	7.589	149986.71	1372.877
438	191844	84027672	20.928	7.594	150673.92	1376.019
439	192721	84604519	20.952	7.600	151362.72	1379.160
440	193600	85184000	20.976	7.606	152053.08	1382.301
441	194481	85766121	21.000	7.612	152745.02	1385.442
442	195364	86350888	21.024	7.617	153438.53	1388.584
443	196249	86938307	21.048	7.623	154135.18	1391.726
444	197136	87528384	21.071	7.629	154830.26	1394.868
445	198025	88121125	21.095	7.635	155528.47	1398.009
446	198916	88716536	21.119	7.640	156228.28	1401.150
447	199809	89314623	21.142	7.646	156929.63	1404.291
448	200704	89915392	21.166	7.652	157632.56	1407.432
449	201601	90518849	21.190	7.657	158337.06	1410.574
450	202500	91125000	21.213	7.663	159043.13	1413.717

No.	Square.	Cube.	Square Root.	Cube Root.	Area.	Circum.
451	203401	91733851	21.237	7.669	159750.78	1416.858
452	204304	92345408	21.260	7.674	160459.98	1420.000
453	205209	92959677	21.284	7.680	161170.78	1423.140
454	206116	93576664	21.307	7.686	161883.13	1426.282
455	207025	94196375	21.331	7.691	162597.05	1429.425
456	207936	94818816	21.354	7.697	163312.56	1432.568
457	208849	95443993	21.378	7.703	164029.63	1435.710
458	209764	96071912	21.401	7.708	164748.26	1438.848
459	210681	96702579	21.424	7.714	165468.47	1441.992
460	211600	97336000	21.448	7.719	166190.25	1445.133
461	212521	97972181	21.471	7.725	166913.61	1448.274
462	213444	98611128	21.494	7.731	167638.52	1451.416
463	214369	99252847	21.517	7.736	168365.02	1454.558
464	215296	99897344	21.541	7.742	169093.09	1457.700
465	216225	100544625	21.564	7.747	169822.72	1460.841
466	217156	101194696	21.587	7.753	170553.92	1463.982
467	218089	101847563	21.610	7.758	171286.70	1467.123
468	219024	102503232	21.633	7.764	172021.04	1470.264
469	219961	103161709	21.656	7.769	172756.96	1473.406
470	220900	103823000	21.679	7.775	173494.45	1476.549
471	221841	104487111	21.703	7.780	174233.51	1479.690
472	222784	105154048	21.726	7.786	174974.14	1482.832
473	223729	105823817	21.749	7.791	175716.34	1485.973
474	224676	106496424	21.772	7.797	176460.11	1489.114
475	225625	107171875	21.794	7.802	177205.46	1492.257
476	226576	107850176	21.817	7.808	177952.37	1495.398
477	227529	108531333	21.840	7.813	178700.86	1498.539
478	228484	109215352	21.863	7.819	179450.91	1501.682
479	229441	109902239	21.886	7.824	180202.54	1504.823
480	230400	110592000	21.909	7.830	180955.74	1507.964
481	231361	111284641	21.932	7.835	181710.51	1511.106
482	232324	111980168	21.954	7.841	182466.84	1514.248
483	233289	112678587	21.977	7.846	183224.75	1517.388
484	234256	113379904	22.000	7.851	183984.24	1520.532
485	235225	114084125	22.023	7.857	184745.28	1523.672
486	236196	114791256	22.045	7.862	185507.90	1526.814
487	237169	115501303	22.068	7.868	186272.09	1529.955
488	238144	116214272	22.091	7.873	187037.86	1533.096
489	239121	116930169	22.113	7.878	187805.20	1536.240
490	240100	117649000	22.136	7.884	188574.10	1539.380
491	241081	118370771	22.159	7.889	189344.58	1542.522
492	242064	119095488	22.181	7.894	190116.62	1545.664
493	243049	119823157	22.204	7.900	190890.24	1548.802
494	244036	120553784	22.226	7.905	191665.42	1551.946
495	245025	121287375	22.249	7.910	192442.18	1555.088
496	246016	122023936	22.271	7.916	193220.51	1558.230
497	247009	122763473	22.293	7.921	193998.62	1561.372
498	248004	123505992	22.316	7.926	194781.88	1564.514
499	249001	124251499	22.338	7.932	195564.92	1567.655
500	250000	125000000	22.361	7.937	196349.54	1570.796

No.	Square.	Cube.	Square Root.	Cube Root.	Area.	Circum
501	251001	125751501	22.383	7.942	197135.72	1573.938
502	252004	126506008	22.405	7.948	197923.48	1577.080
503	253009	127263527	22.428	7.953	198712.81	1580.221
504	254016	128024064	22.450	7.958	199503.70	1583.362
505	255025	128787625	22.472	7.963	200296.17	1586.504
506	256036	129554216	22.494	7.969	201090.20	1589.646
507	257049	130323843	22.517	7.974	201885.81	1592.787
508	258064	131096512	22.539	7.979	202682.99	1595.928
509	259081	131872229	22.561	7.984	203480.96	1599.070
510	260100	132651000	22.583	7.990	204282.06	1602.212
511	261121	133432831	22.605	7.995	205083.95	1605.354
512	262144	134217728	22.627	8.000	205887.42	1608.496
513	263169	135005697	22.650	8.005	206692.46	1611.637
514	264196	135796744	22.672	8.010	207499.05	1614.778
515	265225	136590875	22.694	8.016	208307.23	1617.920
516	266256	137388096	22.716	8.021	209116.97	1621.062
517	267289	138188413	22.738	8.026	209928.29	1624.203
518	268324	138991832	22.760	8.031	210741.18	1627.344
519	269361	139798359	22.782	8.036	211555.64	1630.488
520	270400	140608000	22.804	8.041	212371.66	1633.628
521	271441	141420761	22.825	8.047	213189.26	1636.770
522	272484	142236648	22.847	8.052	214008.44	1639.912
523	273529	143055667	22.869	8.057	214829.18	1643.053
524	274576	143877824	22.891	8.062	215651.49	1646.194
525	275625	144703125	22.913	8.067	216475.37	1649.336
526	276676	145315576	22.935	8.072	217300.82	1652.478
527	277729	146383183	22.956	8.077	218127.85	1655.619
528	278784	147197952	22.978	8.082	218956.44	1658.760
529	279841	148035889	23.000	8.088	219786.61	1661.902
530	280900	148877000	23.022	8.093	220618.34	1665.044
531	281961	149721291	23.043	8.098	221451.65	1668.186
532	283024	150568768	23.065	8.103	222286.53	1671.328
533	284089	151419437	23.087	8.108	223122.98	1674.469
534	285156	152273304	23.108	8.113	223961.00	1677.610
535	286225	153130375	23.130	8.118	224800.59	1680.752
536	287296	153990656	23.152	8.123	225641.75	1683.894
537	288369	154854153	23.173	8.128	226484.48	1687.035
538	289444	155720872	23.195	8.133	227328.78	1690.176
539	290521	156590819	23.216	8.138	228174.66	1693.318
540	291600	157464000	23.238	8.143	229022.10	1696.460
541	292681	158340421	23.259	8.148	229870.33	1699.602
542	293764	159220088	23.281	8.153	230721.70	1702.744
543	294849	160103007	23.302	8.158	231573.86	1705.884
544	295936	160989184	23.324	8.163	232427.59	1709.026
545	297025	161878625	23.345	8.168	233282.89	1712.168
546	298116	162771336	23.367	8.173	234139.76	1715.310
547	299209	163667323	23.388	8.178	234998.20	1718.451
548	300304	164566592	23.409	8.183	235858.21	1721.592
549	301401	165469149	23.431	8.188	236719.79	1724.733
550	302500	166375000	23.452	8.193	237582.94	1727.876

No.	Square.	Cube.	Square Root.	Cube Root.	Area.	Circum.
551	303601	167284151	23.473	8.198	238447.67	1731.018
552	304704	168196608	23.495	8.203	239297.96	1734.160
553	305809	169112377	23.516	8.208	240165.83	1737.301
554	306916	170031464	23.537	8.213	241043.26	1740.442
555	308025	170953875	23.558	8.218	241922.27	1743.584
556	309136	171879616	23.580	8.223	242794.84	1746.726
557	310249	172808693	23.601	8.228	243668.99	1749.867
558	311364	173741112	23.622	8.233	244544.71	1752.968
559	312481	174676879	23.643	8.238	245442.00	1756.110
560	313600	175616000	23.664	8.243	246300.86	1759.292
561	314721	176558481	23.685	8.248	247181.29	1762.434
562	315844	177504328	23.707	8.253	248063.30	1765.576
563	316969	178453547	23.728	8.258	248946.87	1768.717
564	318096	179406144	23.749	8.262	249832.01	1771.858
565	319225	180362125	23.770	8.267	250718.73	1775.000
566	320356	181321496	23.791	8.272	251607.01	1778.142
567	321489	182284263	23.812	8.277	252496.87	1781.283
568	322624	183250432	23.833	8.282	253388.30	1784.424
569	323761	184220009	23.854	8.286	254281.30	1787.566
570	324900	185193000	23.875	8.291	255175.86	1790.708
571	326041	186169411	23.896	8.296	256072.00	1793.849
572	327184	187149248	23.917	8.301	256969.71	1796.990
573	328329	188132517	23.937	8.306	257868.99	1800.132
574	329476	189119224	23.958	8.311	258769.84	1803.274
575	330625	190109375	23.979	8.316	259672.27	1806.416
576	331776	191102976	24.000	8.320	260576.26	1809.558
577	332929	192100033	24.021	8.325	261481.83	1812.699
578	334084	193100552	24.042	8.330	262388.96	1815.840
579	335241	194104539	24.062	8.335	263297.66	1818.981
580	336400	195112000	24.083	8.340	264207.94	1822.124
581	337561	196122941	24.104	8.344	265119.79	1825.265
582	338724	197137368	24.125	8.349	266033.21	1828.406
583	339889	198155287	24.145	8.354	266948.20	1831.548
584	341056	199176704	24.166	8.359	267864.76	1834.690
585	342225	200201625	24.187	8.363	268782.89	1837.832
586	343396	201230056	24.207	8.368	269702.59	1840.933
587	344569	202262003	24.228	8.373	270623.87	1844.074
588	345744	203297472	24.249	8.378	271546.70	1847.256
589	346921	204336469	24.269	8.382	272470.33	1850.398
590	348100	205379000	24.290	8.387	273397.10	1853.540
591	349281	206425071	24.310	8.392	274324.65	1856.682
592	350464	207474688	24.331	8.397	275253.78	1859.823
593	351649	208527857	24.352	8.401	276184.48	1862.964
594	352836	209584584	24.372	8.406	277116.74	1866.106
595	354025	210644875	24.393	8.411	278050.58	1869.248
596	355216	211708736	24.413	8.416	278985.99	1872.390
597	356409	212776173	24.434	8.420	279922.98	1875.531
598	357604	213847192	24.454	8.425	280861.52	1878.672
599	358801	214921799	24.474	8.430	281801.64	1881.814
600	360000	216000000	24.495	8.434	282743.34	1884.956

No.	Square.	Cube.	Square Root.	Cube Root.	Area.	Circum.
601	361201	217081801	24.515	8.439	283686.61	1888.097
602	362404	218167208	24.536	8.444	284631.44	1891.238
603	363609	219256227	24.556	8.448	285577.84	1894.380
604	364816	220348864	24.576	8.453	286525.82	1897.522
605	366025	221445125	24.597	8.458	287475.36	1900.664
606	367236	222545016	24.617	8.462	288426.48	1903.806
607	368449	223648543	24.637	8.467	289379.17	1906.947
608	369664	224755712	24.658	8.472	290333.42	1910.088
609	370881	225866529	24.678	8.476	291289.26	1913.229
610	372100	226981000	24.698	8.481	292246.66	1916.372
611	373321	228099131	24.718	8.486	293205.63	1919.513
612	374544	229220928	24.739	8.490	294166.17	1922.654
613	375769	230346397	24.759	8.495	295129.86	1925.796
614	376996	231475544	24.779	8.499	296091.96	1928.938
615	378225	232608375	24.799	8.504	297057.22	1932.079
616	379456	233744896	24.819	8.509	298024.05	1935.221
617	380689	234885113	24.839	8.513	298992.45	1938.362
618	381924	236029032	24.860	8.518	299962.40	1941.504
619	383161	237176659	24.880	8.522	300933.94	1944.645
620	384400	238328000	24.900	8.527	301907.05	1947.787
621	385641	239483061	24.920	8.532	302881.73	1950.928
622	386884	240641848	24.940	8.536	303857.98	1954.070
623	388129	241804367	24.960	8.541	304837.16	1957.211
624	389376	242970624	24.980	8.545	305815.19	1960.353
625	390625	244140625	25.000	8.550	306796.16	1963.495
626	391876	245314376	25.020	8.554	307778.69	1966.636
627	393129	246491883	25.040	8.559	308762.79	1969.778
628	394384	247673152	25.060	8.564	309748.47	1972.919
629	395641	248858189	25.080	8.568	310735.72	1976.061
630	396900	250047000	25.100	8.573	311724.53	1979.203
631	398161	251239591	25.120	8.577	312714.92	1982.344
632	399424	252435968	25.140	8.582	313706.87	1985.486
633	400689	253636137	25.160	8.586	314700.41	1988.628
634	401956	254840104	25.180	8.591	315695.50	1991.769
635	403225	256047875	25.200	8.595	316692.17	1994.911
636	404496	257259456	25.220	8.600	317690.42	1998.052
637	405769	258474853	25.239	8.604	318690.24	2001.194
638	407044	259694072	25.259	8.609	319691.61	2004.335
639	408321	260917119	25.278	8.613	320694.56	2007.477
640	409600	262144000	25.298	8.618	321699.09	2010.619
641	410881	263374721	25.318	8.622	322705.19	2013.760
642	412164	264609288	25.338	8.627	323712.85	2016.902
643	413449	265847707	25.357	8.631	324720.52	2020.043
644	414736	267089984	25.377	8.636	325732.89	2023.185
645	416025	268336125	25.397	8.640	326745.27	2026.327
646	417316	269586136	25.417	8.645	327759.22	2029.468
647	418609	270840023	25.436	8.649	328774.74	2032.610
648	419904	272097792	25.456	8.653	329791.82	2035.751
649	421201	273359449	25.475	8.658	330810.48	2038.893
650	422500	274625000	25.495	8.662	331830.72	2042.035

No.	Square.	Cube.	Square Root.	Cube Root.	Area.	Circum.
651	423801	275894451	25.515	8.667	332852.53	2045.177
652	425104	277167808	25.534	8.671	333875.90	2048.318
653	426409	278445077	25.554	8.676	334900.85	2051.460
654	427716	279726264	25.573	8.680	335927.38	2054.602
655	429025	281011375	25.593	8.685	336955.45	2057.743
656	430336	282300416	25.612	8.689	337985.10	2060.885
657	431649	283593393	25.632	8.693	339016.32	2064.026
658	432964	284890312	25.652	8.698	340049.13	2067.167
659	434281	286191179	25.671	8.702	341083.50	2070.309
660	435600	287496000	25.690	8.707	342119.44	2073.451
661	436921	288804781	25.710	8.711	343156.95	2076.592
662	438244	290117528	25.720	8.715	344196.03	2079.734
663	439569	291434247	25.749	8.720	345236.69	2082.876
664	440896	292754944	25.768	8.724	346278.91	2086.017
665	442225	294079625	25.788	8.729	347322.70	2089.159
666	443556	295408296	25.807	8.733	348368.08	2092.300
667	444889	296740963	25.826	8.737	349415.02	2095.442
668	446224	298077632	25.846	8.742	350463.51	2098.583
669	447561	299418309	25.865	8.746	351513.62	2101.725
670	448900	300763000	25.884	8.750	352565.24	2104.867
671	450241	302111711	25.904	8.755	353618.46	2108.008
672	451584	303464448	25.923	8.759	354673.26	2111.150
673	452929	304821217	25.942	8.763	355729.62	2114.291
674	454276	306182024	25.962	8.768	356787.54	2117.433
675	455625	307546875	25.981	8.772	357847.04	2120.575
676	456976	308915776	26.000	8.776	358908.11	2123.716
677	458329	310288733	26.019	8.781	359970.76	2126.858
678	459684	311665752	26.038	8.785	361034.96	2130.000
679	461041	313046839	26.058	8.789	362100.75	2133.141
680	462400	314432000	26.077	8.794	363168.11	2136.283
681	463761	315821241	26.096	8.798	364237.04	2139.425
682	465124	317214568	26.115	8.802	365307.54	2142.566
683	466489	318611987	26.134	8.807	366384.56	2145.708
684	467856	320013504	26.153	8.811	367453.18	2148.849
685	469225	321419125	26.173	8.815	368528.45	2151.991
686	470596	322828856	26.192	8.819	369605.23	2155.133
687	471969	324242703	26.211	8.824	370683.59	2158.274
688	473344	325660672	26.230	8.828	371763.50	2161.416
689	474721	327082769	26.249	8.832	372845.00	2164.557
690	476100	328509000	26.268	8.837	373928.07	2167.699
691	477481	329939371	26.287	8.841	375012.71	2170.840
692	478864	331373888	26.306	8.845	376098.91	2173.982
693	480249	332812557	26.325	8.849	377186.68	2177.124
694	481636	334255384	26.344	8.854	378276.03	2180.265
695	483025	335702375	26.363	8.858	379366.95	2183.407
696	484416	337153536	26.382	8.862	380459.44	2186.548
697	485809	338608873	26.401	8.866	381553.50	2189.690
698	487204	340068392	26.420	8.871	382649.13	2192.832
699	488601	341532099	26.439	8.875	383746.33	2195.973
700	490000	343000000	26.458	8.879	384845.10	2199.115

No.	Square.	Cube.	Square Root.	Cube Root.	Area.	Circum.
701	491401	344472101	26.476	8 883	385945.45	2202.256
702	492804	345948008	26.495	8.887	387047.34	2205.398
703	494209	347428927	26.514	8.892	388150.83	2208.539
704	495616	348913664	26.532	8.896	389255.89	2211.681
705	497025	350402625	26.552	8.900	390362.52	2214.823
706	498436	351895816	26.571	8.904	391470.72	2217.964
707	499849	353393243	26.589	8.909	392580.49	2221.106
708	501264	354894912	26.608	8.913	393691.82	2224.248
709	502681	356400829	26.627	8.917	394804.73	2227.389
710	504100	357911000	26.646	8.921	395919.21	2230.531
711	505521	359425431	26 665	8.925	397035.26	2233.672
712	506944	360944128	26.683	8.929	398152.88	2236.814
713	508369	362467097	26.702	8.934	399272.07	2239.956
714	509796	363994344	26.721	8.938	400392.83	2243.097
715	511225	365525875	26.739	8.942	401515.18	2246.239
716	512656	367061696	26.758	8.946	402639 09	2249.380
717	514089	368601813	26.777	8.950	403764.55	2252.522
718	515524	370146232	26.796	8.955	404891.60	2255.664
719	516961	371694959	26.814	8.959	406020.22	2258.805
720	518400	373248000	26.833	8.963	407150.41	2261.947
721	519841	374805361	26.851	8.967	408282.17	2265.088
722	521284	376367048	26.870	8.971	409415.50	2268.230
723	522729	377933067	26.889	8.975	410550.39	2271.371
724	524176	379503424	26.907	8.979	411686.86	2274.513
725	525625	381078125	26.926	8.984	412824.91	2277.655
726	527076	382657176	26.944	8.988	413964.54	2280.796
727	528529	384240583	26 963	8.992	415105.72	2283.938
728	529984	385828352	26.981	8.996	416248.46	2287.079
729	531441	387420489	27.000	9.000	417392.78	2290.221
730	532900	389017000	27.019	9.004	418538.68	2293.363
731	534361	390617891	27.037	9.008	419684.58	2296.504
732	535824	392223168	27.055	9.012	420835.18	2299.646
733	537289	393832837	27.074	9.016	421985.79	2302.787
734	538756	395446904	27.092	9.021	423137.97	2305.829
735	540225	397065375	27.111	9.025	424291.72	2309.071
736	541696	398688256	27.129	9.029	425447.04	2312.212
737	543169	400315553	27.148	9.033	426603.93	2315.353
738	544644	401947272	27.166	9.037	427762.40	2318.495
739	546121	403583419	27.185	9.041	428922.43	2321.637
740	547600	405224000	27.203	9.045	430084.03	2324.779
741	549081	406869021	27.221	9.049	431247.20	2327.920
742	550564	408518488	27.240	9.053	432411.95	2331.062
743	552049	410172407	27.258	9.057	433576.70	2334.203
744	553536	411830784	27.276	9.061	434746.16	2337.345
745	555025	413493625	27.295	9.065	435915.62	2340.487
746	556516	415160936	27.313	9.069	437086.65	2343.628
747	558009	416832723	27.331	9.073	438259.24	2346 769
748	559504	418508992	27.350	9.078	439433.41	2349.910
749	561001	420189749	27.368	9.082	440609.05	2353.052
750	562500	421875000	27.386	9.086	441786.47	2356.194

No.	Square.	Cube.	Square Root.	Cube Root.	Area.	Circum.
751	564001	423564751	27.404	9.090	442965.37	2359.335
752	565504	425259008	27.423	9.094	444145.81	2362.477
753	567009	426957777	27.441	9.098	445327.83	2365.619
754	568516	428661064	27.459	9.102	446511.42	2368.760
755	570025	430368875	27.477	9.106	447696.59	2371.902
756	571536	432081216	27.495	9.110	448883.33	2375.044
757	573049	433798093	27.514	9.114	450071.63	2378.185
758	574564	435519512	27.532	9.118	451261.51	2381.327
759	576081	437245479	27.550	9.122	452453.05	2384.469
760	577600	438976000	27.568	9.126	453645.98	2387.610
761	579121	440711081	27.586	9.130	454840.57	2390.752
762	580644	442450728	27.604	9.134	456036.73	2393.893
763	582169	444194947	27.622	9.138	457234.46	2397.035
764	583696	445943744	27.641	9.142	458433.76	2400.176
765	585225	447697125	27.659	9.146	459634.64	2403.318
766	586756	449455096	27.677	9.150	460837.08	2406.459
767	588289	451217663	27.695	9.154	462041.09	2409.601
768	589824	452984832	27.713	9.158	463246.69	2412.742
769	591361	454756609	27.731	9.162	464453.84	2415.884
770	592900	456533000	27.749	9.166	465662.57	2419.026
771	594441	458314011	27.767	9.170	466872.87	2422.167
772	595984	460099648	27.785	9.174	468084.74	2425.309
773	597529	461889917	27.803	9.178	469296.61	2428.451
774	599076	463684824	27.821	9.182	470513.19	2431.593
775	600625	465484375	27.839	9.185	471729.77	2434.734
776	602176	467288576	27.857	9.189	472947.92	2437.876
777	603729	469097433	27.875	9.193	474167.65	2441.017
778	605284	470910952	27.893	9.197	475388.94	2444.159
779	606841	472729139	27.911	9.201	476611.80	2447.300
780	608400	474552000	27.928	9.205	477836.24	2450.442
781	609961	476379541	27.946	9.209	479062.25	2453.583
782	611524	478211768	27.964	9.213	480289.83	2456.725
783	613089	480048687	27.982	9.217	481518.98	2459.867
784	614656	481890304	28.000	9.221	482749.70	2463.009
785	616225	483736025	28.018	9.225	483981.98	2466.150
786	617796	485587656	28.036	9.229	485215.85	2469.292
787	619369	487443403	28.054	9.233	486451.27	2472.433
788	620944	489303872	28.071	9.238	487688.27	2475.575
789	622521	491169069	28.089	9.240	488926.85	2478.716
790	624100	493039000	28.107	9.244	490166.99	2481.858
791	625681	494913671	28.125	9.248	491408.71	2485.000
792	627264	496793088	28.142	9.252	492651.98	2488.131
793	628849	498677257	28.160	9.256	493896.85	2491.272
794	630436	500566184	28.178	9.260	495143.28	2494.414
795	632025	502459875	28.196	9.264	496391.27	2497.566
796	633616	504358336	28.213	9.268	497640.85	2500.708
797	635209	506261573	28.231	9.272	498891.98	2503.849
798	636804	508169592	28.249	9.275	500144.69	2506.991
799	638401	510082399	28.267	9.279	501398.97	2509.132
800	640000	512000000	28.284	9.283	502654.82	2513.274

No.	Square.	Cube.	Square Root.	Cube Root.	Area.	Circum.
801	641601	513922401	28.302	9.287	503912.25	2516.416
802	643204	515849608	28.320	9.291	505171.24	2519.557
803	644809	517781627	28.337	9.295	506431.80	2522.698
804	646416	519718464	28.355	9.299	507693.94	2525.840
805	648025	521660125	28.373	9.302	508957.64	2528.982
806	649636	523606616	28.390	9.306	510222.92	2532.123
807	651249	525557943	28.408	9.310	511489.76	2535.265
808	652864	527514112	28.425	9.314	512758.18	2538.406
809	654481	529475129	28.443	9.318	514028.18	2541.548
810	656100	531441000	28.460	9.322	515299.74	2544.690
811	657721	533411731	28.478	9.326	516572.87	2547.831
812	659344	535387328	28.496	9.329	517847.57	2550.973
813	660969	537366797	28.513	9.333	519123.83	2554.115
814	662596	539353144	28.531	9.337	520401.69	2557.256
815	664225	541343375	28.548	9.341	521681.10	2560.398
816	665856	543338496	28.566	9.345	522962.08	2563.540
817	667489	545338513	28.583	9.348	524244.64	2566.681
818	669124	547343432	28.601	9.352	525528.77	2569.823
819	670761	549353259	28.618	9.356	526814.46	2572.964
820	672400	551368000	28.636	9.360	528101.73	2576.106
821	674041	553387661	28.653	9.364	529390.57	2579.247
822	675684	555412248	28.671	9.368	530680.97	2582.388
823	677329	557441767	28.688	9.371	531972.95	2585.530
824	678976	559476224	28.705	9.375	533266.50	2588.672
825	680625	561515625	28.723	9.379	534561.62	2591.814
826	682276	563559976	28.740	9.383	535858.32	2594.955
827	683929	565609283	28.758	9.386	537156.58	2598.097
828	685584	567663552	28.775	9.390	538456.42	2601.239
829	687241	569722789	28.792	9.394	539757.81	2604.380
830	688900	571787000	28.810	9.398	541060.79	2607.522
831	690561	573856191	28.827	9.402	542347.34	2610.663
832	692224	575930368	28.844	9.405	543671.49	2613.805
833	693889	578009537	28.862	9.409	544979.15	2616.946
834	695556	580093704	28.879	9.413	546288.40	2620.088
835	697225	582182875	28.896	9.417	547599.23	2623.230
836	698896	584277056	28.914	9.420	548911.63	2626.371
837	700569	586376253	28.931	9.424	550225.60	2629.513
838	702244	588480472	28.948	9.428	551541.14	2632.654
839	703921	590589719	28.965	9.432	552858.26	2635.796
840	705600	592704000	28.983	9.435	554176.94	2638.938
841	707281	594823321	29.000	9.439	555497.19	2642.079
842	708964	596947688	29.017	9.443	556819.02	2645.221
843	710649	599077107	29.034	9.447	558142.42	2648.363
844	712336	601211584	29.052	9.450	559467.39	2651.504
845	714025	603351125	29.069	9.454	560793.92	2654.646
846	715716	605495736	29.086	9.458	562122.03	2657.787
847	717409	607645423	29.103	9.462	563451.71	2660.929
848	719104	609800192	29.120	9.465	564782.98	2664.071
849	720801	611960049	29.138	9.469	566115.78	2667.212
850	722500	614125000	29.155	9.473	567450.17	2670.354

No.	Square.	Cube.	Square Root.	Cube Root.	Area.	Circum.
851	724201	616295051	29.172	9.476	568786.13	2673.495
852	725904	618470208	29.189	9.480	570123.66	2676.637
853	727609	620650477	29.206	9.484	571462.77	2679.778
854	729316	622835864	29.223	9.488	572803.45	2682.920
855	731025	625026375	29.240	9.491	574145.69	2686.062
856	732736	627222016	29.257	9.495	575489.54	2689.203
857	734449	629422793	29.275	9.499	576834.89	2692.345
858	736164	631628712	29.292	9.502	578181.85	2695.486
859	737881	633839779	29.309	9.506	579530.38	2698.628
860	739600	636056000	29.326	9.510	580880.48	2701.770
861	741321	638277381	29.343	9.513	582232.15	2704.911
862	743044	640503928	29.360	9.517	583585.39	2708.053
863	744769	642735647	29.377	9.521	584940.20	2711.194
864	746496	644972544	29.394	9.524	586296.58	2714.336
865	748225	647214625	29.411	9.528	587654.54	2717.478
866	749956	649461896	29.428	9.532	589014.06	2720.619
867	751689	651714363	29.445	9.535	590375.16	2723.760
868	753424	653972032	29.462	9.539	591737.82	2726.902
869	755161	656234909	29.479	9.543	593102.06	2730.044
870	756900	658503000	29.496	9.546	594467.87	2733.186
871	758641	660776311	29.513	9.550	595835.25	2736.327
872	760384	663054848	29.530	9.554	597204.22	2739.469
873	762129	665338617	29.547	9.557	598574.72	2742.610
874	763876	667627624	29.563	9.561	599946.81	2745.752
875	765625	669921875	29.580	9.565	601320.47	2748.894
876	767376	672221376	29.597	9.568	602695.70	2752.035
877	769129	674526133	29.614	9.572	604072.51	2755.177
878	770884	676836152	29.631	9.576	605450.88	2758.318
879	772641	679151439	29.648	9.579	606830.82	2761.460
880	774400	681472000	29.665	9.583	608212.34	2764.602
881	776161	683797841	29.682	9.586	609595.43	2767.743
882	777924	686128968	29.698	9.590	610980.08	2770.885
883	779689	688465387	29.715	9.594	612366.31	2774.026
884	781456	690807104	29.732	9.597	613754.12	2777.168
885	783225	693154125	29.749	9.601	615143.48	2780.309
886	784996	695506456	29.766	9.605	616534.42	2783.451
887	786769	697864103	29.783	9.608	617926.93	2786.592
888	788544	700227072	29.799	9.612	619321.02	2789.734
889	790321	702595369	29.816	9.615	620716.66	2792.876
890	792100	704969000	29.833	9.619	622113.89	2796.017
891	793881	707347971	29.850	9.623	623512.67	2799.159
892	795664	709732288	29.866	9.626	624913.10	2802.300
893	797449	712121957	29.883	9.630	626314.98	2805.442
894	799236	714516984	29.900	9.633	627718.48	2808.584
895	801025	716917375	29.917	9.637	629123.56	2811.725
896	802816	719323136	29.933	9.641	630530.24	2814.867
897	804609	721734273	29.950	9.644	631938.43	2818.009
898	806404	724150792	29.967	9.648	633348.22	2821.150
899	808201	726572699	29.983	9.651	634759.58	2824.292
900	810000	729000000	30.000	9.655	636172.51	2827.433

No.	Square.	Cube.	Square Root.	Cube Root.	Area.	Circum.
901	811801	731432701	30.017	9.658	637587.01	2830.575
902	813604	733870808	30.033	9.662	639003.08	2833.716
903	815409	736314327	30.050	9.666	640420.73	2836.858
904	817216	738763264	30.067	9.669	641839.94	2840.000
905	819025	741217625	30.083	9.673	643260.73	2843.141
906	820836	743677416	30.100	9.676	644683.09	2846.283
907	822649	746142643	30.116	9.680	646107.01	2849.424
908	824464	748613312	30.133	9.683	647532.51	2852.566
909	826281	751089429	30.150	9.687	648959.58	2855.707
910	828100	753571000	30.166	9.691	650388.22	2858.849
911	829921	756058031	30.183	9.694	651818.43	2861.990
912	831744	758550528	30.199	9.698	653250.20	2865.132
913	833569	761048497	30.216	9.701	654683.56	2868.273
914	835396	763551944	30.232	9.705	656118.48	2871.415
915	837225	766060875	30.249	9.708	657554.98	2874.557
916	839056	768575296	30.265	9.712	658993.04	2877.698
917	840889	771095213	30.282	9.715	660432.68	2880.840
918	842724	773620632	30.299	9.719	661873.88	2883.982
919	844561	776151559	30.315	9.722	663316.66	2887.123
920	846400	778688000	30.332	9.726	664761.01	2890.265
921	848241	781229961	30.348	9.729	666206.92	2893.407
922	850084	783777448	30.364	9.733	667654.42	2896.548
923	851929	786330467	30.381	9.736	669103.47	2899.690
924	853776	788889024	30.397	9.740	670554.07	2902.832
925	855625	791453125	30.414	9.743	672006.30	2905.973
926	857476	794022776	30.430	9.747	673460.07	2909.115
927	859329	796597983	30.447	9.750	674915.42	2912.256
928	861184	799178752	30.463	9.754	676372.35	2915.398
929	863041	801765089	30.480	9.758	677830.82	2918.539
930	864900	804357000	30.496	9.761	679290.87	2921.681
931	866761	806954491	30.512	9.764	680752.49	2924.822
932	868624	809557568	30.529	9.768	682215.70	2927.964
933	870489	812166237	30.545	9.771	683680.46	2931.106
934	872356	814780504	30.561	9.775	685146.80	2934.247
935	874225	817400375	30.578	9.778	686614.71	2937.389
936	876096	820025856	30.594	9.783	688084.18	2940.531
937	877969	822656953	30.610	9.785	689555.24	2943.672
938	879844	825293672	30.627	9.789	691027.86	2946.814
939	881721	827936019	30.643	9.792	692502.06	2949.955
940	883600	830584000	30.659	9.796	693977.82	2953.097
941	885481	833237621	30.676	9.799	695455.15	2956.238
942	887364	835896888	30.692	9.803	696934.05	2959.380
943	889249	838561807	30.708	9.806	698414.59	2962.521
944	891136	841232384	30.725	9.810	699896.58	2965.663
945	893025	843908625	30.741	9.813	701380.19	2968.805
946	894916	846590536	30.757	9.817	702865.38	2971.946
947	896809	849278123	30.773	9.820	704351.35	2975.088
948	898704	851971392	30.790	9.824	705840.47	2978.230
949	900601	854670349	30.806	9.827	707330.37	2981.371
950	902500	857375000	30.822	9.830	708821.84	2984.513

No.	Square.	Cube.	Square Root.	Cube Root.	Area.	Circum.
951	904401	860085351	30.838	9.834	710314.88	2987.655
952	906304	862801408	30.854	9.837	711809.47	2990.796
953	908209	865523177	30.871	9.841	713305.68	2993.938
954	910116	868250664	30.887	9.844	714803.44	2997.079
955	912025	870983875	30.903	9.848	716302.76	3000.221
956	913936	873722816	30.919	9.851	717803.65	3003.362
957	915849	876467493	30.935	9.855	719306.12	3006.504
958	917764	879217912	30.952	9.858	720810.16	3009.645
959	919681	881974079	30.968	9.861	722315.77	3012.787
960	921600	884736000	30.984	9.865	723822.95	3015.929
961	923521	887503681	31.000	9.868	725331.70	3019.070
962	925444	890277128	31.016	9.872	726842.02	3022.212
963	927369	893056347	31.032	9.875	728353.91	3025.353
964	929296	895841344	31.048	9.879	729867.36	3028.495
965	931225	898632125	31.064	9.882	731382.40	3031.637
066	933156	901428696	31.081	9.885	732899.01	3034.778
967	935089	904231063	31.097	9.889	734417.18	3037.920
968	937024	907039232	31.113	9.892	735936.96	3041.061
969	938961	909853209	31.129	9.896	737458.25	3044.203
970	940900	912673000	31.145	9.899	738981.13	3047.345
971	942841	915498611	31.161	9.902	740505.59	3050.486
972	944784	918330048	31.177	9.906	742031.62	3053.628
973	946729	921167317	31.193	9.909	743559.22	3056.769
974	948676	924010424	31.209	9.913	745088.39	3059.911
975	950625	926859375	31.225	9.916	746619.13	3063.053
976	952576	929714176	31.241	9.919	748151.44	3066.194
977	954529	932574833	31.257	9.923	749685.32	3069.336
978	956484	935441352	31.273	9.926	751220.78	3072.478
979	958441	938313739	31.289	9.930	752757.80	3075.619
980	960400	941192000	31.305	9.933	754296.40	3078.761
981	962361	944076141	31.321	9.936	755836.56	3081.902
982	964324	946966168	31.337	9.940	757378.30	3085.044
983	966289	949862087	31.353	9.943	758921.60	3088.185
984	968256	952763904	31.369	9.946	760466.48	3091.327
985	970225	955671625	31.385	9.950	762012.93	3094.469
986	972196	958585256	31.401	9.953	763560.95	3097.610
987	974169	961504803	31.417	9.956	765109.54	3100.752
988	976144	964430272	31.432	9.960	766661.70	3103.893
989	978121	967361669	31.448	9.963	768214.44	3107.035
990	980100	970299000	31.464	9.967	769768.74	3110.177
991	982081	973242271	31.480	9.970	771324.61	3113.318
992	984064	976191488	31.496	9.973	772882.06	3116.460
993	986049	979146657	31.512	9.977	774441.07	3119.601
994	988036	982107784	31.528	9.980	776001.66	3122.743
995	990025	985074875	31.544	9.983	777563.82	3125.885
996	992016	988047936	31.560	9.987	779127.55	3129.026
997	994009	991026973	31.575	9.990	780692.85	3132.168
998	996004	994011992	31.591	9.993	782259.72	3135.310
999	998001	997002999	31.607	9.997	783828.14	3138.451
1000	1000000	1000000000	31.623	10.000	785398.16	3141.593

LOGARITHMS OF NUMBERS

FROM 1 TO 10,000.

No.	Log.	No.	Log.	No.	Log.	No.	Log.
1	0.000000	26	1.414973	51	1.707570	76	1.880814
2	0.301030	27	1.431364	52	1.716003	77	1.886491
3	0.477121	28	1.447158	53	1.724276	78	1.892095
4	0.602060	29	1.462398	54	1.732394	79	1.897627
5	0.698970	30	1.477121	55	1.740363	80	1.903090
6	0.778151	31	1.491362	56	1.748188	81	1.908485
7	0.845098	32	1.505150	57	1.755875	82	1.913814
8	0.903090	33	1.518514	58	1.763428	83	1.919078
9	0.954243	34	1.531479	59	1.770852	84	1.924279
10	1.000000	35	1.544068	60	1.778151	85	1.929419
11	1.041393	36	1.556303	61	1.785330	86	1.934498
12	1.079181	37	1.568202	62	1.792392	87	1.939519
13	1.113943	38	1.579784	63	1.799341	88	1.944483
14	1.146128	39	1.591065	64	1.806180	89	1.949390
15	1.176091	40	1.602060	65	1.812913	90	1.954243
16	1.204120	41	1.612784	66	1.819544	91	1.959041
17	1.230449	42	1.623249	67	1.826075	92	1.963788
18	1.255273	43	1.633468	68	1.832509	93	1.968483
19	1.278754	44	1.643453	69	1.838849	94	1.973128
20	1.301030	45	1.653213	70	1.845098	95	1.977724
21	1.322219	46	1.662758	71	1.851258	96	1.982271
22	1.342423	47	1.672098	72	1.857332	97	1.986772
23	1.361728	48	1.681241	73	1.863323	98	1.991226
24	1.380211	49	1.690196	74	1.869232	99	1.995635
25	1.397940	50	1.698970	75	1.875061	100	2.000000

No.	0	1	2	3	4	5	6	7	8	9	Diff.
100	000000	0434	0868	1301	1734	2166	2598	3029	3461	3891	432
1	4321	4751	5181	5609	6038	6466	6894	7321	7748	8174	428
2	8600	9026	9451	9876	$\bar{0}$300	$\bar{0}$724	$\bar{1}$147	$\bar{1}$570	$\bar{1}$993	$\bar{2}$415	424
3	012837	3259	3680	4100	4521	4940	5360	5779	6197	6616	420
4	7033	7451	7868	8284	8700	9116	9532	9947	$\bar{0}$361	$\bar{0}$775	416
5	021189	1603	2016	2428	2841	3252	3664	4075	4486	4896	412
6	5306	5715	6125	6533	6942	7350	7757	8164	8571	8978	408
7	9384	9789	$\bar{0}$195	$\bar{0}$600	$\bar{1}$004	$\bar{1}$408	$\bar{1}$812	$\bar{2}$216	$\bar{2}$619	$\bar{3}$021	404
8	033424	3826	4227	4628	5029	5430	5830	6230	6629	7028	400
9	7426	7825	8223	8620	9017	9414	9811	$\bar{0}$207	$\bar{0}$602	$\bar{0}$998	397
110	041393	1787	2182	2576	2969	3362	3755	4148	4540	4932	393
1	5323	5714	6105	6495	6885	7275	7664	8053	8442	8830	390
2	9218	9606	9993	$\bar{0}$380	$\bar{0}$766	$\bar{1}$153	$\bar{1}$538	$\bar{1}$924	$\bar{2}$309	$\bar{2}$694	386
3	053078	3463	3846	4230	4613	4996	5378	5760	6142	6524	383
4	6905	7286	7666	8046	8426	8805	9185	9563	9942	$\bar{0}$320	379
5	060698	1075	1452	1829	2206	2582	2958	3333	3709	4083	376
6	4458	4832	5206	5580	5953	6326	6699	7071	7443	7815	373
7	8186	8557	8928	9298	9668	$\bar{0}$038	$\bar{0}$407	$\bar{0}$776	$\bar{1}$145	$\bar{1}$514	370
8	071882	2250	2617	2985	3352	3718	4085	4451	4816	5182	366
9	5547	5912	6276	6640	7004	7368	7731	8094	8457	8819	363
120	079181	9543	9904	$\bar{0}$266	$\bar{0}$626	$\bar{0}$987	$\bar{1}$347	$\bar{1}$707	$\bar{2}$067	$\bar{2}$426	360
1	082785	3144	3503	3861	4219	4576	4934	5291	5647	6004	357
2	6360	6716	7071	7426	7781	8136	8490	8845	9198	9552	355
3	9905	$\bar{0}$258	$\bar{0}$611	$\bar{0}$963	$\bar{1}$315	$\bar{1}$667	$\bar{2}$018	$\bar{2}$370	$\bar{2}$721	$\bar{3}$071	352
4	093422	3772	4122	4471	4820	5169	5518	5866	6215	6562	349
5	6910	7257	7604	7951	8298	8644	8990	9335	9681	$\bar{0}$026	346
6	100371	0715	1059	1403	1747	2091	2434	2777	3119	3462	343
7	3804	4146	4487	4828	5169	5510	5851	6191	6531	6871	341
8	7210	7549	7888	8227	8565	8903	9241	9579	9916	$\bar{0}$253	338
9	110590	0926	1263	1599	1934	2270	2605	2940	3275	3609	335
130	113943	4277	4611	4944	5278	5611	5943	6276	6608	6940	333
1	7271	7603	7934	8265	8595	8926	9256	9586	9915	$\bar{0}$245	330
2	120574	0903	1231	1560	1888	2216	2544	2871	3198	3525	328
3	3852	4178	4504	4830	5156	5481	5806	6131	6456	6781	325
4	7105	7429	7753	8076	8399	8722	9045	9368	9690	$\bar{0}$012	323
5	130334	0655	0977	1298	1619	1939	2260	2580	2900	3219	321
6	3539	3858	4177	4496	4814	5133	5451	5769	6086	6403	318
7	6721	7037	7354	7671	7987	8303	8618	8934	9249	9564	316
8	9879	$\bar{0}$194	$\bar{0}$508	$\bar{0}$822	$\bar{1}$136	$\bar{1}$450	$\bar{1}$763	$\bar{2}$076	$\bar{2}$389	$\bar{2}$702	314
9	143015	3327	3639	3951	4263	4574	4885	5196	5507	5818	311
140	146128	6438	6748	7058	7367	7676	7985	8294	8603	8911	309
1	9219	9527	9835	$\bar{0}$142	$\bar{0}$449	$\bar{0}$756	$\bar{1}$063	$\bar{1}$370	$\bar{1}$676	$\bar{1}$982	307
2	152288	2594	2900	3205	3510	3815	4120	4424	4728	5032	305
3	5336	5640	5943	6246	6549	6852	7154	7457	7759	8061	303
4	8362	8664	8965	9266	9567	9868	$\bar{0}$168	$\bar{0}$469	$\bar{0}$769	$\bar{1}$068	301
5	161368	1667	1967	2266	2564	2863	3161	3460	3758	4055	299
6	4353	4650	4947	5244	5541	5838	6134	6430	6726	7022	297
7	7317	7613	7908	8203	8497	8792	9086	9380	9674	9968	295
8	170262	0555	0848	1141	1434	1726	2019	2311	2603	2895	293
9	3186	3478	3769	4060	4351	4641	4932	5222	5512	5802	291
No.	0	1	2	3	4	5	6	7	8	9	Diff.

No.	0	1	2	3	4	5	6	7	8	9	Diff.
150	176091	6381	6670	6959	7248	7536	7825	8113	8401	8689	289
1	8977	9264	9552	9839	$\bar{0}126$	$\bar{0}413$	$\bar{0}699$	$\bar{0}986$	$\bar{1}272$	$\bar{1}558$	287
2	181844	2129	2415	2700	2985	3270	3555	3839	4123	4407	285
3	4691	4975	5259	5542	5825	6108	6391	6674	6956	7239	283
4	7521	7803	8084	8366	8647	8928	9209	9490	9771	$\bar{0}051$	281
5	190322	0612	0892	1171	1451	1730	2010	2289	2567	2846	279
6	3125	3403	3681	3959	4237	4514	4792	5069	5346	5623	278
7	5900	6176	6453	6729	7005	7281	7556	7832	8107	8382	276
8	8657	8932	9206	9481	9755	$\bar{0}029$	$\bar{0}303$	$\bar{0}577$	$\bar{0}850$	$\bar{1}124$	274
9	201397	1670	1943	2216	2488	2761	3033	3305	3577	3848	272
160	204120	4391	4663	4934	5204	5475	5746	6016	6286	6556	271
1	6826	7096	7365	7634	7904	8173	8441	8710	8979	9247	269
2	9515	9783	$\bar{0}051$	$\bar{0}319$	$\bar{0}586$	$\bar{0}853$	$\bar{1}121$	$\bar{1}388$	$\bar{1}654$	$\bar{1}921$	267
3	212188	2454	2720	2986	3252	3518	3783	4049	4314	4579	266
4	4844	5109	5373	5638	5902	6166	6430	6694	6957	7221	264
5	7484	7747	8010	8273	8536	8798	9060	9323	9585	9846	262
6	220108	0370	0631	0892	1153	1414	1675	1936	2196	2456	261
7	2716	2976	3236	3496	3755	4015	4274	4533	4792	5051	259
8	5309	5568	5826	6084	6342	6600	6858	7115	7372	7630	258
9	7887	8144	8400	8657	8913	9170	9426	9682	9938	$\bar{0}193$	256
170	230449	0704	0960	1215	1470	1724	1979	2234	2488	2742	255
1	2996	3250	3504	3757	4011	4264	4517	4770	5023	5276	253
2	5528	5781	6033	6285	6537	6789	7041	7292	7544	7795	252
3	8046	8297	8548	8799	9049	9299	9550	9800	$\bar{0}050$	$\bar{0}300$	250
4	240549	0799	1048	1297	1546	1795	2044	2293	2541	2790	249
5	3038	3286	3534	3782	4030	4277	4525	4772	5019	5266	248
6	5513	5759	6006	6252	6499	6745	6991	7237	7482	7728	246
7	7973	8219	8464	8709	8954	9198	9443	9687	9932	$\bar{0}176$	245
8	250420	0664	0908	1151	1395	1638	1881	2125	2368	2610	243
9	2853	3096	3338	3580	3822	4064	4306	4548	4790	5031	242
180	255273	5514	5755	5996	6237	6477	6718	6958	7198	7439	241
1	7679	7918	8158	8398	8637	8877	9116	9355	9594	9833	239
2	260071	0310	0548	0787	1025	1263	1501	1739	1976	2214	238
3	2451	2688	2925	3162	3399	3636	3873	4109	4346	4582	237
4	4818	5054	5290	5525	5761	5996	6232	6467	6702	6937	235
5	7172	7406	7641	7875	8110	8344	8578	8812	9046	9279	234
6	9513	9746	9980	$\bar{0}213$	$\bar{0}446$	$\bar{0}679$	$\bar{0}912$	$\bar{1}144$	$\bar{1}377$	$\bar{1}609$	233
7	271842	2074	2306	2538	2770	3001	3233	3464	3696	3927	232
8	4158	4389	4620	4850	5081	5311	5542	5772	6002	6232	230
9	6462	6692	6921	7151	7380	7609	7838	8067	8296	8525	229
190	278754	8982	9211	9439	9667	9895	$\bar{0}123$	$\bar{0}351$	$\bar{0}578$	$\bar{0}806$	228
1	281033	1261	1488	1715	1942	2169	2396	2622	2849	3075	227
2	3301	3527	3753	3979	4205	4431	4656	4882	5107	5332	226
3	5557	5782	6007	6232	6456	6681	6905	7130	7354	7578	225
4	7802	8026	8249	8473	8696	8920	9143	9366	9589	9812	223
5	290035	0257	0480	0702	0925	1147	1369	1591	1813	2034	222
6	2256	2478	2699	2920	3141	3363	3584	3804	4025	4246	221
7	4466	4687	4907	5127	5347	5567	5787	6007	6226	6446	220
8	6665	6884	7104	7323	7542	7761	7979	8198	8416	8635	219
9	8853	9071	9289	9507	9725	9943	$\bar{0}161$	$\bar{0}378$	$\bar{0}595$	$\bar{0}813$	218
No.	0	1	2	3	4	5	6	7	8	9	Diff.

No.	0	1	2	3	4	5	6	7	8	9	Diff.
200	301030	1247	1464	1681	1898	2114	2331	2547	2764	2980	217
1	3196	3412	3628	3844	4059	4275	4491	4706	4921	5136	216
2	5351	5566	5781	5996	6211	6425	6639	6854	7068	7282	215
3	7496	7710	7924	8137	8351	8564	8778	8991	9204	9417	213
4	9630	9843	$\bar{0}056$	$\bar{0}268$	$\bar{0}481$	$\bar{0}693$	$\bar{0}906$	$\bar{1}118$	$\bar{1}330$	$\bar{1}542$	212
5	311754	1966	2177	2389	2600	2812	3023	3234	3445	3656	211
6	3867	4078	4289	4499	4710	4920	5130	5340	5551	5760	210
7	5970	6180	6390	6599	6809	7018	7227	7436	7646	7854	209
8	8063	8272	8481	8689	8898	9106	9314	9522	9730	9938	208
9	320146	0354	0562	0769	0977	1184	1391	1598	1805	2012	207
210	322219	2426	2633	2839	3046	3252	3458	3665	3871	4077	206
1	4282	4488	4694	4899	5105	5310	5516	5721	5926	6131	205
2	6336	6541	6745	6950	7155	7359	7563	7767	7972	8176	204
3	8380	8583	8787	8991	9194	9398	9601	9805	$\bar{0}008$	$\bar{0}211$	203
4	330414	0617	0819	1022	1225	1427	1630	1832	2034	2236	202
5	2438	2640	2842	3044	3246	3447	3649	3850	4051	4253	202
6	4454	4655	4856	5057	5257	5458	5658	5859	6059	6260	201
7	6460	6660	6860	7060	7260	7459	7659	7858	8058	8257	200
8	8456	8656	8855	9054	9253	9451	9650	9849	$\bar{0}047$	$\bar{0}246$	199
9	340444	0642	0841	1039	1237	1435	1632	1830	2028	2225	198
220	342423	2620	2817	3014	3212	3409	3606	3802	3999	4196	197
1	4392	4589	4785	4981	5178	5374	5570	5766	5962	6157	196
2	6353	6549	6744	6939	7135	7330	7525	7720	7915	8110	195
3	8305	8500	8694	8889	9083	9278	9472	9666	9860	$\bar{0}054$	194
4	350248	0442	0636	0829	1023	1216	1410	1603	1796	1989	193
5	2183	2375	2568	2761	2954	3147	3339	3532	3724	3916	193
6	4108	4301	4493	4685	4876	5068	5260	5452	5643	5834	192
7	6026	6217	6408	6599	6790	6981	7172	7363	7554	7744	191
8	7935	8125	8316	8506	8696	8886	9076	9266	9456	9646	190
9	9835	$\bar{0}025$	$\bar{0}215$	$\bar{0}404$	$\bar{0}593$	$\bar{0}783$	$\bar{0}972$	$\bar{1}161$	$\bar{1}350$	$\bar{1}539$	189
230	361728	1917	2105	2294	2482	2671	2859	3048	3236	3424	188
1	3612	3800	3988	4176	4363	4551	4739	4926	5113	5301	188
2	5488	5675	5862	6049	6236	6423	6610	6796	6983	7169	187
3	7356	7542	7729	7915	8101	8287	8473	8659	8845	9030	186
4	9216	9401	9587	9772	9958	$\bar{0}143$	$\bar{0}328$	$\bar{0}513$	$\bar{0}698$	$\bar{0}883$	185
5	371068	1253	1437	1622	1806	1991	2175	2360	2544	2728	184
6	2912	3096	3280	3464	3647	3831	4015	4198	4382	4565	184
7	4748	4932	5115	5298	5481	5664	5846	6029	6212	6394	183
8	6577	6759	6942	7124	7306	7488	7670	7852	8034	8216	182
9	8398	8580	8761	8943	9124	9306	9487	9668	9849	$\bar{0}030$	181
240	380211	0392	0573	0754	0934	1115	1296	1476	1656	1837	181
1	2017	2197	2377	2557	2737	2917	3097	3277	3456	3636	180
2	3815	3995	4174	4353	4533	4712	4891	5070	5249	5428	179
3	5606	5785	5964	6142	6321	6499	6677	6856	7034	7212	178
4	7390	7568	7746	7923	8101	8279	8456	8634	8811	8989	178
5	9166	9343	9520	9698	9875	$\bar{0}051$	$\bar{0}228$	$\bar{0}405$	$\bar{0}582$	$\bar{0}759$	177
6	390935	1112	1288	1464	1641	1817	1993	2169	2345	2521	176
7	2697	2873	3048	3224	3400	3575	3751	3926	4101	4277	176
8	4452	4627	4802	4977	5152	5326	5501	5676	5850	6025	175
9	6199	6374	6548	6722	6896	7071	7245	7419	7592	7766	174
No.	0	1	2	3	4	5	6	7	8	9	Diff.

No.	0	1	2	3	4	5	6	7	8	9	Diff.
250	397940	8114	8287	8461	8634	8808	8981	9154	9328	9501	173
1	9674	9847	$\bar{0}$020	$\bar{0}$192	$\bar{0}$365	$\bar{0}$538	$\bar{0}$711	$\bar{0}$883	$\bar{1}$056	$\bar{1}$228	173
2	401401	1573	1745	1917	2089	2261	2433	2605	2777	2949	172
3	3121	3292	3464	3635	3807	3978	4149	4320	4492	4663	171
4	4834	5005	5176	5346	5517	5688	5858	6029	6199	6370	171
5	6540	6710	6881	7051	7221	7391	7561	7731	7901	8070	170
6	8240	8410	8579	8749	8918	9087	9257	9426	9595	9764	169
7	9933	$\bar{0}$102	$\bar{0}$271	$\bar{0}$440	$\bar{0}$609	$\bar{0}$777	$\bar{0}$946	$\bar{1}$114	$\bar{1}$283	$\bar{1}$451	169
8	411620	1788	1956	2124	2293	2461	2629	2796	2964	3132	168
9	3300	3467	3635	3803	3970	4137	4305	4472	4639	4806	167
260	414973	5140	5307	5474	5641	5808	5974	6141	6308	6474	167
1	6641	6807	6973	7139	7306	7472	7638	7804	7970	8135	166
2	8301	8467	8633	8798	8964	9129	9295	9460	9625	9791	165
3	9956	$\bar{0}$121	$\bar{0}$286	$\bar{0}$451	$\bar{0}$616	$\bar{0}$781	$\bar{0}$945	$\bar{1}$110	$\bar{1}$275	$\bar{1}$439	165
4	421604	1768	1933	2097	2261	2426	2590	2754	2918	3082	164
5	3246	3410	3574	3737	3901	4065	4228	4392	4555	4718	164
6	4882	5045	5208	5371	5534	5697	5860	6023	6186	6349	163
7	6511	6674	6836	6999	7161	7324	7486	7648	7811	7973	162
8	8135	8297	8459	8621	8783	8944	9106	9268	9429	9591	162
9	9752	9914	$\bar{0}$075	$\bar{0}$236	$\bar{0}$398	$\bar{0}$559	$\bar{0}$720	$\bar{0}$881	$\bar{1}$042	$\bar{1}$203	161
270	431364	1525	1685	1846	2007	2167	2328	2488	2649	2809	161
1	2969	3130	3290	3450	3610	3770	3930	4090	4249	4409	160
2	4569	4729	4888	5048	5207	5367	5526	5685	5844	6004	159
3	6163	6322	6481	6640	6799	6957	7116	7275	7433	7592	159
4	7751	7909	8067	8226	8384	8542	8701	8859	9017	9175	158
5	9333	9491	9648	9806	9964	$\bar{0}$122	$\bar{0}$279	$\bar{0}$437	$\bar{0}$594	$\bar{0}$752	158
6	440909	1066	1224	1381	1538	1695	1852	2009	2166	2323	157
7	2480	2637	2793	2950	3106	3263	3419	3576	3732	3889	157
8	4045	4201	4357	4513	4669	4825	4981	5137	5293	5449	156
9	5604	5760	5915	6071	6226	6382	6537	6692	6848	7003	155
280	447158	7313	7468	7623	7778	7933	8088	8242	8397	8552	155
1	8706	8861	9015	9170	9324	9478	9633	9787	9941	$\bar{0}$095	154
2	450249	0403	0557	0711	0865	1018	1172	1326	1479	1633	154
3	1786	1940	2093	2247	2400	2553	2706	2859	3012	3165	153
4	3318	3471	3624	3777	3930	4082	4235	4387	4540	4692	153
5	4845	4997	5150	5302	5454	5606	5758	5910	6062	6214	152
6	6366	6518	6670	6821	6973	7125	7276	7428	7579	7731	152
7	7882	8033	8184	8336	8487	8638	8789	8940	9091	9242	151
8	9392	9543	9694	9845	9995	$\bar{0}$146	$\bar{0}$296	$\bar{0}$447	$\bar{0}$597	$\bar{0}$748	151
9	460898	1048	1198	1348	1499	1649	1799	1948	2098	2248	150
290	462398	2548	2697	2847	2997	3146	3296	3445	3594	3744	150
1	3893	4042	4191	4340	4490	4639	4788	4936	5085	5234	149
2	5383	5532	5680	5829	5977	6126	6274	6423	6571	6719	149
3	6868	7016	7164	7312	7460	7608	7756	7904	8052	8200	148
4	8347	8495	8643	8790	8938	9085	9233	9380	9527	9675	148
5	9822	9969	$\bar{0}$116	$\bar{0}$263	$\bar{0}$410	$\bar{0}$557	$\bar{0}$704	$\bar{0}$851	$\bar{0}$998	$\bar{1}$145	147
6	471292	1438	1585	1732	1878	2025	2171	2318	2464	2610	146
7	2756	2903	3049	3195	3341	3487	3633	3779	3925	4071	146
8	4216	4362	4508	4653	4799	4944	5090	5235	5381	5526	146
9	5671	5816	5962	6107	6252	6397	6542	6687	6832	69,6	145
No.	0	1	2	3	4	5	6	7	8	9	Diff.

No.	0	1	2	3	4	5	6	7	8	9	Diff.
300	477121	7266	7411	7555	7700	7844	7989	8133	8278	8422	145
1	8566	8711	8855	8999	9143	9287	9431	9575	9719	9863	144
2	480007	0151	0294	0438	0582	0725	0869	1012	1156	1299	144
3	1443	1586	1729	1872	2016	2159	2302	2445	2588	2731	143
4	2874	3016	3159	3302	3445	3587	3730	3872	4015	4157	143
5	4300	4442	4585	4727	4869	5011	5153	5295	5437	5579	142
6	5721	5863	6005	6147	6289	6430	6572	6714	6855	6997	142
7	7138	7280	7421	7563	7704	7845	7986	8127	8269	8410	141
8	8551	8692	8833	8974	9114	9255	9396	9537	9677	9818	141
9	9958	$\bar{0}$099	$\bar{0}$239	$\bar{0}$380	$\bar{0}$520	$\bar{0}$661	$\bar{0}$801	$\bar{0}$941	$\bar{1}$081	$\bar{1}$222	140
310	491362	1502	1642	1782	1922	2062	2201	2341	2481	2621	140
1	2760	2900	3040	3179	3319	3458	3597	3737	3876	4015	139
2	4155	4294	4433	4572	4711	4850	4989	5128	5267	5406	139
3	5544	5683	5822	5960	6099	6238	6376	6515	6653	6791	139
4	6930	7068	7206	7344	7483	7621	7759	7897	8035	8173	138
5	8311	8448	8586	8724	8862	8999	9137	9275	9412	9550	138
6	9687	9824	9962	$\bar{0}$099	$\bar{0}$236	$\bar{0}$374	$\bar{0}$511	$\bar{0}$648	$\bar{0}$785	$\bar{0}$922	137
7	501059	1196	1333	1470	1607	1744	1880	2017	2154	2291	137
8	2427	2564	2700	2837	2973	3109	3246	3382	3518	3655	136
9	3791	3927	4063	4199	4335	4471	4607	4743	4878	5014	136
320	505150	5286	5421	5557	5693	5828	5964	6099	6234	6370	136
1	6505	6640	6776	6911	7046	7181	7316	7451	7586	7721	135
2	7856	7991	8126	8260	8395	8530	8664	8799	8934	9068	135
3	9203	9337	9471	9606	9740	9874	$\bar{0}$009	$\bar{0}$143	$\bar{0}$277	$\bar{0}$411	134
4	510545	0679	0813	0947	1081	1215	1349	1482	1616	1750	134
5	1883	2017	2151	2284	2418	2551	2684	2818	2951	3084	133
6	3218	3351	3484	3617	3750	3883	4016	4149	4282	4415	133
7	4548	4681	4813	4946	5079	5211	5344	5476	5609	5741	133
8	5874	6006	6139	6271	6403	6535	6668	6800	6932	7064	132
9	7196	7328	7460	7592	7724	7855	7987	8119	8251	8382	132
330	518514	8646	8777	8909	9040	9171	9303	9434	9566	9697	131
1	9828	9959	$\bar{0}$090	$\bar{0}$221	$\bar{0}$353	$\bar{0}$484	$\bar{0}$615	$\bar{0}$745	$\bar{0}$876	$\bar{1}$007	131
2	521138	1269	1400	1530	1661	1792	1922	2053	2183	2314	131
3	2444	2575	2705	2835	2966	3096	3226	3356	3486	3616	130
4	3746	3876	4006	4136	4266	4396	4526	4656	4785	4915	130
5	5045	5174	5304	5434	5563	5693	5822	5951	6081	6210	129
6	6339	6469	6598	6727	6856	6985	7114	7243	7372	7501	129
7	7630	7759	7888	8016	8145	8274	8402	8531	8660	8788	129
8	8917	9045	9174	9302	9430	9559	9687	9815	9943	$\bar{0}$072	128
9	530200	0328	0456	0584	0712	0840	0968	1096	1223	1351	128
340	531479	1607	1734	1862	1990	2117	2245	2372	2500	2627	128
1	2754	2882	3009	3136	3264	3391	3518	3645	3772	3899	127
2	4026	4153	4280	4407	4534	4661	4787	4914	5041	5167	127
3	5294	5421	5547	5674	5800	5927	6053	6180	6306	6432	126
4	6558	6685	6811	6937	7063	7189	7315	7441	7567	7693	126
5	7819	7945	8071	8197	8322	8448	8574	8699	8825	8951	126
6	9076	9202	9327	9452	9578	9703	9829	9954	$\bar{0}$079	$\bar{0}$204	125
7	540329	0455	0580	0705	0830	0955	1080	1205	1330	1454	125
8	1579	1704	1829	1953	2078	2203	2327	2452	2576	2701	125
9	2825	2950	3074	3199	3323	3447	3571	3696	3820	3944	124
No.	0	1	2	3	4	5	6	7	8	9	Diff.

No.	0	1	2	3	4	5	6	7	8	9	Diff.
350	544068	4192	4316	4440	4564	4688	4812	4936	5060	5183	124
1	5307	5431	5555	5678	5802	5925	6049	6172	6296	6419	124
2	6543	6666	6789	6913	7036	7159	7282	7405	7529	7652	123
3	7775	7898	8021	8144	8267	8389	8512	8635	8758	8881	123
4	9003	9126	9249	9371	9494	9616	9739	9861	9984	$\bar{0}106$	123
5	550228	0351	0473	0595	0717	0840	0962	1084	1206	1328	122
6	1450	1572	1694	1816	1938	2060	2181	2303	2425	2547	122
7	2668	2790	2911	3033	3155	3276	3398	3519	3640	3762	121
8	3883	4004	4126	4247	4368	4489	4610	4731	4852	4973	121
9	5094	5215	5336	5457	5578	5699	5820	5940	6061	6182	121
360	556303	6423	6544	6664	6785	6905	7026	7146	7267	7387	120
1	7507	7627	7748	7868	7988	8108	8228	8349	8469	8589	120
2	8709	8829	8948	9068	9188	9308	9428	9548	9667	9787	120
3	9907	$\bar{0}026$	$\bar{0}146$	$\bar{0}265$	$\bar{0}385$	$\bar{0}504$	$\bar{0}624$	$\bar{0}743$	$\bar{0}863$	$\bar{0}982$	119
4	561101	1221	1340	1459	1578	1698	1817	1936	2055	2174	119
5	2293	2412	2531	2650	2769	2887	3006	3125	3244	3362	119
6	3481	3600	3718	3837	3955	4074	4192	4311	4429	4548	119
7	4666	4784	4903	5021	5139	5257	5376	5494	5612	5730	118
8	5848	5966	6084	6202	6320	6437	6555	6673	6791	6909	118
9	7026	7144	7262	7379	7497	7614	7732	7849	7967	8084	118
370	568202	8319	8436	8554	8671	8788	8905	9023	9140	9257	117
1	9374	9491	9608	9725	9842	9959	$\bar{0}076$	$\bar{0}193$	$\bar{0}309$	$\bar{0}426$	117
2	570543	0660	0776	0893	1010	1126	1243	1359	1476	1592	117
3	1709	1825	1942	2058	2174	2291	2407	2523	2639	2755	116
4	2872	2988	3104	3220	3336	3452	3568	3684	3800	3915	116
5	4031	4147	4263	4379	4494	4610	4726	4841	4957	5072	116
6	5188	5303	5419	5534	5650	5765	5880	5996	6111	6226	115
7	6341	6457	6572	6687	6802	6917	7032	7147	7262	7377	115
8	7492	7607	7722	7836	7951	8066	8181	8295	8410	8525	115
9	8639	8754	8868	8983	9097	9212	9326	9441	9555	9669	114
380	579784	9898	$\bar{0}012$	$\bar{0}126$	$\bar{0}241$	$\bar{0}355$	$\bar{0}469$	$\bar{0}583$	$\bar{0}697$	$\bar{0}811$	114
1	580925	1039	1153	1267	1381	1495	1608	1722	1836	1950	114
2	2063	2177	2291	2404	2518	2631	2745	2858	2972	3085	114
3	3199	3312	3426	3539	3652	3765	3879	3992	4105	4218	113
4	4331	4444	4557	4670	4783	4896	5009	5122	5235	5348	113
5	5461	5574	5686	5799	5912	6024	6137	6250	6362	6475	113
6	6587	6700	6812	6925	7037	7149	7262	7374	7486	7599	112
7	7711	7823	7935	8047	8160	8272	8384	8496	8608	8720	112
8	8832	8944	9056	9167	9279	9391	9503	9615	9726	9838	112
9	9950	$\bar{0}061$	$\bar{0}173$	$\bar{0}284$	$\bar{0}396$	$\bar{0}507$	$\bar{0}619$	$\bar{0}730$	$\bar{0}842$	$\bar{0}953$	112
390	591065	1176	1287	1399	1510	1621	1732	1843	1955	2066	111
1	2177	2288	2399	2510	2621	2732	2843	2954	3064	3175	111
2	3286	3397	3508	3618	3729	3840	3950	4061	4171	4282	111
3	4393	4503	4614	4724	4834	4945	5055	5165	5276	5386	110
4	5496	5606	5717	5827	5937	6047	6157	6267	6377	6487	110
5	6597	6707	6817	6927	7037	7146	7256	7366	7476	7586	110
6	7695	7805	7914	8024	8134	8243	8353	8462	8572	8681	110
7	8791	8900	9009	9119	9228	9337	9446	9556	9665	9774	109
8	9883	9992	$\bar{0}101$	$\bar{0}210$	$\bar{0}319$	$\bar{0}428$	$\bar{0}537$	$\bar{0}646$	$\bar{0}755$	$\bar{0}864$	109
9	600973	1082	1191	1299	1408	1517	1625	1734	1843	1951	109
No.	0	1	2	3	4	5	6	7	8	9	Diff.

No.	0	1	2	3	4	5	6	7	8	9	Diff.
400	602060	2169	2277	2386	2494	2603	2711	2819	2928	3036	108
1	3144	3253	3361	3469	3577	3686	3794	3902	4010	4118	108
2	4226	4334	4442	4550	4658	4766	4874	4982	5089	5197	108
3	5305	5413	5521	5628	5736	5844	5951	6059	6166	6274	108
4	6381	6489	6596	6704	6811	6919	7026	7133	7241	7348	107
5	7455	7562	7669	7777	7884	7991	8098	8205	8312	8419	107
6	8526	8633	8740	8847	8954	9061	9167	9274	9381	9488	107
7	9594	9701	9808	9914	0̄021	0̄128	0̄234	0̄341	0̄447	0̄554	107
8	610660	0767	0873	0979	1086	1192	1298	1405	1511	1617	106
9	1723	1829	1936	2042	2148	2254	2360	2466	2572	2678	106
410	612784	2890	2996	3102	3207	3313	3419	3525	3630	3736	106
1	3842	3947	4053	4159	4264	4370	4475	4581	4686	4792	106
2	4897	5003	5108	5213	5319	5424	5529	5634	5740	5845	105
3	5950	6055	6160	6265	6370	6476	6581	6686	6790	6895	105
4	7000	7105	7210	7315	7420	7525	7629	7734	7839	7943	105
5	8048	8153	8257	8362	8466	8571	8676	8780	8884	8989	105
6	9093	9198	9302	9406	9511	9615	9719	9824	9928	0̄032	104
7	620136	0240	0344	0448	0552	0656	0760	0864	0968	1072	104
8	1176	1280	1384	1488	1592	1695	1799	1903	2007	2110	104
9	2214	2318	2421	2525	2628	2732	2835	2939	3042	3146	104
420	623249	3353	3456	3559	3663	3766	3869	3973	4076	4179	103
1	4282	4385	4488	4591	4695	4798	4901	5004	5107	5210	103
2	5312	5415	5518	5621	5724	5827	5929	6032	6135	6238	103
3	6340	6443	6546	6648	6751	6853	6956	7058	7161	7263	103
4	7366	7468	7571	7673	7775	7878	7980	8082	8185	8287	102
5	8389	8491	8593	8695	8797	8900	9002	9104	9206	9308	102
6	9410	9512	9613	9715	9817	9919	0̄021	0̄123	0̄224	0̄326	102
7	630428	0530	0631	0733	0835	0936	1038	1139	1241	1342	102
8	1444	1545	1647	1748	1849	1951	2052	2153	2255	2356	101
9	2457	2559	2660	2761	2862	2963	3064	3165	3266	3367	101
430	633468	3569	3670	3771	3872	3973	4074	4175	4276	4376	101
1	4477	4578	4679	4779	4880	4981	5081	5182	5283	5383	101
2	5484	5584	5685	5785	5886	5986	6087	6187	6287	6388	100
3	6488	6588	6688	6789	6889	6989	7089	7189	7290	7390	100
4	7490	7590	7690	7790	7890	7990	8090	8190	8290	8389	100
5	8489	8589	8689	8789	8888	8988	9088	9188	9287	9387	100
6	9486	9586	9686	9785	9885	9984	0̄084	0̄183	0̄283	0̄382	99
7	640481	0581	0680	0779	0879	0978	1077	1177	1276	1375	99
8	1474	1573	1672	1771	1871	1970	2069	2168	2267	2366	99
9	2465	2563	2662	2761	2860	2959	3058	3156	3255	3354	99
440	643453	3551	3650	3749	3847	3946	4044	4143	4242	4340	98
1	4439	4537	4636	4734	4832	4931	5029	5127	5226	5324	98
2	5422	5521	5619	5717	5815	5913	6011	6110	6208	6306	98
3	6404	6502	6600	6698	6796	6894	6992	7089	7187	7285	98
4	7383	7481	7579	7676	7774	7872	7969	8067	8165	8262	98
5	8360	8458	8555	8653	8750	8848	8945	9043	9140	9237	97
6	9335	9432	9530	9627	9724	9821	9919	0̄016	0̄113	0̄210	97
7	650308	0405	0502	0599	0696	0793	0890	0987	1084	1181	97
8	1278	1375	1472	1569	1666	1762	1859	1956	2053	2150	97
9	2246	2343	2440	2536	2633	2730	2826	2923	3019	3116	97
No.	0	1	2	3	4	5	6	7	8	9	Diff.

No.	0	1	2	3	4	5	6	7	8	9	Diff.
450	653213	3309	3405	3502	3598	3695	3791	3888	3984	4080	96
1	4177	4273	4369	4465	4562	4658	4754	4850	4946	5042	96
2	5138	5235	5331	5427	5523	5619	5715	5810	5906	6002	96
3	6098	6194	6290	6386	6482	6577	6673	6769	6864	6960	96
4	7056	7152	7247	7343	7438	7534	7629	7725	7820	7916	96
5	8011	8107	8202	8298	8393	8488	8584	8679	8774	8870	95
6	8965	9060	9155	9250	9346	9441	9536	9631	9726	9821	95
7	9916	$\bar{0}$011	$\bar{0}$106	$\bar{0}$201	$\bar{0}$296	$\bar{0}$391	$\bar{0}$486	$\bar{0}$581	$\bar{0}$676	$\bar{0}$771	95
8	660865	0960	1055	1150	1245	1339	1434	1529	1623	1718	95
9	1813	1907	2002	2096	2191	2286	2380	2475	2569	2663	95
460	662758	2852	2947	3041	3135	3230	3324	3418	3512	3607	94
1	3701	3795	3889	3983	4078	4172	4266	4360	4454	4548	94
2	4642	4736	4830	4924	5018	5112	5206	5299	5393	5487	94
3	5581	5675	5769	5862	5956	6050	6143	6237	6331	6424	94
4	6518	6612	6705	6799	6892	6986	7079	7173	7266	7360	94
5	7453	7546	7640	7733	7826	7920	8013	8106	8199	8293	93
6	8386	8479	8572	8665	8759	8852	8945	9038	9131	9224	93
7	9317	9410	9503	9596	9689	9782	9875	9967	$\bar{0}$060	$\bar{0}$153	93
8	670246	0339	0431	0524	0617	0710	0802	0895	0988	1080	93
9	1173	1265	1358	1451	1543	1636	1728	1821	1913	2005	93
470	672098	2190	2283	2375	2467	2560	2652	2744	2836	2929	92
1	3021	3113	3205	3297	3390	3482	3574	3666	3758	3850	92
2	3942	4034	4126	4218	4310	4402	4494	4586	4677	4769	92
3	4861	4953	5045	5137	5228	5320	5412	5503	5595	5687	92
4	5778	5870	5962	6053	6145	6236	6328	6419	6511	6602	92
5	6694	6785	6876	6968	7059	7151	7242	7333	7424	7516	91
6	7607	7698	7789	7881	7972	8063	8154	8245	8336	8427	91
7	8518	8609	8700	8791	8882	8973	9064	9155	9246	9337	91
8	9428	9519	9610	9700	9791	9882	9973	$\bar{0}$063	$\bar{0}$154	$\bar{0}$245	91
9	680336	0426	0517	0607	0698	0789	0879	0970	1060	1151	91
480	681241	1332	1422	1513	1603	1693	1784	1874	1964	2055	90
1	2145	2235	2326	2416	2506	2596	2686	2777	2867	2957	90
2	3047	3137	3227	3317	3407	3497	3587	3677	3767	3857	90
3	3947	4037	4127	4217	4307	4396	4486	4576	4666	4756	90
4	4845	4935	5025	5114	5204	5294	5383	5473	5563	5652	90
5	5742	5831	5921	6010	6100	6189	6279	6368	6458	6547	89
6	6636	6726	6815	6904	6994	7083	7172	7261	7351	7440	89
7	7529	7618	7707	7796	7886	7975	8064	8153	8242	8331	89
8	8420	8509	8598	8687	8776	8865	8953	9042	9131	9220	89
9	9309	9398	9486	9575	9664	9753	9841	9930	$\bar{0}$019	$\bar{0}$107	89
490	690196	0285	0373	0462	0550	0639	0728	0816	0905	0993	89
1	1081	1170	1258	1347	1435	1524	1612	1700	1789	1877	88
2	1965	2053	2142	2230	2318	2406	2494	2583	2671	2759	88
3	2847	2935	3023	3111	3199	3287	3375	3463	3551	3639	88
4	3727	3815	3903	3991	4078	4166	4254	4342	4430	4517	88
5	4605	4693	4781	4868	4956	5044	5131	5219	5307	5394	88
6	5482	5569	5657	5744	5832	5919	6007	6094	6182	6269	87
7	6356	6444	6531	6618	6706	6793	6880	6968	7055	7142	87
8	7229	7317	7404	7491	7578	7665	7752	7839	7926	8014	87
9	8101	8188	8275	8362	8449	8535	8622	8709	8796	8883	87
No.	0	1	2	3	4	5	6	7	8	9	Diff.

No.	0	1	2	3	4	5	6	7	8	9	Diff.
500	698970	9057	9144	9231	9317	9404	9491	9578	9664	9751	87
1	9838	9924	$\bar{0}$011	$\bar{0}$098	$\bar{0}$184	$\bar{0}$271	$\bar{0}$358	$\bar{0}$444	$\bar{0}$531	$\bar{0}$617	87
2	700704	0790	0877	0963	1050	1136	1222	1309	1395	1482	86
3	1568	1654	1741	1827	1913	1999	2086	2172	2258	2344	86
4	2431	2517	2603	2689	2775	2861	2947	3033	3119	3205	86
5	3291	3377	3463	3549	3635	3721	3807	3893	3979	4065	86
6	4151	4236	4322	4408	4494	4579	4665	4751	4837	4922	86
7	5008	5094	5179	5265	5350	5436	5522	5607	5693	5778	86
8	5864	5949	6035	6120	6206	6291	6376	6462	6547	6632	85
9	6718	6803	6888	6974	7059	7144	7229	7315	7400	7485	85
510	707570	7655	7740	7826	7911	7996	8081	8166	8251	8336	85
1	8421	8506	8591	8676	8761	8846	8931	9015	9100	9185	85
2	9270	9355	9440	9524	9609	9694	9779	9863	9948	$\bar{0}$033	85
3	710117	0202	0287	0371	0456	0540	0625	0710	0794	0879	85
4	0963	1048	1132	1217	1301	1385	1470	1554	1639	1723	84
5	1807	1892	1976	2060	2144	2229	2313	2397	2481	2566	84
6	2650	2734	2818	2902	2986	3070	3154	3238	3323	3407	84
7	3491	3575	3659	3742	3826	3910	3994	4078	4162	4246	84
8	4330	4414	4497	4581	4665	4749	4833	4916	5000	5084	84
9	5167	5251	5335	5418	5502	5586	5669	5753	5836	5920	84
520	716003	6087	6170	6254	6337	6421	6504	6588	6671	6754	83
1	6838	6921	7004	7088	7171	7254	7338	7421	7504	7587	83
2	7671	7754	7837	7920	8003	8086	8169	8253	8336	8419	83
3	8502	8585	8668	8751	8834	8917	9000	9083	9165	9248	83
4	9331	9414	9497	9580	9663	9745	9828	9911	9994	$\bar{0}$077	83
5	720159	0242	0325	0407	0490	0573	0655	0738	0821	0003	83
6	0986	1068	1151	1233	1316	1398	1481	1563	1646	1728	82
7	1811	1893	1975	2058	2140	2222	2305	2387	2469	2552	82
8	2634	2716	2798	2881	2963	3045	3127	3209	3291	3374	82
9	3456	3538	3620	3702	3784	3866	3948	4030	4112	4194	82
530	724276	4358	4440	4522	4604	4685	4767	4849	4931	5013	82
1	5095	5176	5258	5340	5422	5503	5585	5667	5748	5830	82
2	5912	5993	6075	6156	6238	6320	6401	6483	6564	6646	82
3	6727	6809	6890	6972	7053	7134	7216	7297	7379	7460	81
4	7541	7623	7704	7785	7866	7948	8029	8110	8191	8273	81
5	8354	8435	8516	8597	8678	8759	8841	8922	9003	9084	81
6	9165	9246	9327	9408	9489	9570	9651	9732	9813	9893	81
7	9974	$\bar{0}$055	$\bar{0}$136	$\bar{0}$217	$\bar{0}$298	$\bar{0}$378	$\bar{0}$459	$\bar{0}$540	$\bar{0}$621	$\bar{0}$702	81
8	730782	0863	0944	1024	1105	1186	1266	1347	1428	1508	81
9	1589	1669	1750	1830	1911	1991	2072	2152	2233	2313	81
540	732394	2474	2555	2635	2715	2796	2876	2956	3037	3117	80
1	3197	3278	3358	3438	3518	3598	3679	3759	3839	3919	80
2	3999	4079	4160	4240	4320	4400	4480	4560	4640	4720	80
3	4800	4880	4960	5040	5120	5200	5279	5359	5439	5519	80
4	5599	5679	5759	5838	5918	5998	6078	6157	6237	6317	80
5	6397	6476	6556	6635	6715	6795	6874	6954	7034	7113	80
6	7193	7272	7352	7431	7511	7590	7670	7749	7829	7908	79
7	7987	8067	8146	8225	8305	8384	8463	8543	8622	8701	79
8	8781	8860	8939	9018	9097	9177	9256	9335	9414	9493	79
9	9572	9651	9731	9810	9889	9968	$\bar{0}$047	$\bar{0}$126	$\bar{0}$205	$\bar{0}$284	79
No.	0	1	2	3	4	5	6	7	8	9	Diff.

No.	0	1	2	3	4	5	6	7	8	9	Diff.
550	740363	0442	0521	0600	0678	0757	0836	0915	0994	1073	79
1	1152	1230	1309	1388	1467	1546	1624	1703	1782	1860	79
2	1939	2018	2096	2175	2254	2332	2411	2489	2568	2647	79
3	2725	2804	2882	2961	3039	3118	3196	3275	3353	3431	78
4	3510	3588	3667	3745	3823	3902	3980	4058	4136	4215	78
5	4293	4371	4449	4528	4606	4684	4762	4840	4919	4997	78
6	5075	5153	5231	5309	5387	5465	5543	5621	5699	5777	78
7	5855	5933	6011	6089	6167	6245	6323	6401	6479	6556	78
8	6634	6712	6790	6868	6945	7023	7101	7179	7256	7334	78
9	7412	7489	7567	7645	7722	7800	7878	7955	8033	8110	78
560	748188	8266	8343	8421	8498	8576	8653	8731	8808	8885	77
1	8963	9040	9118	9195	9272	9350	9427	9504	9582	9659	77
2	9736	9814	9891	9968	0045	0123	0200	0277	0354	0431	77
3	750508	0586	0663	0740	0817	0894	0971	1048	1125	1202	77
4	1279	1356	1433	1510	1587	1664	1741	1818	1895	1972	77
5	2048	2125	2202	2279	2356	2433	2509	2586	2663	2740	77
6	2816	2893	2970	3047	3123	3200	3277	3353	3430	3506	77
7	3583	3660	3736	3813	3889	3966	4042	4119	4195	4272	77
8	4348	4425	4501	4578	4654	4730	4807	4883	4960	5036	76
9	5112	5189	5265	5341	5417	5494	5570	5646	5722	5799	76
570	755875	5951	6027	6103	6180	6256	6332	6408	6484	6560	76
1	6636	6712	6788	6864	6940	7016	7092	7168	7244	7320	76
2	7396	7472	7548	7624	7700	7775	7851	7927	8003	8079	76
3	8155	8230	8306	8382	8458	8533	8609	8685	8761	8836	76
4	8912	8988	9063	9139	9214	9290	9366	9441	9517	9592	76
5	9668	9743	9819	9894	9970	0045	0121	0196	0272	0347	75
6	760422	0498	0573	0649	0724	0799	0875	0950	1025	1101	75
7	1176	1251	1326	1402	1477	1552	1627	1702	1778	1853	75
8	1928	2003	2078	2153	2228	2303	2378	2453	2529	2604	75
9	2679	2754	2829	2904	2978	3053	3128	3203	3278	3353	75
580	763428	3503	3578	3653	3727	3802	3877	3952	4027	4101	75
1	4176	4251	4326	4400	4475	4550	4624	4699	4774	4848	75
2	4923	4998	5072	5147	5221	5296	5370	5445	5520	5594	75
3	5669	5743	5818	5892	5966	6041	6115	6190	6264	6338	74
4	6413	6487	6562	6636	6710	6785	6859	6933	7007	7082	74
5	7156	7230	7304	7379	7453	7527	7601	7675	7749	7823	74
6	7898	7972	8046	8120	8194	8268	8342	8416	8490	8564	74
7	8638	8712	8786	8860	8934	9008	9082	9156	9230	9303	74
8	9377	9451	9525	9599	9673	9746	9820	9894	9968	0042	74
9	770115	0189	0263	0336	0410	0484	0557	0631	0705	0778	74
590	770852	0926	0999	1073	1146	1220	1293	1367	1440	1514	74
1	1587	1661	1734	1808	1881	1955	2028	2102	2175	2248	73
2	2322	2395	2468	2542	2615	2688	2762	2835	2908	2981	73
3	3055	3128	3201	3274	3348	3421	3494	3567	3640	3713	73
4	3786	3860	3933	4006	4079	4152	4225	4298	4371	4444	73
5	4517	4590	4663	4736	4809	4882	4955	5028	5100	5173	73
6	5246	5319	5392	5465	5538	5610	5683	5756	5829	5902	73
7	5974	6047	6120	6193	6265	6338	6411	6483	6556	6629	73
8	6701	6774	6846	6919	6992	7064	7137	7209	7282	7354	73
9	7427	7499	7572	7644	7717	7789	7862	7934	8006	8079	72
No.	0	1	2	3	4	5	6	7	8	9	Diff.

No.	0	1	2	3	4	5	6	7	8	9	Diff.
600	778151	8224	8296	8368	8441	8513	8585	8658	8730	8802	72
1	8874	8947	9019	9091	9163	9236	9308	9380	9452	9524	72
2	9596	9669	9741	9813	9885	9957	0̄029	0̄101	0̄173	0̄245	72
3	780317	0389	0461	0533	0605	0677	0749	0821	0893	0965	72
4	1037	1109	1181	1253	1324	1396	1468	1540	1612	1684	72
5	1755	1827	1899	1971	2042	2114	2186	2258	2329	2401	72
6	2473	2544	2616	2688	2759	2831	2902	2974	3046	3117	72
7	3189	3260	3332	3403	3475	3546	3618	3689	3761	3832	71
8	3904	3975	4046	4118	4189	4261	4332	4403	4475	4546	71
9	4617	4689	4760	4831	4902	4974	5045	5116	5187	5259	71
610	785330	5401	5472	5543	5615	5686	5757	5828	5899	5970	71
1	6041	6112	6183	6254	6325	6396	6467	6538	6609	6680	71
2	6751	6822	6893	6964	7035	7106	7177	7248	7319	7390	71
3	7460	7531	7602	7673	7744	7815	7885	7956	8027	8098	71
4	8168	8239	8310	8381	8451	8522	8593	8663	8734	8804	71
5	8875	8946	9016	9087	9157	9228	9299	9369	9440	9510	71
6	9581	9651	9722	9792	9863	9933	0̄004	0̄074	0̄144	0̄215	70
7	790285	0356	0426	0496	0567	0637	0707	0778	0848	0918	70
8	0988	1059	1129	1199	1269	1340	1410	1480	1550	1620	70
9	1691	1761	1831	1901	1971	2041	2111	2181	2252	2322	70
620	792392	2462	2532	2602	2672	2742	2812	2882	2952	3022	70
1	3092	3162	3231	3301	3371	3441	3511	3581	3651	3721	70
2	3790	3860	3930	4000	4070	4139	4209	4279	4349	4418	70
3	4488	4558	4627	4697	4767	4836	4906	4976	5045	5115	70
4	5185	5254	5324	5393	5463	5532	5602	5672	5741	5811	70
5	5880	5949	6019	6088	6158	6227	6297	6366	6436	6505	69
6	6574	6644	6713	6782	6852	6921	6990	7060	7129	7198	69
7	7268	7337	7406	7475	7545	7614	7683	7752	7821	7890	69
8	7960	8029	8098	8167	8236	8305	8374	8443	8513	8582	69
9	8651	8720	8789	8858	8927	8996	9065	9134	9203	9272	69
630	799341	9409	9478	9547	9616	9685	9754	9823	9892	9961	69
1	800029	0098	0167	0236	0305	0373	0442	0511	0580	0648	69
2	0717	0786	0854	0923	0992	1061	1129	1198	1266	1335	69
3	1404	1472	1541	1609	1678	1747	1815	1884	1952	2021	69
4	2089	2158	2226	2295	2363	2432	2500	2568	2637	2705	68
5	2774	2842	2910	2979	3047	3116	3184	3252	3321	3389	68
6	3457	3525	3594	3662	3730	3798	3867	3935	4003	4071	68
7	4139	4208	4276	4344	4412	4480	4548	4616	4685	4753	68
8	4821	4889	4957	5025	5093	5161	5229	5297	5365	5433	68
9	5501	5569	5637	5705	5773	5841	5908	5976	6044	6112	68
640	806180	6248	6316	6384	6451	6519	6587	6655	6723	6790	68
1	6858	6926	6994	7061	7129	7197	7264	7332	7400	7467	68
2	7535	7603	7670	7738	7806	7873	7941	8008	8076	8143	68
3	8211	8279	8346	8414	8481	8549	8616	8684	8751	8818	67
4	8886	8953	9021	9088	9156	9223	9290	9358	9425	9492	67
5	9560	9627	9694	9762	9829	9896	9964	0̄031	0̄098	0̄165	67
6	810233	0300	0367	0434	0501	0569	0636	0703	0770	0837	67
7	0904	0971	1039	1106	1173	1240	1307	1374	1441	1508	67
8	1575	1642	1709	1776	1843	1910	1977	2044	2111	2178	67
9	2245	2312	2379	2445	2512	2579	2646	2713	2780	2847	67
No.	0	1	2	3	4	5	6	7	8	9	Diff.

No.	0	1	2	3	4	5	6	7	8	9	Diff.
650	812913	2980	3047	3114	3181	3247	3314	3381	3448	3514	67
1	3581	3648	3714	3781	3848	3914	3981	4048	4114	4181	67
2	4248	4314	4381	4447	4514	4581	4647	4714	4780	4847	67
3	4913	4980	5046	5113	5179	5246	5312	5378	5445	5511	66
4	5578	5644	5711	5777	5843	5910	5976	6042	6109	6175	66
5	6241	6308	6374	6440	6506	6573	6639	6705	6771	6838	66
6	6904	6970	7036	7102	7169	7235	7301	7367	7433	7499	66
7	7565	7631	7698	7764	7830	7896	7962	8028	8094	8160	66
8	8226	8292	8358	8424	8490	8556	8622	8688	8754	8820	66
9	8885	8951	9017	9083	9149	9215	9281	9346	9412	9478	66
660	819544	9610	9676	9741	9807	9873	9939	0̄004	0̄070	0̄136	66
1	820201	0267	0333	0399	0464	0530	0595	0661	0727	0792	66
2	0858	0924	0989	1055	1120	1186	1251	1317	1382	1448	66
3	1514	1579	1645	1710	1775	1841	1906	1972	2037	2103	65
4	2168	2233	2299	2364	2430	2495	2560	2626	2691	2756	65
5	2822	2887	2952	3018	3083	3148	3213	3279	3344	3409	65
6	3474	3539	3605	3670	3735	3800	3865	3930	3996	4061	65
7	4126	4191	4256	4321	4386	4451	4516	4581	4646	4711	65
8	4776	4841	4906	4971	5036	5101	5166	5231	5296	5361	65
9	5426	5491	5556	5621	5686	5751	5815	5880	5945	6010	65
670	826075	6140	6204	6269	6334	6399	6464	6528	6593	6658	65
1	6723	6787	6852	6917	6981	7046	7111	7175	7240	7305	65
2	7369	7434	7499	7563	7628	7692	7757	7821	7886	7951	65
3	8015	8080	8144	8209	8273	8338	8402	8467	8531	8595	64
4	8660	8724	8789	8853	8918	8982	9046	9111	9175	9239	64
5	9304	9368	9432	9497	9561	9625	9690	9754	9818	9882	64
6	9947	0̄011	0̄075	0̄139	0̄204	0̄268	0̄332	0̄396	0̄460	0̄525	64
7	830589	0653	0717	0781	0845	0909	0973	1037	1102	1166	64
8	1230	1294	1358	1422	1486	1550	1614	1678	1742	1806	64
9	1870	1934	1998	2062	2126	2189	2253	2317	2381	2445	64
680	832509	2573	2637	2700	2764	2828	2892	2956	3020	3083	64
1	3147	3211	3275	3338	3402	3466	3530	3593	3657	3721	64
2	3784	3848	3912	3975	4039	4103	4166	4230	4294	4357	64
3	4421	4484	4548	4611	4675	4739	4802	4866	4929	4993	64
4	5056	5120	5183	5247	5310	5373	5437	5500	5564	5627	63
5	5691	5754	5817	5881	5944	6007	6071	6134	6197	6261	63
6	6324	6387	6451	6514	6577	6641	6704	6767	6830	6894	63
7	6957	7020	7083	7146	7210	7273	7336	7399	7462	7525	63
8	7588	7652	7715	7778	7841	7904	7967	8030	8093	8156	63
9	8219	8282	8345	8408	8471	8534	8597	8660	8723	8786	63
690	838849	8912	8975	9038	9101	9164	9227	9289	9352	9415	63
1	9478	9541	9604	9667	9729	9792	9855	9918	9981	0̄043	63
2	840106	0169	0232	0294	0357	0420	0482	0545	0608	0671	63
3	0733	0796	0859	0921	0984	1046	1109	1172	1234	1297	63
4	1359	1422	1485	1547	1610	1672	1735	1797	1860	1922	63
5	1985	2047	2110	2172	2235	2297	2360	2422	2484	2547	62
6	2609	2672	2734	2796	2859	2921	2983	3046	3108	3170	62
7	3233	3295	3357	3420	3482	3544	3606	3669	3731	3793	62
8	3855	3918	3980	4042	4104	4166	4229	4291	4353	4415	62
9	4477	4539	4601	4664	4726	4788	4850	4912	4974	5036	62
No.	0	1	2	3	4	5	6	7	8	9	Diff.

No.	0	1	2	3	4	5	6	7	8	9	Diff.
700	845098	5160	5222	5284	5346	5408	5470	5532	5594	5656	62
1	5718	5780	5842	5904	5966	6028	6090	6151	6213	6275	62
2	6337	6399	6461	6523	6585	6646	6708	6770	6832	6894	62
3	6955	7017	7079	7141	7202	7264	7326	7388	7449	7511	62
4	7573	7634	7696	7758	7819	7881	7943	8004	8066	8128	62
5	8189	8251	8312	8374	8435	8497	8559	8620	8682	8743	62
6	8805	8866	8928	8989	9051	9112	9174	9235	9297	9358	61
7	9419	9481	9542	9604	9665	9726	9788	9849	9911	9972	61
8	850033	0095	0156	0217	0279	0340	0401	0462	0524	0585	61
9	0646	0707	0769	0830	0891	0952	1014	1075	1136	1197	61
710	851258	1320	1381	1442	1503	1564	1625	1686	1747	1809	61
1	1870	1931	1992	2053	2114	2175	2236	2297	2358	2419	61
2	2480	2541	2602	2663	2724	2785	2846	2907	2968	3029	61
3	3090	3150	3211	3272	3333	3394	3455	3516	3577	3637	61
4	3698	3759	3820	3881	3941	4002	4063	4124	4185	4245	61
5	4306	4367	4428	4488	4549	4610	4670	4731	4792	4852	61
6	4913	4974	5034	5095	5156	5216	5277	5337	5398	5459	61
7	5519	5580	5640	5701	5761	5822	5882	5943	6003	6064	61
8	6124	6185	6245	6306	6366	6427	6487	6548	6608	6668	60
9	6729	6789	6850	6910	6970	7031	7091	7152	7212	7272	60
720	857332	7393	7453	7513	7574	7634	7694	7755	7815	7875	60
1	7935	7995	8056	8116	8176	8236	8297	8357	8417	8477	60
2	8537	8597	8657	8718	8778	8838	8898	8958	9018	9078	60
3	9138	9198	9258	9318	9379	9439	9499	9559	9619	9679	60
4	9739	9799	9859	9918	9978	0̄038	0̄098	0̄158	0̄218	0̄278	60
5	860338	0398	0458	0518	0578	0637	0697	0757	0817	0877	60
6	0937	0996	1056	1116	1176	1236	1295	1355	1415	1475	60
7	1534	1594	1654	1714	1773	1833	1893	1952	2012	2072	60
8	2131	2191	2251	2310	2370	2430	2489	2549	2608	2668	60
9	2728	2787	2847	2906	2966	3025	3085	3144	3204	3263	60
730	863323	3382	3442	3501	3561	3620	3680	3739	3799	3858	59
1	3917	3977	4036	4096	4155	4214	4274	4333	4392	4452	59
2	4511	4570	4630	4689	4748	4808	4867	4926	4985	5045	59
3	5104	5163	5222	5282	5341	5400	5459	5519	5578	5637	59
4	5696	5755	5814	5874	5933	5992	6051	6110	6169	6228	59
5	6287	6346	6405	6465	6524	6583	6642	6701	6760	6819	59
6	6878	6937	6996	7055	7114	7173	7232	7291	7350	7409	59
7	7467	7526	7585	7644	7703	7762	7821	7880	7939	7998	59
8	8056	8115	8174	8233	8292	8350	8409	8468	8527	8586	59
9	8644	8703	8762	8821	8879	8938	8997	9056	9114	9173	59
740	869232	9290	9349	9408	9466	9525	9584	9642	9701	9760	59
1	9818	9877	9935	9994	0̄053	0̄111	0̄170	0̄228	0̄287	0̄345	59
2	870404	0462	0521	0579	0638	0696	0755	0813	0872	0930	58
3	0989	1047	1106	1164	1223	1281	1339	1398	1456	1515	58
4	1573	1631	1690	1748	1806	1865	1923	1981	2040	2098	58
5	2156	2215	2273	2331	2389	2448	2506	2564	2622	2681	58
6	2739	2797	2855	2913	2972	3030	3088	3146	3204	3262	58
7	3321	3379	3437	3495	3553	3611	3669	3727	3785	3844	58
8	3902	3960	4018	4076	4134	4192	4250	4308	4366	4424	58
9	4482	4540	4598	4656	4714	4772	4830	4888	4945	5003	58
No.	0	1	2	3	4	5	6	7	8	9	Diff.

No.	0	1	2	3	4	5	6	7	8	9	Diff.
750	875061	5119	5177	5235	5293	5351	5409	5466	5524	5582	58
1	5640	5698	5756	5813	5871	5929	5987	6045	6102	6160	58
2	6218	6276	6333	6391	6449	6507	6564	6622	6680	6737	58
3	6795	6853	6910	6968	7026	7083	7141	7199	7256	7314	58
4	7371	7429	7487	7544	7602	7659	7717	7774	7832	7889	58
5	7947	8004	8062	8119	8177	8234	8292	8349	8407	8464	57
6	8522	8579	8637	8694	8752	8809	8866	8924	8981	9039	57
7	9096	9153	9211	9268	9325	9383	9440	9497	9555	9612	57
8	9669	9726	9784	9841	9898	9956	0̄013	0̄070	0̄127	0̄185	57
9	880242	0299	0356	0413	0471	0528	0585	0642	0699	0756	57
760	880814	0871	0928	0985	1042	1099	1156	1213	1271	1328	57
1	1385	1442	1499	1556	1613	1670	1727	1784	1841	1898	57
2	1955	2012	2069	2126	2183	2240	2297	2354	2411	2468	57
3	2525	2581	2638	2695	2752	2809	2866	2923	2980	3037	57
4	3093	3150	3207	3264	3321	3377	3434	3491	3548	3605	57
5	3661	3718	3775	3832	3888	3945	4002	4059	4115	4172	57
6	4229	4285	4342	4399	4455	4512	4569	4625	4682	4739	57
7	4795	4852	4909	4965	5022	5078	5135	5192	5248	5305	57
8	5361	5418	5474	5531	5587	5644	5700	5757	5813	5870	57
9	5926	5983	6039	6096	6152	6209	6265	6321	6378	6434	56
770	886491	6547	6604	6660	6716	6773	6829	6885	6942	6998	56
1	7054	7111	7167	7223	7280	7336	7392	7449	7505	7561	56
2	7617	7674	7730	7786	7842	7898	7955	8011	8067	8123	56
3	8179	8236	8292	8348	8404	8460	8516	8573	8629	8685	56
4	8741	8797	8853	8909	8965	9021	9077	9134	9190	9246	56
5	9302	9358	9414	9470	9526	9582	9638	9694	9750	9806	56
6	9862	9918	9974	0̄030	0̄086	0̄141	0̄197	0̄253	0̄309	0̄365	56
7	890421	0477	0533	0589	0645	0700	0756	0812	0868	0924	56
8	0980	1035	1091	1147	1203	1259	1314	1370	1426	1482	56
9	1537	1593	1649	1705	1760	1816	1872	1928	1983	2039	56
780	892095	2150	2206	2262	2317	2373	2429	2484	2540	2595	56
1	2651	2707	2762	2818	2873	2929	2985	3040	3096	3151	56
2	3207	3262	3318	3373	3429	3484	3540	3595	3651	3706	56
3	3762	3817	3873	3928	3984	4039	4094	4150	4205	4261	55
4	4316	4371	4427	4482	4538	4593	4648	4704	4759	4814	55
5	4870	4925	4980	5036	5091	5146	5201	5257	5312	5367	55
6	5423	5478	5533	5588	5644	5699	5754	5809	5864	5920	55
7	5975	6030	6085	6140	6195	6251	6306	6361	6416	6471	55
8	6526	6581	6636	6692	6747	6802	6857	6912	6967	7022	55
9	7077	7132	7187	7242	7297	7352	7407	7462	7517	7572	55
790	897627	7682	7737	7792	7847	7902	7957	8012	8067	8122	55
1	8176	8231	8286	8341	8396	8451	8506	8561	8615	8670	55
2	8725	8780	8835	8890	8944	8999	9054	9109	9164	9218	55
3	9273	9328	9383	9437	9492	9547	9602	9656	9711	9766	55
4	9821	9875	9930	9985	0̄039	0̄094	0̄149	0̄203	0̄258	0̄312	55
5	900367	0422	0476	0531	0586	0640	0695	0749	0804	0859	55
6	0913	0968	1022	1077	1131	1186	1240	1295	1349	1404	55
7	1458	1513	1567	1622	1676	1731	1785	1840	1894	1948	54
8	2003	2057	2112	2166	2221	2275	2329	2384	2438	2492	54
9	2547	2601	2655	2710	2764	2818	2873	2927	2981	3036	54
No.	0	1	2	3	4	5	6	7	8	9	Diff.

No.	0	1	2	3	4	5	6	7	8	9	Diff.
800	903090	3144	3199	3253	3307	3361	3416	3470	3524	3578	54
1	3633	3687	3741	3795	3849	3904	3958	4012	4066	4120	54
2	4174	4229	4283	4337	4391	4445	4499	4553	4607	4661	54
3	4716	4770	4824	4878	4932	4986	5040	5094	5148	5202	54
4	5256	5310	5364	5418	5472	5526	5580	5634	5688	5742	54
5	5796	5850	5904	5958	6012	6066	6119	6173	6227	6281	54
6	6335	6389	6443	6497	6551	6604	6658	6712	6766	6820	54
7	6874	6927	6981	7035	7089	7143	7196	7250	7304	7358	54
8	7411	7465	7519	7573	7626	7680	7734	7787	7841	7895	54
9	7949	8002	8056	8110	8163	8217	8270	8324	8378	8431	54
810	908485	8539	8592	8646	8699	8753	8807	8860	8914	8967	54
1	9021	9074	9128	9181	9235	9289	9342	9396	9449	9503	54
2	9556	9610	9663	9716	9770	9823	9877	9930	9984	$\bar{0}037$	53
3	910091	0144	0197	0251	0304	0358	0411	0464	0518	0571	53
4	0624	0678	0731	0784	0838	0891	0944	0998	1051	1104	53
5	1158	1211	1264	1317	1371	1424	1477	1530	1584	1637	53
6	1690	1743	1797	1850	1903	1956	2009	2063	2116	2169	53
7	2222	2275	2328	2381	2435	2488	2541	2594	2647	2700	53
8	2753	2806	2859	2913	2966	3019	3072	3125	3178	3231	53
9	3284	3337	3390	3443	3496	3549	3602	3655	3708	3761	53
820	913814	3867	3920	3973	4026	4079	4132	4184	4237	4290	53
1	4343	4396	4449	4502	4555	4608	4660	4713	4766	4819	53
2	4872	4925	4977	5030	5083	5136	5189	5241	5294	5347	53
3	5400	5453	5505	5558	5611	5664	5716	5769	5822	5875	53
4	5927	5980	6033	6085	6138	6191	6243	6296	6349	6401	53
5	6454	6507	6559	6612	6664	6717	6770	6822	6875	6927	53
6	6980	7033	7085	7138	7190	7243	7295	7348	7400	7453	53
7	7506	7558	7611	7663	7716	7768	7820	7873	7925	7978	52
8	8030	8083	8135	8188	8240	8293	8345	8397	8450	8502	52
9	8555	8607	8659	8712	8764	8816	8869	8921	8973	9026	52
830	919078	9130	9183	9235	9287	9340	9392	9444	9496	9549	52
1	9601	9653	9706	9758	9810	9862	9914	9967	$\bar{0}019$	$\bar{0}071$	52
2	920123	0176	0228	0280	0332	0384	0436	0489	0541	0593	52
3	0645	0697	0749	0801	0853	0906	0958	1010	1062	1114	52
4	1166	1218	1270	1322	1374	1426	1478	1530	1582	1634	52
5	1686	1738	1790	1842	1894	1946	1998	2050	2102	2154	52
6	2206	2258	2310	2362	2414	2466	2518	2570	2622	2674	52
7	2725	2777	2829	2881	2933	2985	3037	3089	3140	3192	52
8	3244	3296	3348	3399	3451	3503	3555	3607	3658	3710	52
9	3762	3814	3865	3917	3969	4021	4072	4124	4176	4228	52
840	924279	4331	4383	4434	4486	4538	4589	4641	4693	4744	52
1	4796	4848	4899	4951	5003	5054	5106	5157	5209	5261	52
2	5312	5364	5415	5467	5518	5570	5621	5673	5725	5776	52
3	5828	5879	5931	5982	6034	6085	6137	6188	6240	6291	51
4	6342	6394	6445	6497	6548	6600	6651	6702	6754	6805	51
5	6857	6908	6959	7011	7062	7114	7165	7216	7268	7319	51
6	7370	7422	7473	7524	7576	7627	7678	7730	7781	7832	51
7	7883	7935	7986	8037	8088	8140	8191	8242	8293	8345	51
8	8396	8447	8498	8549	8601	8652	8703	8754	8805	8857	51
9	8908	8959	9010	9061	9112	9163	9215	9266	9317	9368	51
No.	0	1	2	3	4	5	6	7	8	9	Diff.

No.	0	1	2	3	4	5	6	7	8	9	Diff.
850	929419	9470	9521	9572	9623	9674	9725	9776	9827	9879	51
1	9930	9981	0̄032	0̄083	0̄134	0̄185	0̄236	0̄287	0̄338	0̄389	51
2	930440	0491	0542	0592	0643	0694	0745	0796	0847	0898	51
3	0949	1000	1051	1102	1153	1204	1254	1305	1356	1407	51
4	1458	1509	1560	1610	1661	1712	1763	1814	1865	1915	51
5	1966	2017	2068	2118	2169	2220	2271	2322	2372	2423	51
6	2474	2524	2575	2626	2677	2727	2778	2829	2879	2930	51
7	2981	3031	3082	3133	3183	3234	3285	3335	3386	3437	51
8	3487	3538	3589	3639	3690	3740	3791	3841	3892	3943	51
9	3993	4044	4094	4145	4195	4246	4296	4347	4397	4448	51
860	934498	4549	4599	4650	4700	4751	4801	4852	4902	4953	50
1	5003	5054	5104	5154	5205	5255	5306	5356	5406	5457	50
2	5507	5558	5608	5658	5709	5759	5809	5860	5910	5960	50
3	6011	6061	6111	6162	6212	6262	6313	6363	6413	6463	50
4	6514	6564	6614	6665	6715	6765	6815	6865	6916	6966	50
5	7016	7066	7117	7167	7217	7267	7317	7367	7418	7468	50
6	7518	7568	7618	7668	7718	7769	7819	7869	7919	7969	50
7	8019	8069	8119	8169	8219	8269	8320	8370	8420	8470	50
8	8520	8570	8620	8670	8720	8770	8820	8870	8920	8970	50
9	9020	9070	9120	9170	9220	9270	9320	9369	9419	9469	50
870	939519	9569	9619	9669	9719	9769	9819	9869	9918	9968	50
1	940018	0068	0118	0168	0218	0267	0317	0367	0417	0467	50
2	0516	0566	0616	0666	0716	0765	0815	0865	0915	0964	50
3	1014	1064	1114	1163	1213	1263	1313	1362	1412	1462	50
4	1511	1561	1611	1660	1710	1760	1809	1859	1909	1958	50
5	2008	2058	2107	2157	2207	2256	2306	2355	2405	2455	50
6	2504	2554	2603	2653	2702	2752	2801	2851	2901	2950	50
7	3000	3049	3099	3148	3198	3247	3297	3346	3396	3445	49
8	3495	3544	3593	3643	3692	3742	3791	3841	3890	3939	49
9	3989	4038	4088	4137	4186	4236	4285	4335	4384	4433	49
880	944483	4532	4581	4631	4680	4729	4779	4828	4877	4927	49
1	4976	5025	5074	5124	5173	5222	5272	5321	5370	5419	49
2	5469	5518	5567	5616	5665	5715	5764	5813	5862	5912	49
3	5961	6010	6059	6108	6157	6207	6256	6305	6354	6403	49
4	6452	6501	6551	6600	6649	6698	6747	6796	6845	6894	49
5	6943	6992	7041	7090	7140	7189	7238	7287	7336	7385	49
6	7434	7483	7532	7581	7630	7679	7728	7777	7826	7875	49
7	7924	7973	8022	8070	8119	8168	8217	8266	8315	8364	49
8	8413	8462	8511	8560	8609	8657	8706	8755	8804	8853	49
9	8902	8951	8999	9048	9097	9146	9195	9244	9292	9341	49
890	949390	9439	9488	9536	9585	9634	9683	9731	9780	9829	49
1	9878	9926	9975	0̄024	0̄073	0̄121	0̄170	0̄219	0̄267	0̄316	49
2	950365	0414	0462	0511	0560	0608	0657	0706	0754	0803	49
3	0851	0900	0949	0997	1046	1095	1143	1192	1240	1289	49
4	1338	1386	1435	1483	1532	1580	1629	1677	1726	1775	49
5	1823	1872	1920	1969	2017	2066	2114	2163	2211	2260	48
6	2308	2356	2405	2453	2502	2550	2599	2647	2696	2744	48
7	2792	2841	2889	2938	2986	3034	3083	3131	3180	3228	48
8	3276	3325	3373	3421	3470	3518	3566	3615	3663	3711	48
9	3760	3808	3856	3905	3953	4001	4049	4098	4146	4194	48
No.	0	1	2	3	4	5	6	7	8	9	Diff.

No.	0	1	2	3	4	5	6	7	8	9	Diff.
900	954243	4291	4339	4387	4435	4484	4532	4580	4628	4677	48
1	4725	4773	4821	4869	4918	4966	5014	5062	5110	5158	48
2	5207	5255	5303	5351	5399	5447	5495	5543	5592	5640	48
3	5688	5736	5784	5832	5880	5928	5976	6024	6072	6120	48
4	6168	6216	6265	6313	6361	6409	6457	6505	6553	6601	48
5	6649	6697	6745	6793	6840	6888	6936	6984	7032	7080	48
6	7128	7176	7224	7272	7320	7368	7416	7464	7512	7559	48
7	7607	7655	7703	7751	7799	7847	7894	7942	7990	8038	48
8	8086	8134	8181	8229	8277	8325	8373	8421	8468	8516	48
9	8564	8612	8659	8707	8755	8803	8850	8898	8946	8994	48
910	959041	9089	9137	9185	9232	9280	9328	9375	9423	9471	48
1	9518	9566	9614	9661	9709	9757	9804	9852	9900	9947	48
2	9995	$\bar{0}042$	$\bar{0}090$	$\bar{0}138$	$\bar{0}185$	$\bar{0}233$	$\bar{0}280$	$\bar{0}328$	$\bar{0}376$	$\bar{0}423$	48
3	960471	0518	0566	0613	0661	0709	0756	0804	0851	0899	48
4	0946	0994	1041	1089	1136	1184	1231	1279	1326	1374	48
5	1421	1469	1516	1563	1611	1658	1706	1753	1801	1848	47
6	1895	1943	1990	2038	2085	2132	2180	2227	2275	2322	47
7	2369	2417	2464	2511	2559	2606	2653	2701	2748	2795	47
8	2843	2890	2937	2985	3032	3079	3126	3174	3221	3268	47
9	3316	3363	3410	3457	3504	3552	3599	3646	3693	3741	47
920	963788	3835	3882	3929	3977	4024	4071	4118	4165	4212	47
1	4260	4307	4354	4401	4448	4495	4542	4590	4637	4684	47
2	4731	4778	4825	4872	4919	4966	5013	5061	5108	5155	47
3	5202	5249	5296	5343	5390	5437	5484	5531	5578	5625	47
4	5672	5719	5766	5813	5860	5907	5954	6001	6048	6095	47
5	6142	6189	6236	6283	6329	6376	6423	6470	6517	6564	47
6	6611	6658	6705	6752	6799	6845	6892	6939	6986	7033	47
7	7080	7127	7173	7220	7267	7314	7361	7408	7454	7501	47
8	7548	7595	7642	7688	7735	7782	7829	7875	7922	7969	47
9	8016	8062	8109	8156	8203	8249	8296	8343	8390	8436	47
930	968483	8530	8576	8623	8670	8716	8763	8810	8856	8903	47
1	8950	8996	9043	9090	9136	9183	9229	9276	9323	9369	47
2	9416	9463	9509	9556	9602	9649	9695	9742	9789	9835	47
3	9882	9928	9975	$\bar{0}021$	$\bar{0}068$	$\bar{0}114$	$\bar{0}161$	$\bar{0}207$	$\bar{0}254$	$\bar{0}300$	47
4	970347	0393	0440	0486	0533	0579	0626	0672	0719	0765	46
5	0812	0858	0904	0951	0997	1044	1090	1137	1183	1229	46
6	1276	1322	1369	1415	1461	1508	1554	1601	1647	1693	46
7	1740	1786	1832	1879	1925	1971	2018	2064	2110	2157	46
8	2203	2249	2295	2342	2388	2434	2481	2527	2573	2619	46
9	2666	2712	2758	2804	2851	2897	2943	2989	3035	3082	46
940	973128	3174	3220	3266	3313	3359	3405	3451	3497	3543	46
1	3590	3636	3682	3728	3774	3820	3866	3913	3959	4005	46
2	4051	4097	4143	4189	4235	4281	4327	4374	4420	4466	46
3	4512	4558	4604	4650	4696	4742	4788	4834	4880	4926	46
4	4972	5018	5064	5110	5156	5202	5248	5294	5340	5386	46
5	5432	5478	5524	5570	5616	5662	5707	5753	5799	5845	46
6	5891	5937	5983	6029	6075	6121	6167	6212	6258	6304	46
7	6350	6396	6442	6488	6533	6579	6625	6671	6717	6763	46
8	6808	6854	6900	6946	6992	7037	7083	7129	7175	7220	46
9	7266	7312	7358	7403	7449	7495	7541	7586	7632	7678	46
No.	0	1	2	3	4	5	6	7	8	9	Diff.

No.	0	1	2	3	4	5	6	7	8	9	Diff.
950	977724	7769	7815	7861	7906	7952	7998	8043	8089	8135	46
1	8181	8226	8272	8317	8363	8409	8454	8500	8546	8591	46
2	8637	8683	8728	8774	8819	8865	8911	8956	9002	9047	46
3	9093	9138	9184	9230	9275	9321	9366	9412	9457	9503	46
4	9548	9594	9639	9685	9730	9776	9821	9867	9912	9958	46
5	980003	0049	0094	0140	0185	0231	0276	0322	0367	0412	45
6	0458	0503	0549	0594	0640	0685	0730	0776	0821	0867	45
7	0912	0957	1003	1048	1093	1139	1184	1229	1275	1320	45
8	1366	1411	1456	1501	1547	1592	1637	1683	1728	1773	45
9	1819	1864	1909	1954	2000	2045	2090	2135	2181	2226	45
960	982271	2316	2362	2407	2452	2497	2543	2588	2633	2678	45
1	2723	2769	2814	2859	2904	2949	2994	3040	3085	3130	45
2	3175	3220	3265	3310	3356	3401	3446	3491	3536	3581	45
3	3626	3671	3716	3762	3807	3852	3897	3942	3987	4032	45
4	4077	4122	4167	4212	4257	4302	4347	4392	4437	4482	45
5	4527	4572	4617	4662	4707	4752	4797	4842	4887	4932	45
6	4977	5022	5067	5112	5157	5202	5247	5292	5337	5382	45
7	5426	5471	5516	5561	5606	5651	5696	5741	5786	5830	45
8	5875	5920	5965	6010	6055	6100	6144	6189	6234	6279	45
9	6324	6369	6413	6458	6503	6548	6593	6637	6682	6727	45
970	986772	6817	6861	6906	6951	6996	7040	7085	7130	7175	45
1	7219	7264	7309	7353	7398	7443	7488	7532	7577	7622	45
2	7666	7711	7756	7800	7845	7890	7934	7979	8024	8068	45
3	8113	8157	8202	8247	8291	8336	8381	8425	8470	8514	45
4	8559	8604	8648	8693	8737	8782	8826	8871	8916	8960	45
5	9005	9049	9094	9138	9183	9227	9272	9316	9361	9405	45
6	9450	9494	9539	9583	9628	9672	9717	9761	9806	9850	44
7	9895	9939	9983	$\bar{0}028$	$\bar{0}072$	$\bar{0}117$	$\bar{0}161$	$\bar{0}206$	$\bar{0}250$	$\bar{0}294$	44
8	990339	0383	0428	0472	0516	0561	0605	0650	0694	0738	44
9	0783	0827	0871	0916	0960	1004	1049	1093	1137	1182	44
980	991226	1270	1315	1359	1403	1448	1492	1536	1580	1625	44
1	1669	1713	1758	1802	1846	1890	1935	1979	2023	2067	44
2	2111	2156	2200	2244	2288	2333	2377	2421	2465	2509	44
3	2554	2598	2642	2686	2730	2774	2819	2863	2907	2951	44
4	2995	3039	3083	3127	3172	3216	3260	3304	3348	3392	44
5	3436	3480	3524	3568	3613	3657	3701	3745	3789	3833	44
6	3877	3921	3965	4009	4053	4097	4141	4185	4229	4273	44
7	4317	4361	4405	4449	4493	4537	4581	4625	4669	4713	44
8	4757	4801	4845	4889	4933	4977	5021	5065	5108	5152	44
9	5196	5240	5284	5328	5372	5416	5460	5504	5547	5591	44
990	995635	5679	5723	5767	5811	5854	5898	5942	5986	6030	44
1	6074	6117	6161	6205	6249	6293	6337	6380	6424	6468	44
2	6512	6555	6599	6643	6687	6731	6774	6818	6862	6906	44
3	6949	6993	7037	7080	7124	7168	7212	7255	7299	7343	44
4	7386	7430	7474	7517	7561	7605	7648	7692	7736	7779	44
5	7823	7867	7910	7954	7998	8041	8085	8129	8172	8216	44
6	8259	8303	8347	8390	8434	8477	8521	8564	8608	8652	44
7	8695	8739	8782	8826	8869	8913	8956	9000	9043	9087	44
8	9131	9174	9218	9261	9305	9348	9392	9435	9479	9522	44
9	9565	9609	9652	9696	9739	9783	9826	9870	9913	9957	43
No.	0	1	2	3	4	5	6	7	8	9	Diff.

Table of Natural Sines and Tangents.

Deg.	Min.	Sine.	Tangent.	Deg.	Min.	Sine.	Tangent.
0	10	0029089	0029089	12	30	2164396	2216947
	15	0043633	0043634		45	2206974	2262769
	30	0087265	0087269	13	00	2249511	2308682
	45	0130896	0130907		15	2292004	2354687
1	00	0174524	0174551		30	2334454	2400788
	15	0218149	0218201		45	2376859	2446984
	30	0261769	0261859	14	00	2419219	2493280
	45	0305385	0305528		15	2461533	2539676
2	00	0348995	0349208		30	2503800	2586176
	15	0392598	0392901		45	2546019	2632780
	30	0436194	0436609	15	00	2588190	2679492
	45	0479781	0480334		15	2630312	2726313
3	00	0523360	0524078		30	2672384	2773245
	15	0566928	0567841		45	2714404	2820292
	30	0610485	0611626	16	00	2756374	2867454
	45	0654031	0655435		15	2798290	2914734
4	00	0697565	0699268		30	2840153	2962135
	15	0741085	0743128		45	2881963	3009658
	30	0784591	0787017	17	00	2923717	3057307
	45	0828082	0830936		15	2965416	3105083
5	00	0871557	0874887		30	3007058	3152988
	15	0915016	0918871		45	3048643	3201025
	30	0958458	0962890	18	00	3090170	3249197
	45	1001881	1006947		15	3131638	3297505
6	00	1045285	1051042		30	3173047	3345953
	15	1088669	1095178		45	3214395	3394543
	30	1132032	1139356		00	3255682	3443276
	45	1175374	1183578		15	3296906	3492156
7	00	1218693	1227846		30	3338069	3541186
	15	1261990	1272161		45	3379167	3590367
	30	1305262	1316525	20	00	3420201	3639702
	45	1348509	1360940		15	3461171	3689195
8	00	1391731	1405408		30	3502074	3738847
	15	1434926	1449931		45	3542910	3788661
	30	1478094	1494510	21	00	3583679	3838640
	45	1521234	1539147		15	3624380	3888787
9	00	1564345	1583844		30	3665012	3939105
	15	1607426	1628603		45	3705574	3989595
	30	1650476	1673426	22	00	3746066	4040262
	45	1693495	1718314		15	3786486	4091108
10	00	1736482	1763270		30	3826834	4142136
	15	1779435	1808295		45	3867110	4193348
	30	1822355	1853390	23	00	3907311	4244748
	45	1865240	1898559		15	3947439	4296339
11	00	1908090	1943803		30	3987491	4348124
	15	1950903	1989124		45	4027467	4400105
	30	1993679	2034523	24	00	4067366	4452287
	45	2036418	2080003		15	4107189	4504672
12	00	2079117	2125566		30	4146932	4557263
	15	2121777	2171213		45	4186597	4610063

Table of Natural Sines and Tangents.—Continued.

Deg.	Min.	Sine.	Tangent.	Deg.	Min.	Sine.	Tangent.
25	00	4226183	4663077	50	00	7660444	11917536
	30	4305111	4769755		30	7716246	12130970
26	00	4383711	4877326	51	00	7771460	12348972
	30	4461978	4985816		30	7826082	12571723
27	00	4539905	5095254	52	00	7880108	12799416
	30	4617486	5205671		30	7933533	13032254
28	00	4694716	5317094	53	00	7986355	13270448
	30	4771588	5429557		30	8038569	13514224
29	00	4848096	5543091	54	00	8090170	13763819
	30	4924236	5657728		30	8141155	14019483
30	00	5000000	5773503	55	00	8191520	14281480
	30	5075384	5890450		30	8241262	14550090
31	00	5150381	6008606	56	00	8290376	14825610
	30	5224986	6128008		30	8338858	15108352
32	00	5299193	6248694	57	00	8386706	15398650
	30	5372996	6370703		30	8433914	15696856
33	00	5446390	6494076	58	00	8480481	16003345
	30	5519370	6618856		30	8526402	16318517
34	00	5591929	6745085	59	00	8571673	16642795
	30	5664062	6872810		30	8616292	16976631
35	00	5735764	7002075	60	00	8660254	17320508
	30	5807030	7132931	61	00	8746197	18040478
36	00	5877853	7265425	62	00	8829476	18807265
	30	5948228	7399611	63	00	8910065	19626105
37	00	6018150	7535541	64	00	8987940	20503038
	30	6087614	7673270	65	00	9063078	21445069
38	00	6156615	7812856	66	00	9135455	22460368
	30	6225146	7954359	67	00	9205049	23558524
39	00	6293204	8097840	68	00	9271839	24750869
	30	6360782	8243364	69	00	9335804	26050891
40	00	6427876	8390996	70	00	9396926	27474774
	30	6494480	8540807	71	00	9455186	29042109
41	00	6560590	8692867	72	00	9510565	30776835
	30	6626200	8847253	73	00	9563048	32708526
42	00	6691306	9004040	74	00	9612617	34874144
	30	6755902	9163312	75	00	9659258	37320508
43	00	6819984	9325151	76	00	9702957	40107809
	30	6883546	9489646	77	00	9743701	43314759
44	00	6946584	9656888	78	00	9781476	47046301
	30	7009093	9826973	79	00	9816272	51445540
45	00	7071068	10000000	80	00	9848078	56712818
	30	7132504	10176074	81	00	9876883	63137515
46	00	7193398	10355303	82	00	9902681	71153697
	30	7253744	10537801	83	00	9925462	81443464
47	00	7313537	10723687	84	00	9945219	95143645
	30	7372773	10913085	85	00	9961947	114300520
48	00	7431448	11106125	86	00	9975641	143006660
	30	7489557	11302944	87	00	9986295	190811370
49	00	7547096	11503684	88	00	9993908	286362530
	30	7604060	11708496	89	00	9998477	572899620

LOGARITHMS SINE.

Deg.	0′	10′	20′	30′	40′	50′	60′	Deg.
0		7.46372	7.26475	7.94084	8.06577	8.16268	8.24185	89
1	8.24185	8.30879	8.36677	8.41791	8.46366	8.50504	8.54281	88
2	8.54281	8.57756	8.60973	8.63968	8.66768	8.69399	8.71880	87
3	8.71880	8.74225	8.76451	8.78567	8.80585	8.82513	8.84358	86
4	8.84358	8.86128	8.87828	8.89464	8.91040	8.92560	8.94029	85
5	8.94029	8.95449	8.96824	8.98157	8.99449	9.00704	9.01923	84
6	9.01923	9.03108	9.04262	9.05385	9.06480	9.07548	9.08589	83
7	9.08589	9.09606	9.10599	9.11569	9.12518	9.13447	9.14355	82
8	9.14355	9.15249	9.16116	9.16970	9.17807	9.18628	9.19433	81
9	9.19433	9.20223	9.20999	9.21760	9.22509	9.23244	9.23967	80
10	9.23967	9.24677	9.25376	9.26063	9.26739	9.27404	9.28059	79
11	9.28059	9.28704	9.29339	9.29965	9.30581	9.31189	9.31787	78
12	9.31787	9.32378	9.32959	9.33533	9.34099	9.34657	9.35208	77
13	9.35208	9.35752	9.36288	9.36818	9.37341	9.37857	9.38367	76
14	9.38367	9.38871	9.39368	9.39860	9.40345	9.40825	9.41299	75
15	9.41299	9.41768	9.42231	9.42689	9.43142	9.43590	9.44033	74
16	9.44033	9.44472	9.44905	9.45334	9.45758	9.46178	9.46593	73
17	9.46593	9.47004	9.47411	9.47814	9.48212	9.48607	9.48998	72
18	9.48998	9.49385	9.49768	9 50147	9.50523	9.50895	9.51264	71
19	9.51264	9.51629	9.51991	9.52349	9.52704	9.53056	9.53405	70
20	9.53405	9.53750	9.54093	9.54432	9.54768	9.55102	9.55432	69
21	9.55432	9.55760	9.56085	9.56407	9.56726	9.57043	9.57357	68
22	9.57357	9.57668	9.57977	9.58284	9.58587	9.58889	9.59187	67
23	9.59187	9.59484	9.59778	9.60070	9.60359	9.60646	9.60931	66
24	9.60931	9.61214	9.61494	9.61772	9.62048	9.62322	9.62594	65
25	9.62594	9.62864	9.63132	9.63398	9.63662	9.63924	9.64184	64
26	9.64184	9.64442	9.64698	9.64952	9.65205	9.65455	9.65704	63
27	9.65704	9.65951	9.66197	9.66440	9.66682	9.66922	9.67160	62
28	9.67160	9.67397	9.67632	9.67866	9.68098	9.68328	9.68557	61
29	9.68557	9.68784	9.69009	9.69233	9.69456	9.69677	9.69897	60
30	9.69897	9.70115	9.70331	9.70546	9.70760	9.70773	9.71183	59
31	9.71183	9.71393	9.71601	9.71808	9.72014	9.72218	9.72421	58
32	9.72421	9.72622	9.72822	9.73021	9.73219	9.73415	9.73610	57
33	9.73610	9.73804	9.73997	9.74188	9.74379	9.74568	9.74756	56
34	9.74756	9.74942	9.75128	9.75312	9.75496	9.75678	6.75859	55
35	9.75859	9.76039	9.76217	9.76395	9.76572	9.76747	9.76921	54
36	9.76921	9.77095	9.77267	9.77438	9.77609	9.77778	9.77946	53
37	9.77946	9.78113	9.78279	9.78444	9.78608	9.78772	9.78934	52
38	9.78934	9.79095	9.79255	9.79415	9.79573	9.79730	9.79887	51
39	9.79887	9.80042	9.80197	9.80351	9.80503	9.80655	9.80806	50
40	9.80806	9.80956	9.81106	9.81254	9.81401	9.81548	9.81694	49
41	9.81694	9.81839	9.81983	9.82126	9.82268	9.82410	9.82551	48
42	9.82551	9.82691	9.82830	9.82968	9.83105	9.83242	9.83378	47
43	9.83378	9.83513	9.83647	9.83781	9.83914	9.84045	9.84177	46
44	9.84177	9.84307	9.84437	9.84566	9.84694	9.84821	9.84948	45
Deg.	60′	50′	40′	30′	20′	10′	0′	Deg.

LOGARITHM COSINE.

LOGARITHMS SINE.

Deg.	0′	10′	20′	30′	40′	50′	60′	Deg.
45	9.84948	9.85074	9.85199	9.85324	9.85448	9.85571	9.85693	44
46	9.85693	9.85815	9.85936	9.86056	9.86175	9.86294	9.86412	43
47	9.86412	9.86530	9.86647	9.86763	9.86878	9.86993	9.87107	42
48	9.87107	9.87220	9.87333	9.87445	9.87557	9.87667	9.87778	41
49	9.87778	9.87887	9.87996	9.88104	9.88212	9.88319	9.88425	40
50	9.88425	9.88531	9.88636	9.88740	9.88844	9.88947	9.89050	39
51	9.89050	9.89152	9.89253	9.89354	9.89454	9.89554	9.89653	38
52	9.89653	9.89751	9.89849	9.89946	9.90043	9.90139	9.90234	37
53	9.90234	9.90329	9.90424	9.90517	9.90611	9.90703	9.90795	36
54	9.90795	9.90887	9.90978	9.91068	9.91158	9.91247	9.91336	35
55	9.91336	9.91424	9.91512	9.94599	9.91685	9.91771	9.91857	34
56	9.91857	9.91942	9.92026	9.92110	9.92194	9.92276	9.92359	33
57	9.92359	9.92440	9.92522	9.92602	9.92683	9.92762	9.92842	32
58	9.92842	9.92920	9.92998	9.93076	9.93153	9.93230	9.93306	31
59	9.95306	9.93382	9.93457	9.93532	9.93606	9.93679	9.93753	30
60	9.93753	9.93825	9.93898	9.93969	9.94040	9.94111	9.94181	29
61	9.94181	9.94251	9.94321	9.94389	9.94458	9.94526	9.94593	28
62	9.94593	9.94660	9.94726	9.94792	9.94858	9.94923	9.94988	27
63	9.94988	9.95052	9.95115	9.95179	9.95241	9.95304	9.95366	26
64	9.95366	9.95427	9.95488	9.95548	9.95608	9.95668	9.95727	25
65	9.95727	9.95786	9.95844	9.95902	9.95959	9.96016	9.96073	24
66	9.96073	9.96129	9.96184	9.96239	9.96294	9.96348	9.96402	23
67	9.96402	9.96456	9.96509	9.96561	9.96613	9.96665	9.96716	22
68	9.96716	9.96767	9.96817	9.96867	9.96917	9.96966	9.97015	21
69	9.97015	9.97063	9.97111	9.97158	9.97205	9.97252	9.97298	20
70	9.97298	9.97344	9.97389	9.97434	9.97479	9.97523	9.97567	19
71	9.97567	9.97610	9.97653	9.97695	9.97737	9.97779	9.97820	18
72	9.97820	9.97861	9.97901	9.97942	9.97981	9.98020	9.98059	17
73	9.98059	9.98098	9.98136	9.98173	9.98210	9.98247	9.98284	16
74	9.98284	9.98320	9.98355	9.98391	9.98425	9.98460	9.98494	15
75	9.98494	9.98528	9.98561	9.98594	9.98626	9.98658	9.98690	14
76	9.98690	9.98721	9.98752	9.98783	9.98813	9.98843	9.98872	13
77	9.98872	9.98901	9.98930	9.98958	9.98986	9.99013	9.99040	12
78	9.99040	9.99067	9.99093	9.99119	9.99144	9.99169	9.99194	11
79	9.99194	9.99219	9.99243	9.99266	9.99289	9.99312	9.99335	10
80	9.99335	9.99357	9.99378	9.99400	9.99421	9.99441	9.99462	9
81	9.99462	9.99481	9.99501	9.99520	9.99539	9.99557	9.99575	8
82	9.99575	9.99592	9.99610	9.99626	9.99643	9.99659	9.99675	7
83	9.99675	9.99690	9.99705	9.99719	9.99734	9.99748	9.99761	6
84	9.99761	9.99774	9.99787	9.99799	9.99811	9.99823	9.99834	5
85	9.99834	9.99845	9.99855	9.99865	9.99875	9.99885	9.99894	4
86	9.99894	9.99902	9.99911	9.99918	9.99926	9.99933	9.99940	3
87	9.99940	9.99946	9.99952	9.99958	9.99964	9.99968	9.99973	2
88	9.99973	9.99977	9.99981	9.99985	9.99988	9.99991	9.99993	1
89	9.99993	9.99995	9.99997	9.99998	9.99999	9.99999		0
Deg.	60′	50′	40′	30′	20′	10′	0′	Deg.

LOGARITHM COSINE.

Logarithms Tangent.

Deg.	0′	10′	20′	30′	40′	50′	60′	Deg.
0		7.46372	7.76476	7.94085	8.06580	8.16272	8.24192	89
1	8.24192	8.30888	8.36689	8.41806	8.46384	8.50526	8.54308	88
2	8.54308	8.57787	8.61009	8.64009	8.66816	8.69452	8.71939	87
3	8.71939	8.74292	8.76524	8.78648	8.80674	8.82610	8.84464	86
4	8.84464	8.86243	8.87952	8.89598	8.91184	8.92715	8.94195	85
5	8.94195	8.95626	8.97013	8.98357	8.99662	9.00929	9.02162	84
6	9.02162	9.03360	9.04528	9.05665	9.06775	9.07857	9.08914	83
7	9.08914	9.09946	9.10955	9.11942	9.12908	9.13854	9.14780	82
8	9.14780	9.15687	9.16577	9.17449	9.18305	9.19146	9.19971	81
9	9.19971	9.20781	9.21578	9.22360	9.23130	9.23887	9.24631	80
10	9.24631	9.25364	9.26086	9.26796	9.27496	9.28185	9.28863	79
11	9.28865	9.29534	9.30195	9.30846	9.31488	9.32122	9.32747	78
12	9.32747	9.33364	9.33973	9.34575	9.35169	9.35756	9.36336	77
13	9.36336	9.36909	9.37475	9.38035	9.38588	9.39136	9.39677	76
14	9.39677	9.40212	9.40741	9.41265	9.41784	9.42297	9.42805	75
15	9.42805	9.43308	9.43805	9.44298	9.44787	9.45270	9.45749	74
16	9.45749	9.46224	9.46694	9.47160	9.47622	9.48080	9.48533	73
17	9.48533	9.48983	9.49429	9.49872	9.50310	9.50746	9.51177	72
18	9.51177	9.51605	9.52030	9.52452	9.52870	9.53285	9.53697	71
19	9.53697	9.54106	9.54511	9.54914	9.55314	9.55712	9.56106	70
20	9.56106	9.56498	9.56887	9.57273	9.57657	9.58038	9.58417	69
21	9.58417	9.58794	9.59168	9.59539	9.59909	9.60276	9.60641	68
22	9.60641	9.61003	9.61364	9.61722	9.62078	9.62433	9.62785	67
23	9.62785	9.63135	9.63483	9.63830	9.64174	9.64517	9.64858	66
24	9.64858	9.65197	9.65534	9.65870	9.66204	9.66536	9.66867	65
25	9.66867	9.67196	9.67523	9.67849	9.68174	9.68496	9.68818	64
26	9.68818	9.69138	9.69456	9.69773	9.70089	9.70403	9.70716	63
27	9.70716	9.71028	9.71338	9.71647	9.71955	9.72262	9.72567	62
28	9.72567	9.72871	9.73174	9.73476	9.73777	9.74076	9.74375	61
29	9.74374	9.74672	9.74968	9.75264	9.75558	9.75851	9.76143	60
30	9.76143	9.76435	9.76725	9.77014	9.77303	9.77590	9.77877	59
31	9.77877	9.78163	9.78447	9.78731	9.79015	9.79293	9.79578	58
32	9.79578	9.79859	9.80139	9.80418	9.80697	9.80974	9.81251	57
33	9.81251	9.81527	9.81803	9.82078	9.82352	9.82625	9.82898	56
34	9.82898	9.83170	9.83442	9.83713	9.83983	9.84253	9.84522	55
35	9.84522	9.84791	9.85059	9.85326	9.85593	9.85860	9.86126	54
36	9.86126	9.86391	9.86656	9.86920	9.87184	9.87448	9.87711	53
37	9.87711	9.87974	9.88236	9.88498	9.88759	9.89020	9.89281	52
38	9.89281	9.89541	9.89801	9.90060	9.90319	9.90578	9.90836	51
39	9.90836	9.91095	9.91352	9.91610	9.91867	9.92121	9.92381	50
40	9.92381	9.92637	9.92894	9.93149	9.93405	9.93661	9.93916	49
41	9.93916	9.94171	9.94497	9.94680	9.94935	9.95189	9.95443	48
42	9.95443	9.95697	9.95926	9.96205	9.96458	9.96712	9.96965	47
43	9.96965	9.97218	9.97471	9.97725	9.97978	9.98230	9.98484	46
44	9.98484	9.98736	9.98989	9.99242	9.99494	9.99747	0.00000	45
Deg.	60′	50′	40′	30′	20′	10′	0′	Deg.

Logarithm Cotangent.

LOGARITHMS TANGENT.

Deg.	0′	10′	20′	30′	40′	50′	60′	Deg.
45	0.00000	0.00252	0.00505	0.00758	0.01010	0.01263	0.01516	44
46	0.01516	0.01769	0.02022	0.02275	0.02528	0.02781	0.03034	43
47	0.03034	0.03287	0.03541	0.03794	0.04048	0.04302	0.04556	42
48	0.04556	0.04810	0.05064	0.05319	0.05573	0.05828	0.06083	41
49	0.06083	0.06339	0.06594	0.06850	0.07106	0.07362	0.07618	40
50	0.07618	0.07875	0.08132	0.08389	0.08647	0.08904	0.09163	39
51	0.09163	0.09421	0.09680	0.09939	0.10199	0.10458	0.10716	38
52	0.10719	0.10979	0.11240	0.11502	0.11763	0.12025	0.12288	37
53	0.12288	0.12551	0.12815	0.13079	0.13343	0.13608	0.13873	36
54	0.13873	0.14139	0.14406	0.14673	0.14940	0.15208	0.15477	35
55	0.15477	0.15746	0.16016	0.16286	0.16557	0.16829	0.17101	34
56	0.17101	0.17374	0.17647	0.17921	0.18196	0.18472	0.18748	33
57	0.18748	0.19025	0.19302	0.19581	0.19860	0.20140	0.20421	32
58	0.20421	0.20702	0.20984	0.21268	0.21552	0.21836	0.22122	31
59	0.22122	0.22409	0.22696	0.22985	0.23274	0.23564	0.23856	30
60	0.23856	0.24148	0.24441	0.24735	0.25031	0.25327	0.25624	29
61	0.25624	0.25923	0.26222	0.26523	0.26825	0.27128	0.27432	28
62	0.27432	0.27737	0.28044	0.28352	0.28661	0.28971	0.29283	27
63	0.29283	0.29596	0.29910	0.30226	0.30543	0.30861	0.31181	26
64	0.31181	0.31503	0.31826	0.32150	0.32476	0.32803	0.33132	25
65	0.33132	0.33463	0.33795	0.34129	0.34465	0.34802	0.35141	24
66	0.35141	0.35482	0.35825	0.36169	0.36516	0.36864	0.37214	23
67	0.37214	0.37567	0.37921	0.38277	0.38635	0.38996	0.39359	22
68	0.39359	0.39723	0.40090	0.40460	0.40831	0.41205	0.41582	21
69	0.41582	0.41961	0.42342	0.42726	0.43112	0.43501	0.43893	20
70	0.43893	0.44287	0.44685	0.45085	0.45488	0.45893	0.46302	19
71	0.46302	0.46714	0.47129	0.47548	0.47969	0.48394	0.48822	18
72	0.48822	0.49254	0.49689	0.50127	0.50570	0.51016	0.51466	17
73	0.51466	0.51919	0.52377	0.52839	0.53305	0.53775	0.54250	16
74	0.54250	0.54729	0.55213	0.55701	0.56194	0.56692	0.57194	15
75	0.57194	0.57702	0.58215	0.58734	0.59258	0.59787	0.60322	14
76	0.60322	0.60864	0.61411	0.61964	0.62524	0.63090	0.63663	13
77	0.63663	0.64243	0.64830	0.65424	0.66026	0.66635	0.67252	12
78	0.67252	0.67877	0.68511	0.69153	0.69804	0.70465	0.71134	11
79	0.71134	0.71814	0.72503	0.73203	0.73913	0.74635	0.75368	10
80	0.75368	0.76112	0.76869	0.77639	0.78422	0.79218	0.80028	9
81	0.80028	0.80853	0.81694	0.82550	0.83422	0.84312	0.85219	8
82	0.85219	0.86145	0.87091	0.88057	0.89044	0.90053	0.91085	7
83	0.91085	0.92142	0.93224	0.94334	0.95471	0.96639	0.97838	6
84	0.97838	0.99070	1.00337	1.01642	1.02986	1.04373	1.05804	5
85	1.05804	1.07284	1.08815	1.10401	1.12047	1.13756	1.15535	4
86	1.15535	1.17389	1.19325	1.21351	1.23475	1.25707	1.28060	3
87	1.28060	1.30547	1.33184	1.35990	1.38990	1.42212	1.45691	2
88	1.45691	1.49473	1.53615	1.58193	1.63310	1.69111	1.75807	1
89	1.75807	1.83727	1.93419	2.05914	2.23523	2.53627		0
Deg.	60′	50′	40′	30′	20′	10′	0′	Deg.

LOGARITHM COTANGENT.

INDEX.

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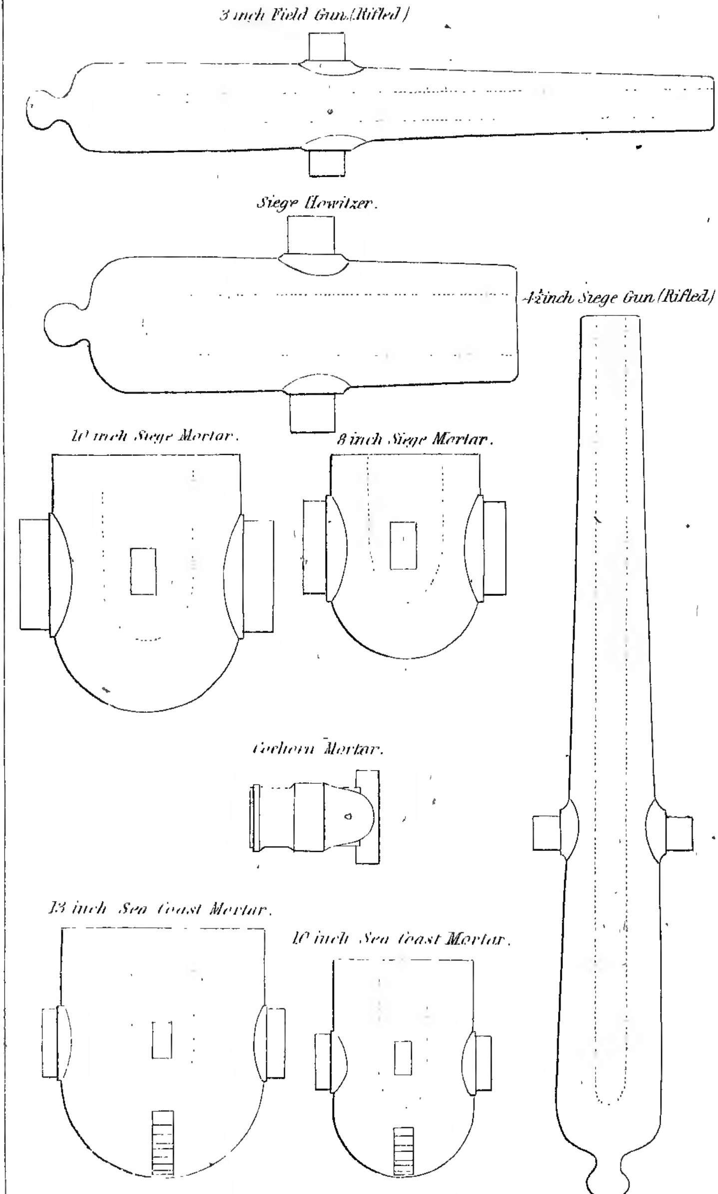
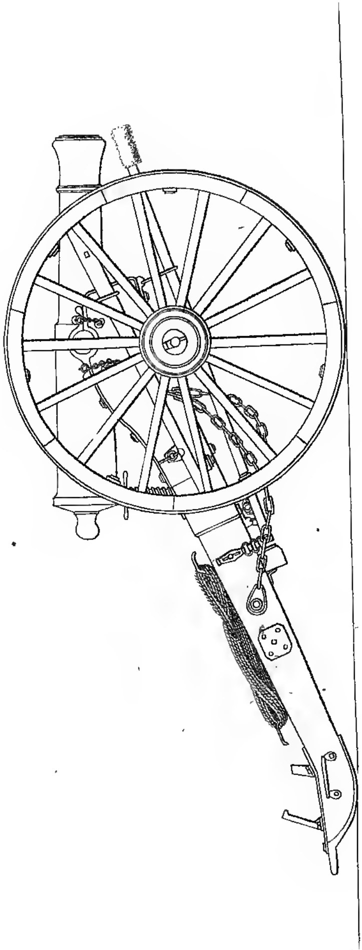
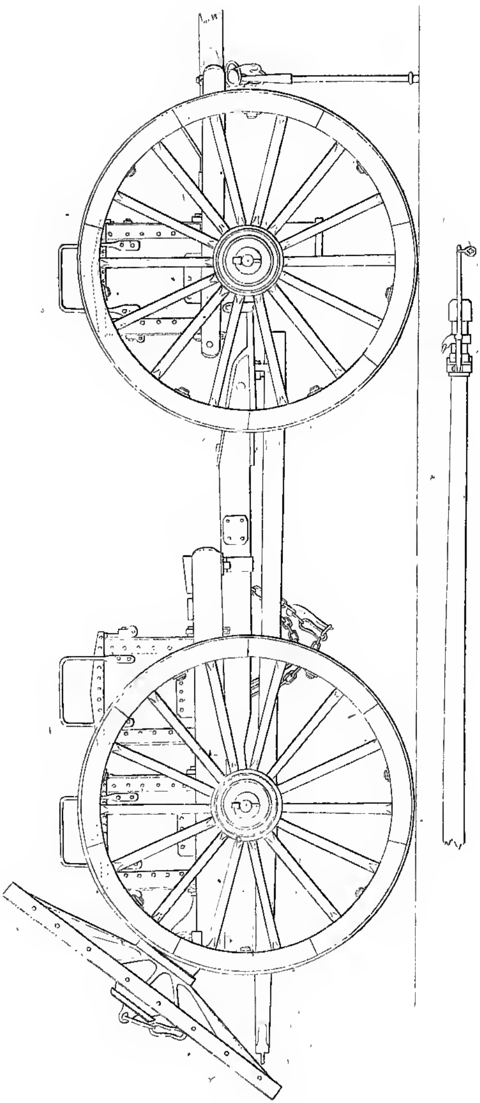
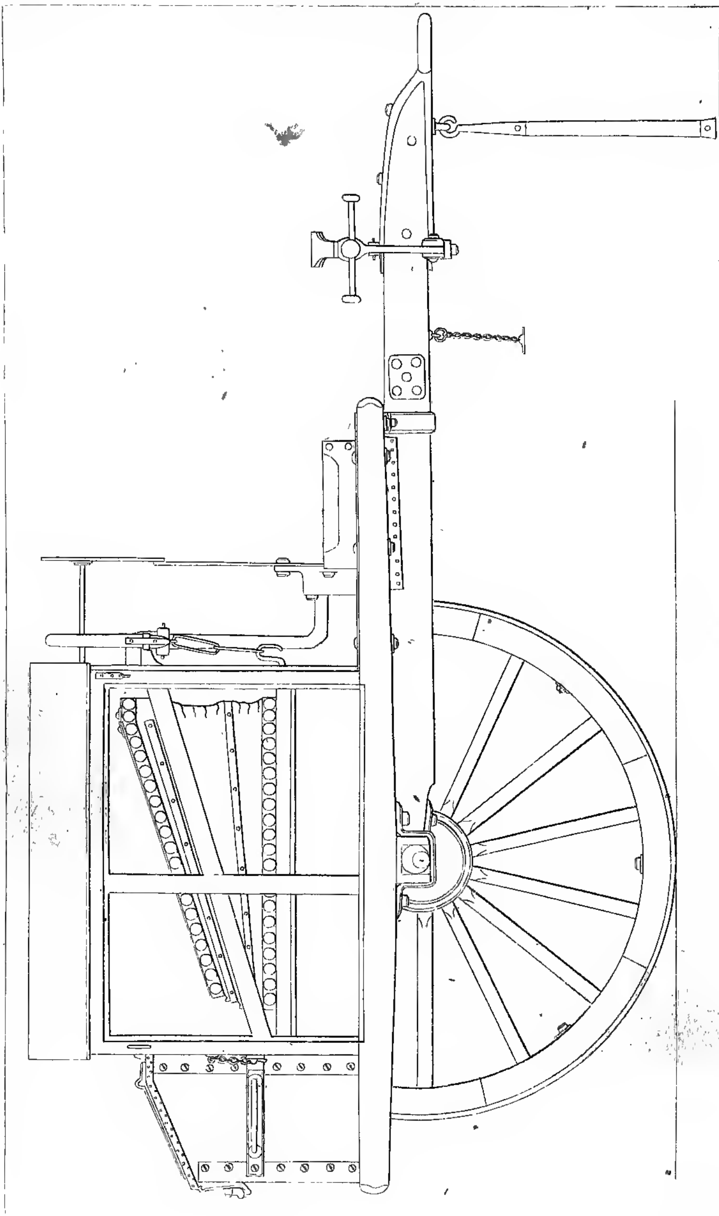


G. Stoke, Del. J. L. Butler Sc.

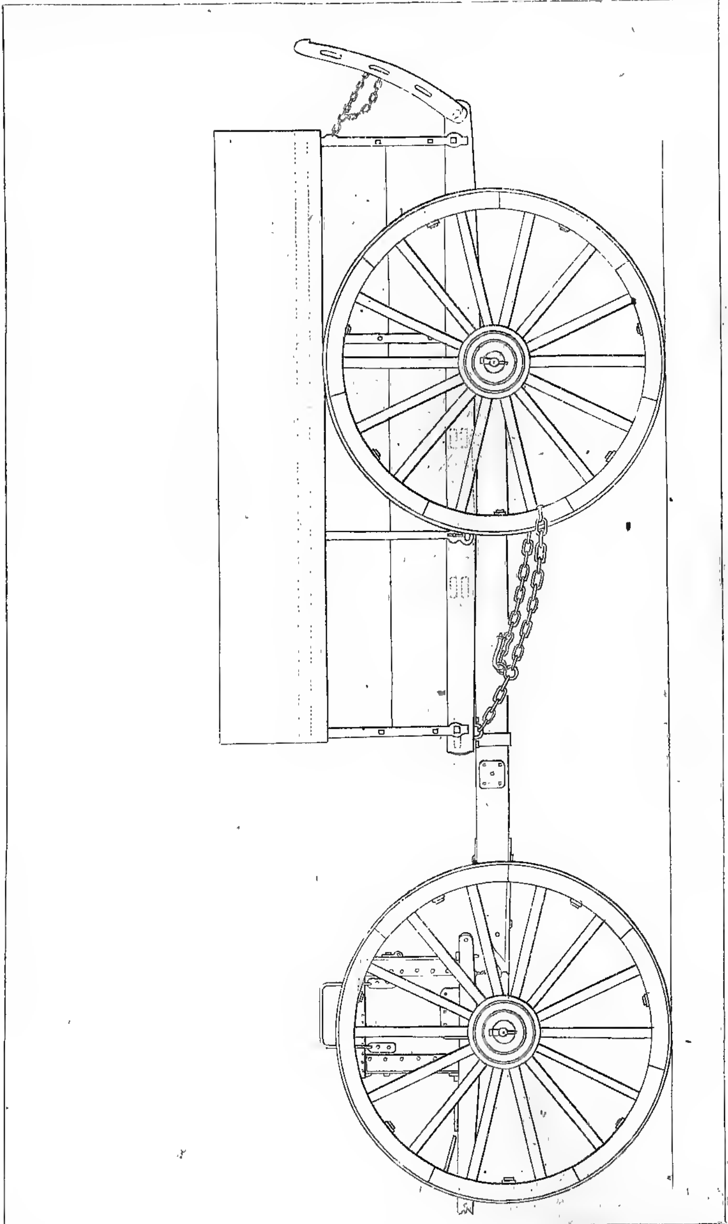




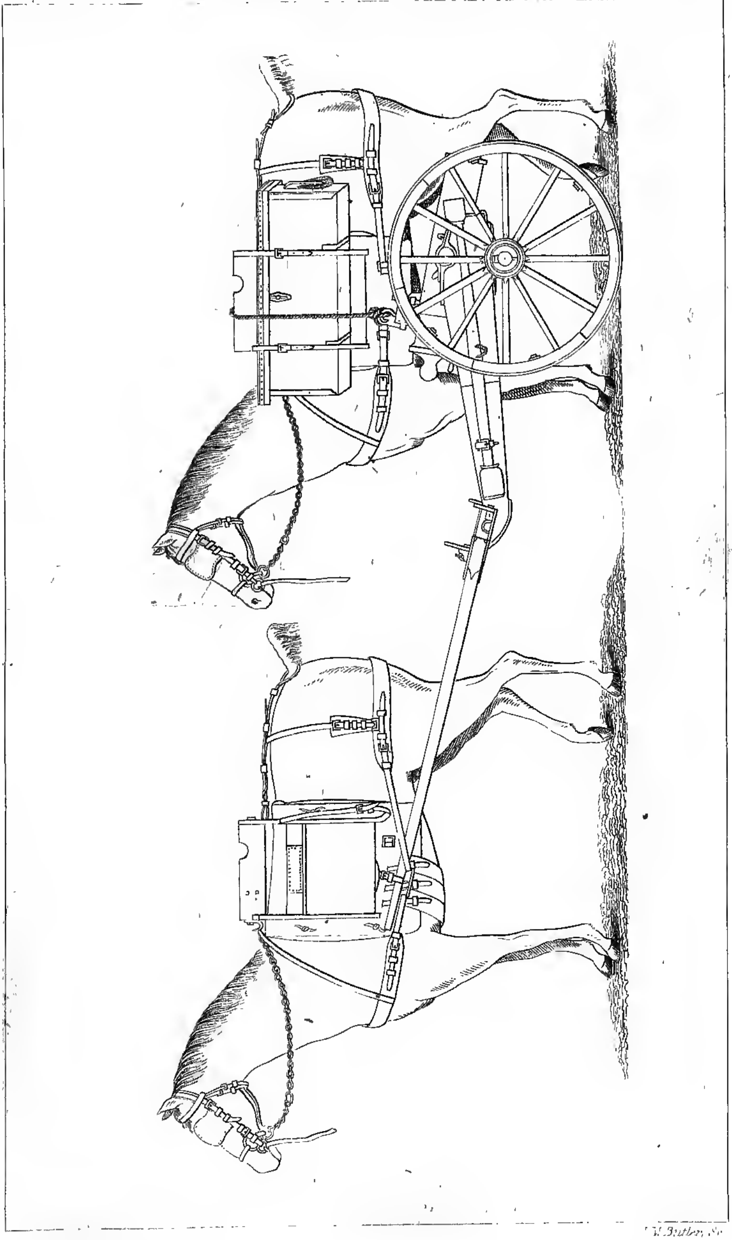
Butler Sc.



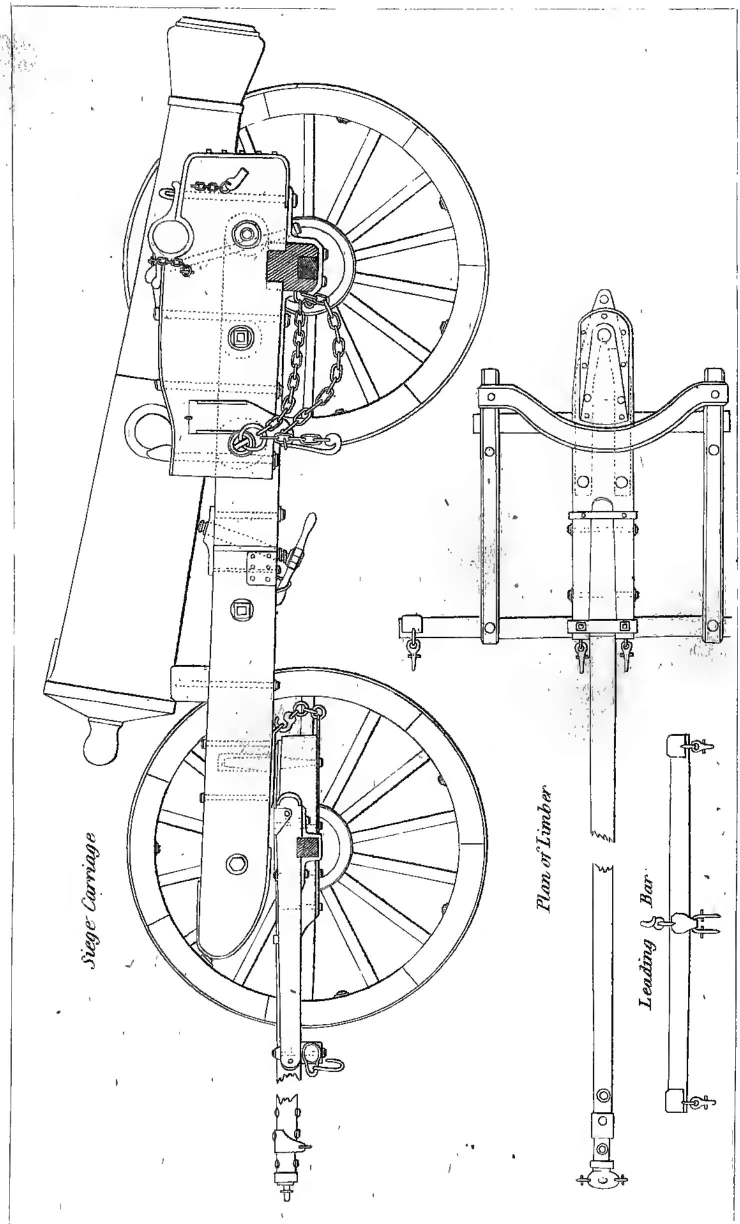
J. Butler Sc.



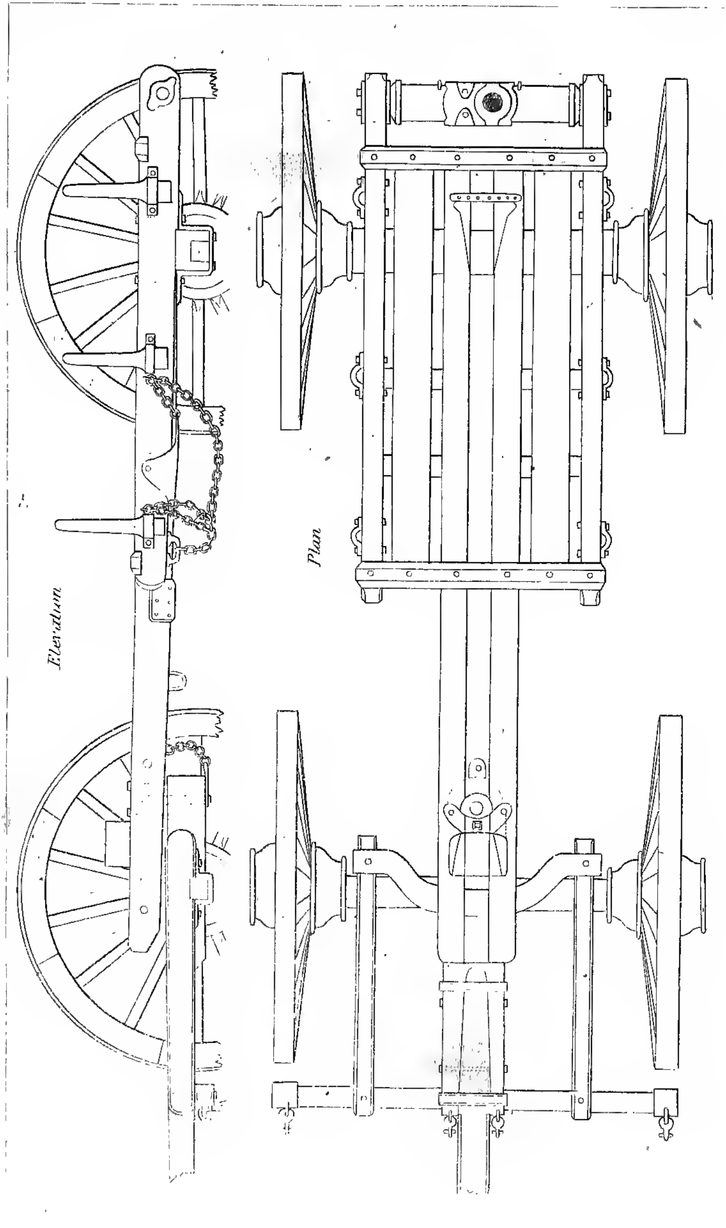
J. M. Butler, Sc.

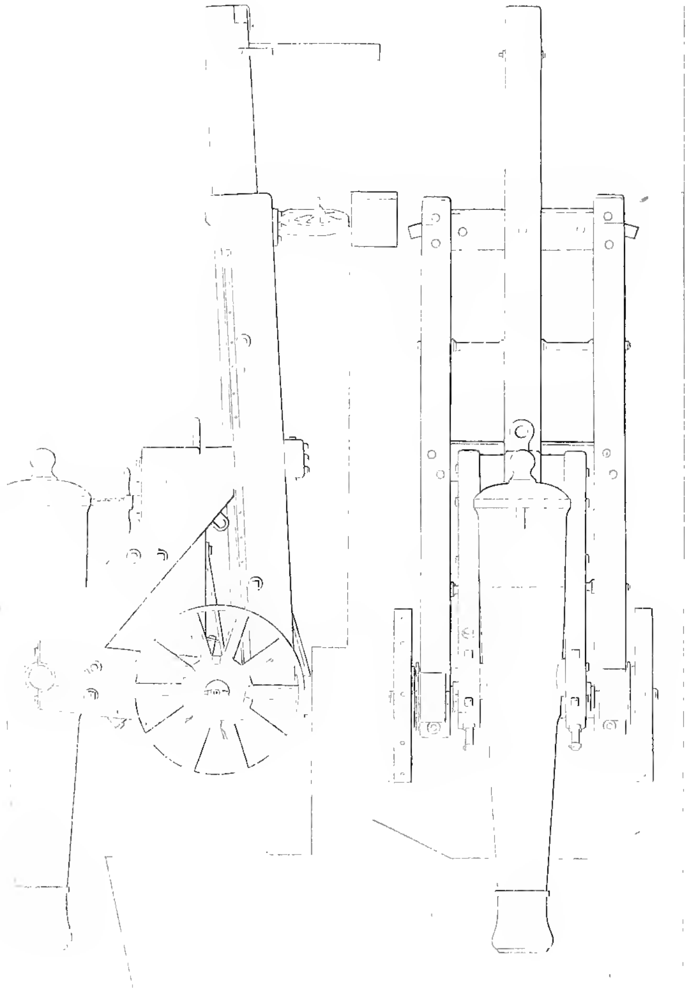


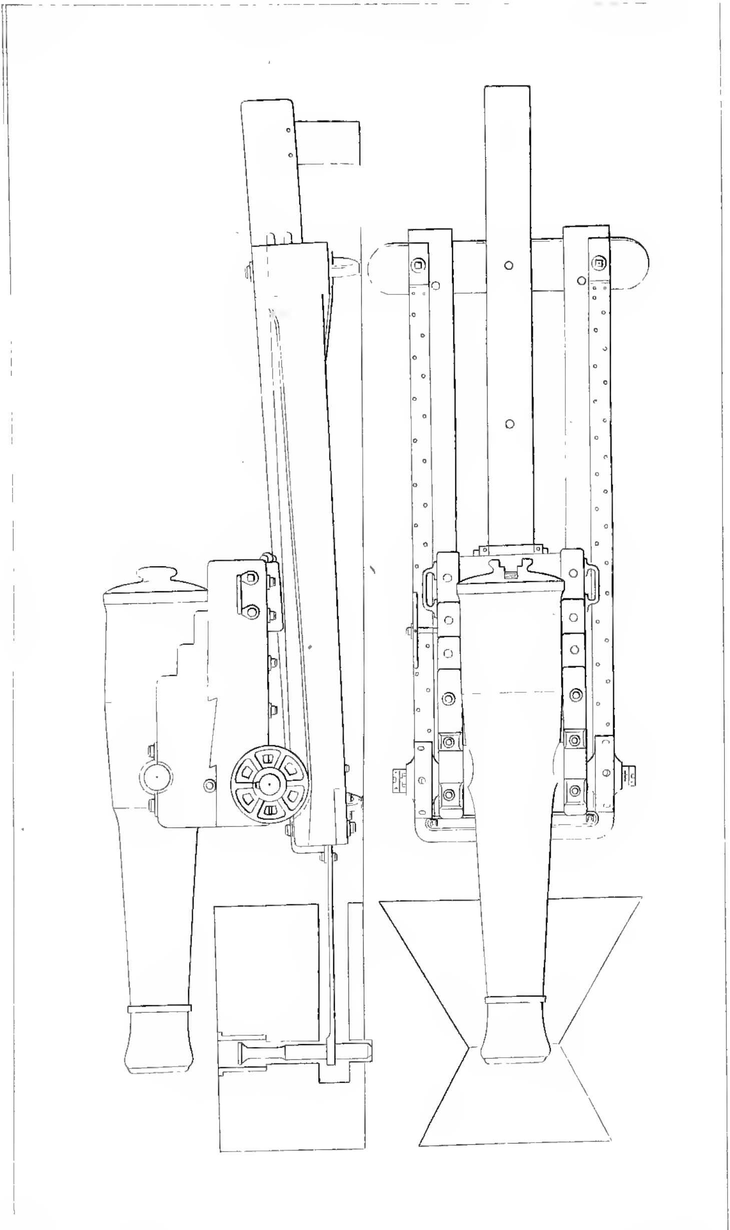
W. Butler, Sc.



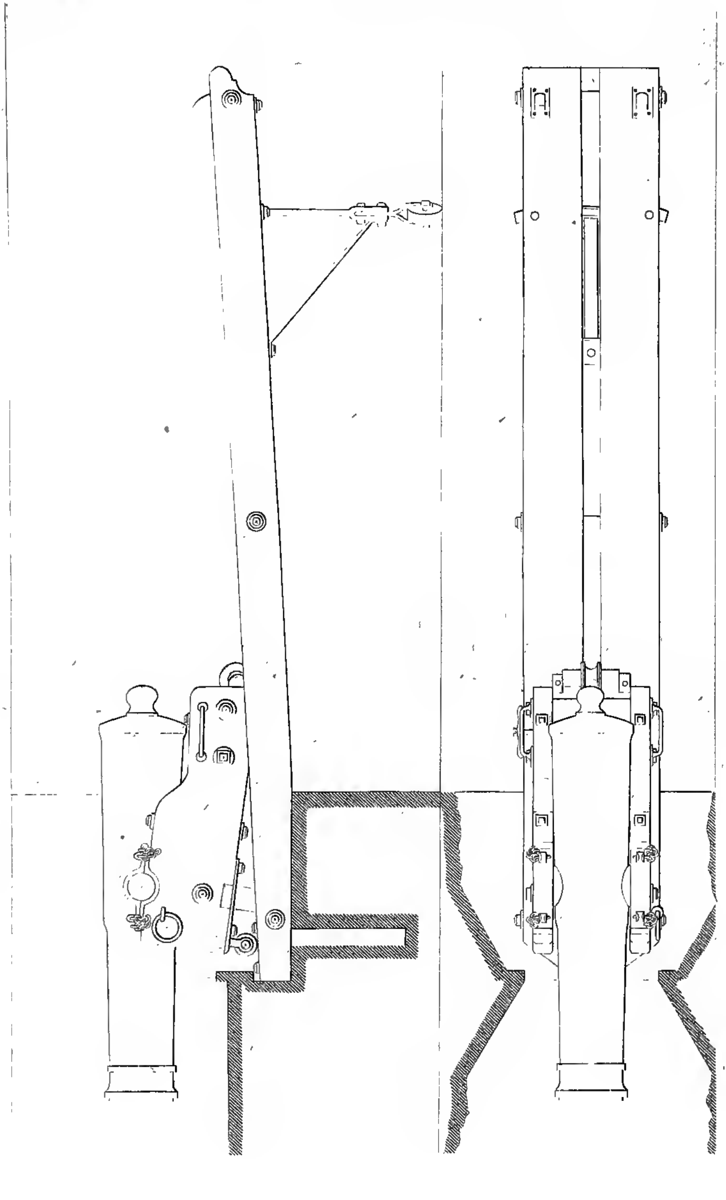
J. M. Butler, Sc.


Elevation
Plan

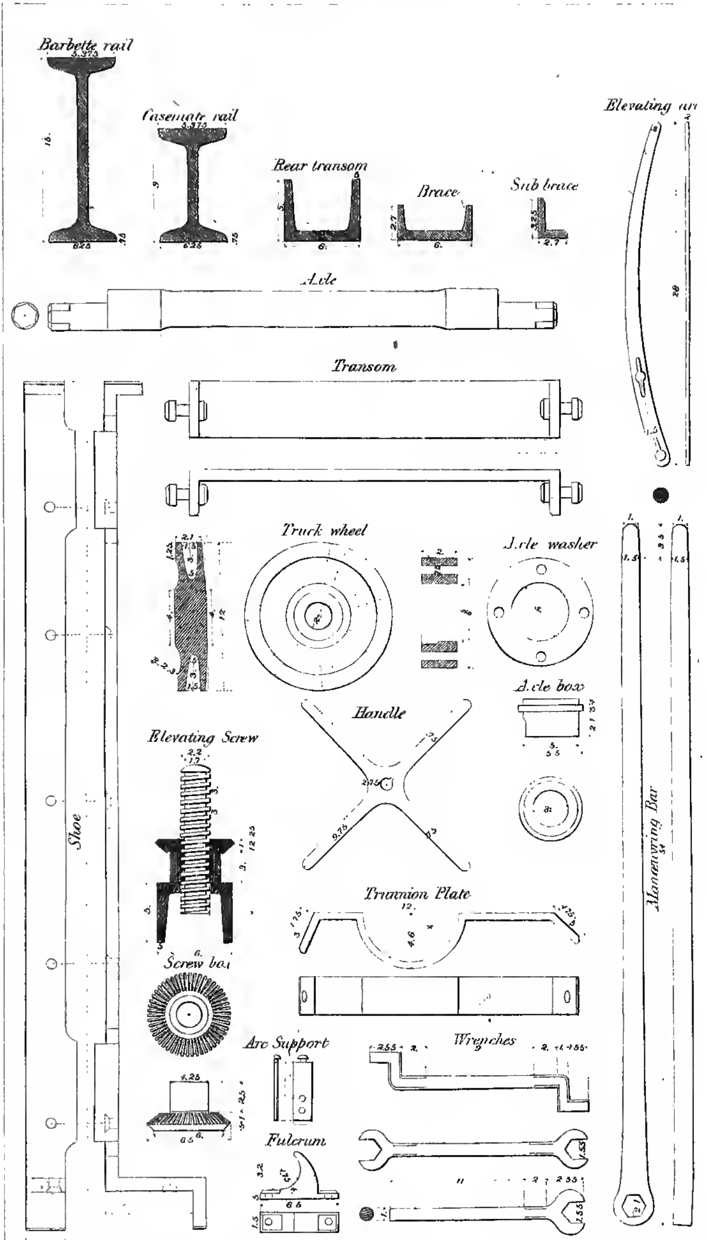




S. C. Benton Lieut. Ordn. Dell. J. M. Butler Sc.

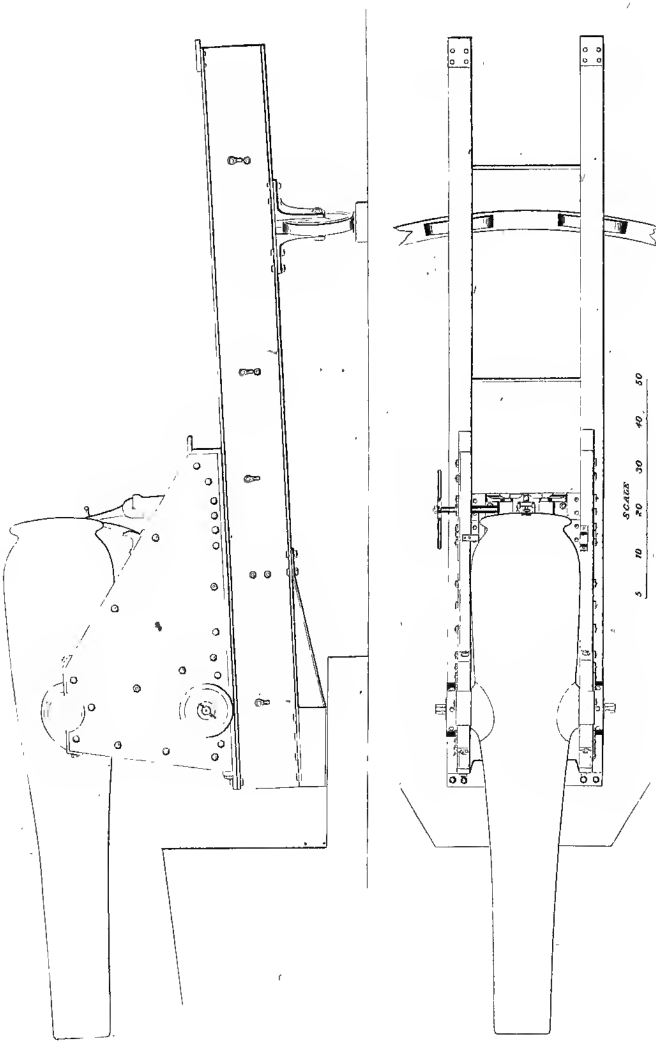


J. W. Butler Delt *J. M. Butler Sc.*

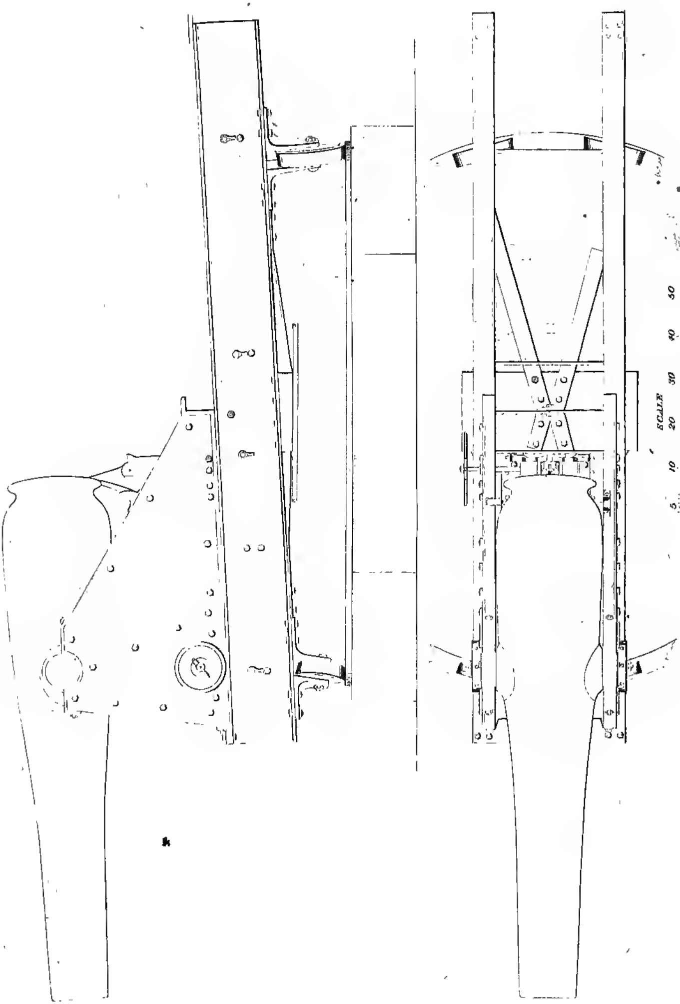


T. T. S. Laidley Del.

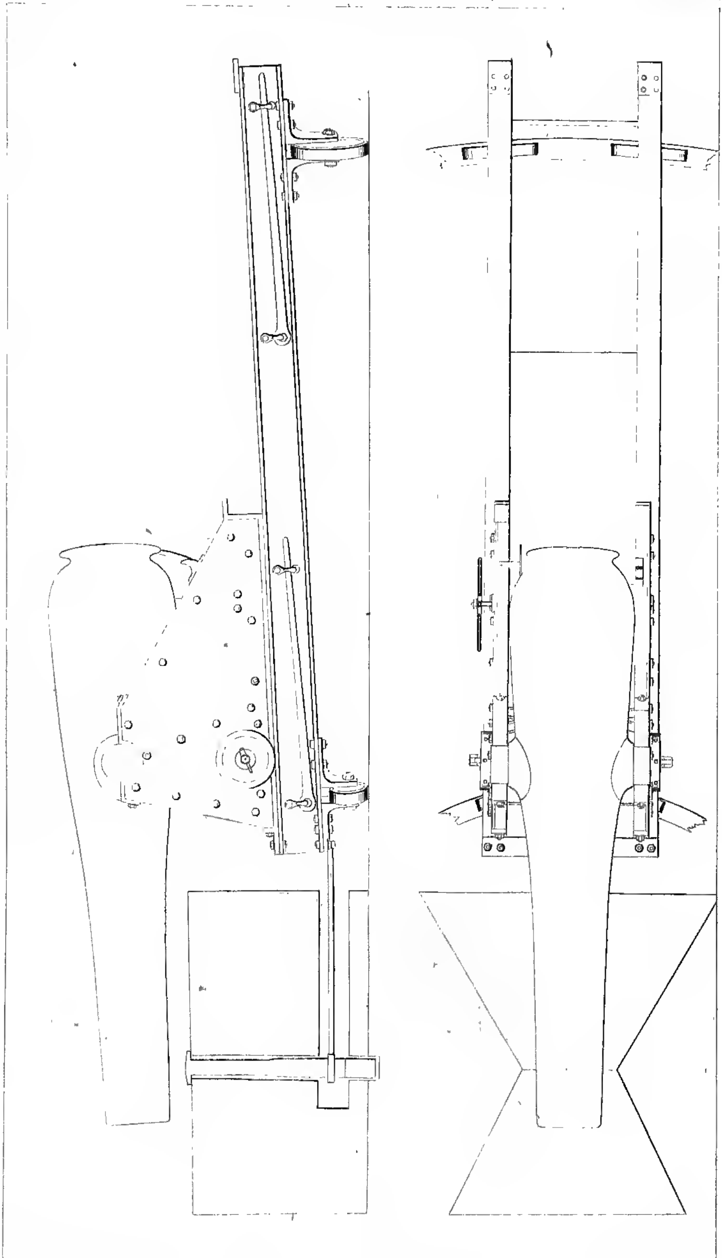
J. M. Butler Sc.



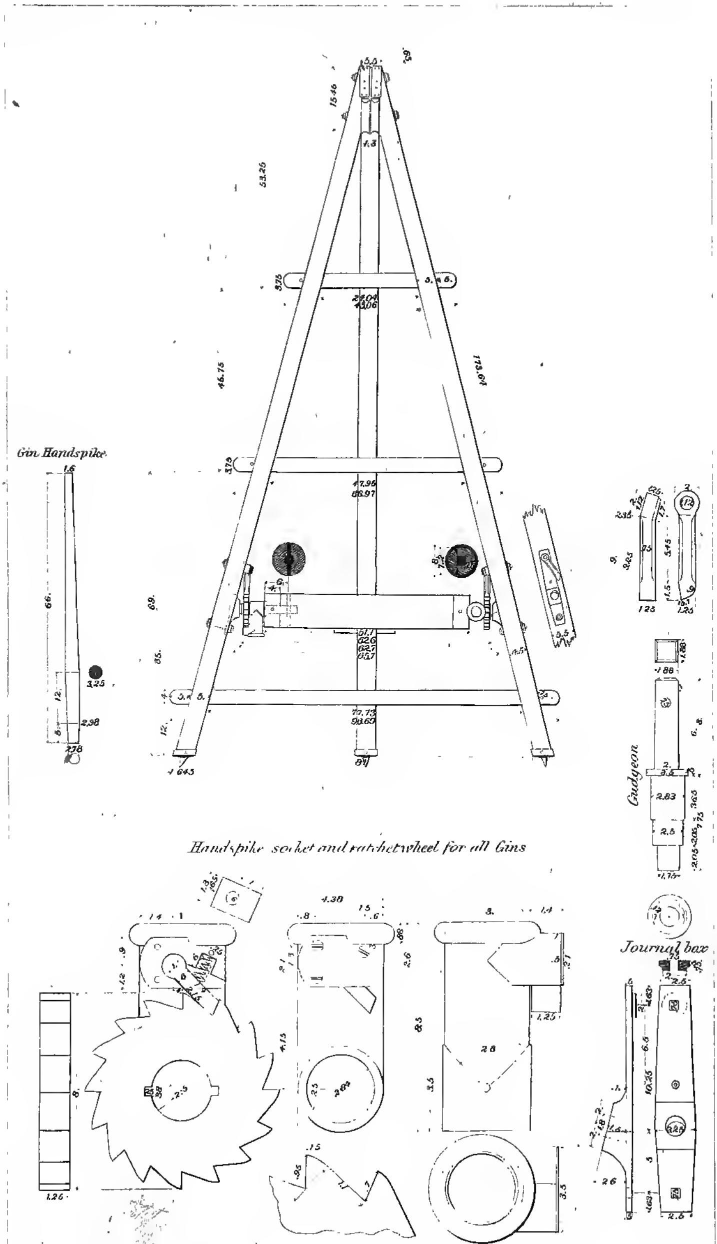
G Stolz Delt J. M. Butler Sc



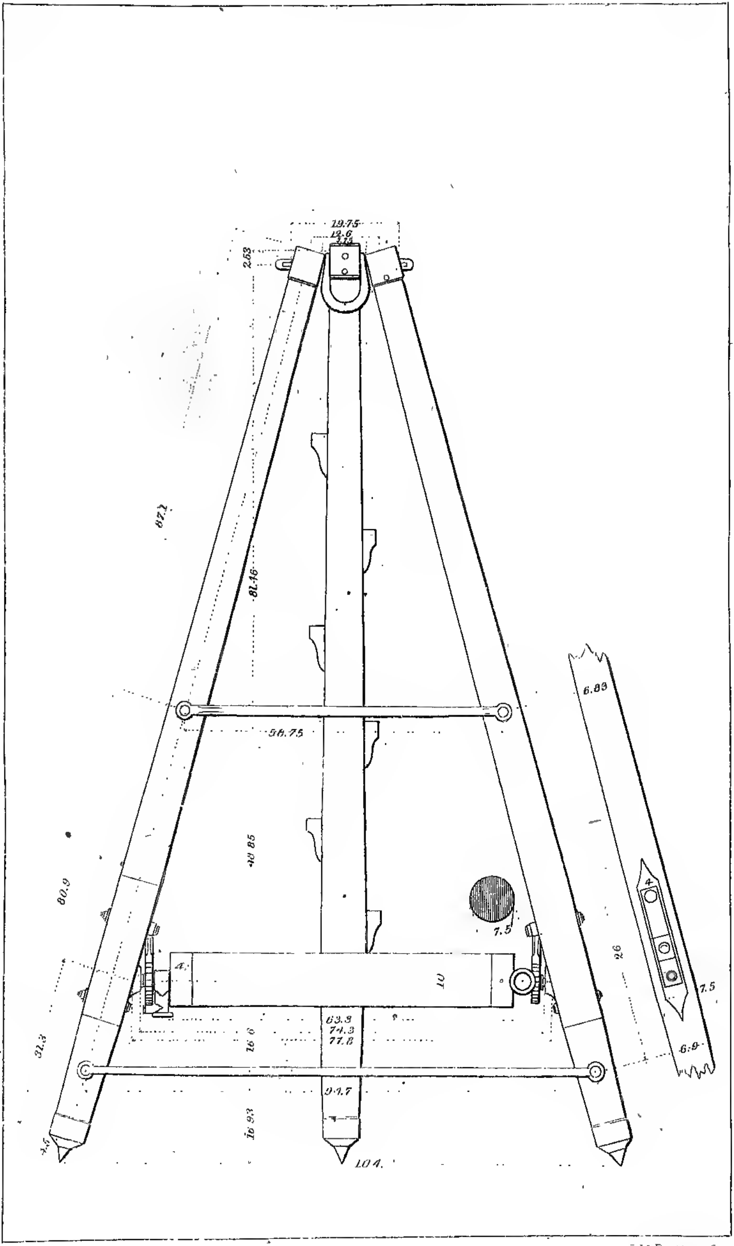
G Stolz. Delt. J.M.Butler Sc.



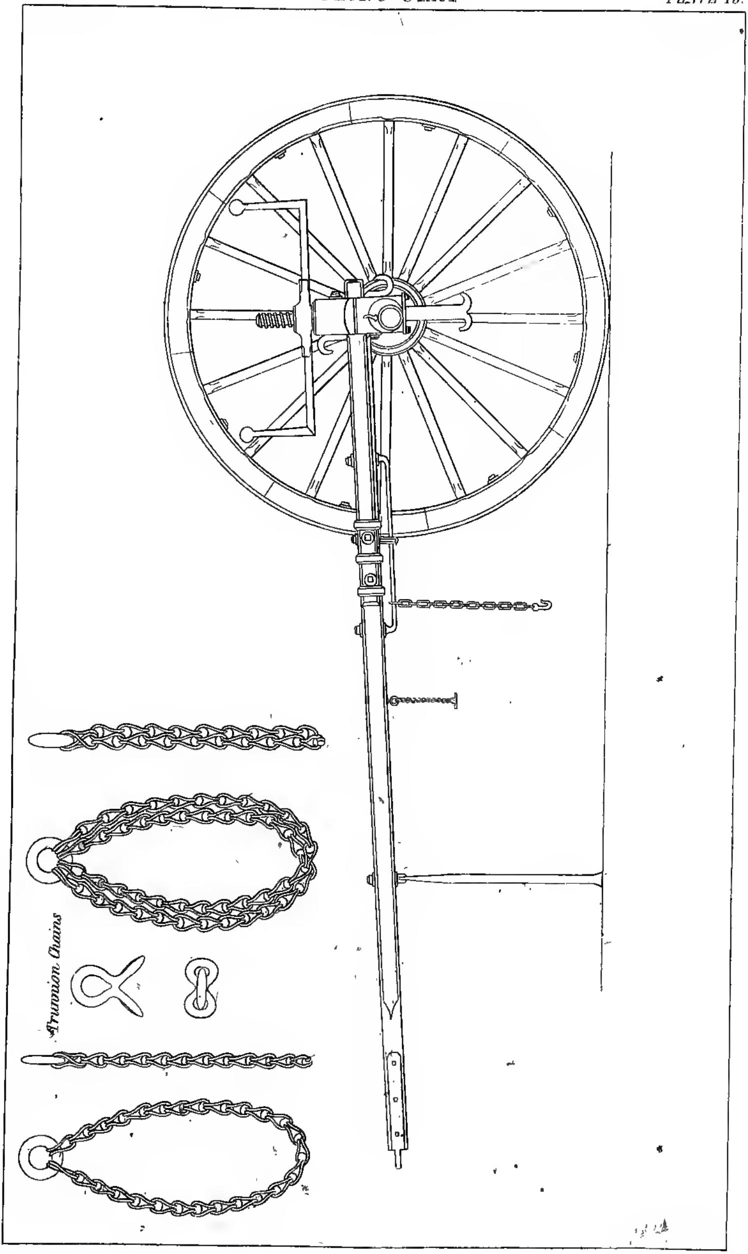
J. M. Butler Sc.



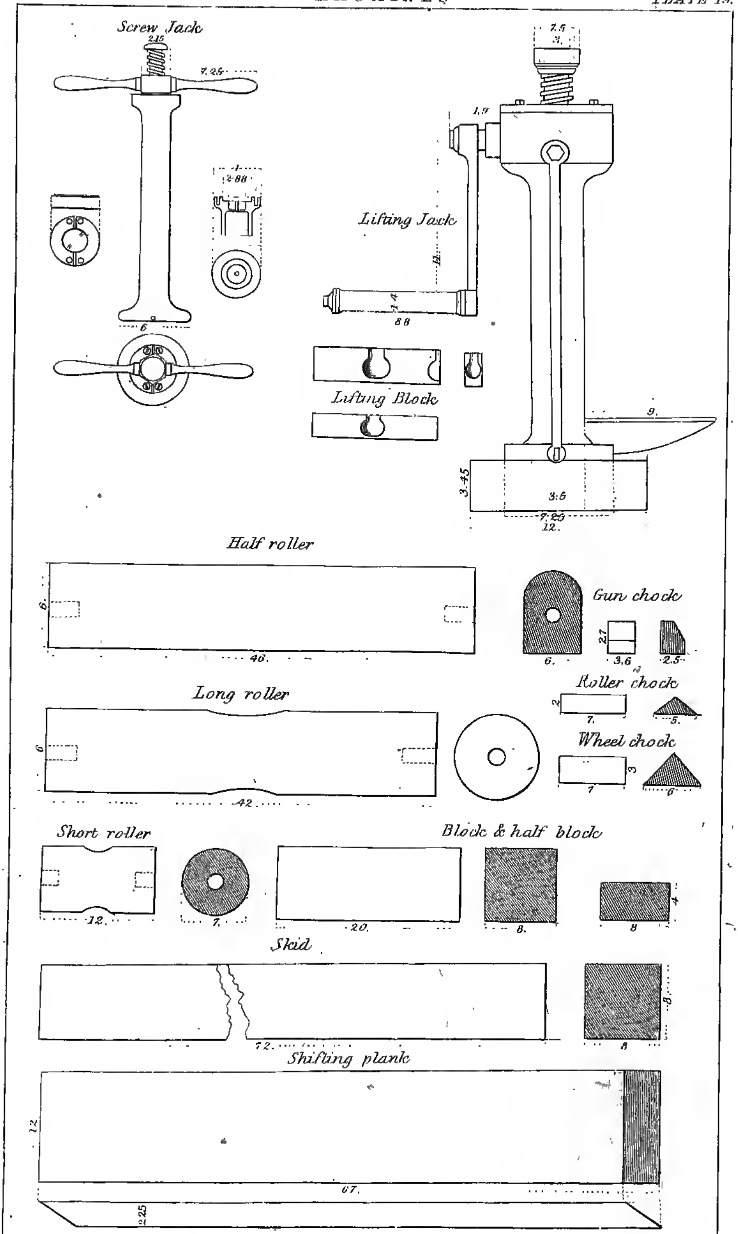
T T S Laidley Delt. J M Butler Sc


19.75
12.6
2.53
87.1
81.46
56.75
48.85
80.9
7.5
4.
10
63.3
74.3
77.8
16.6
31.3
94.7
16.93
104.
6.83
4
26
7.5
6.9

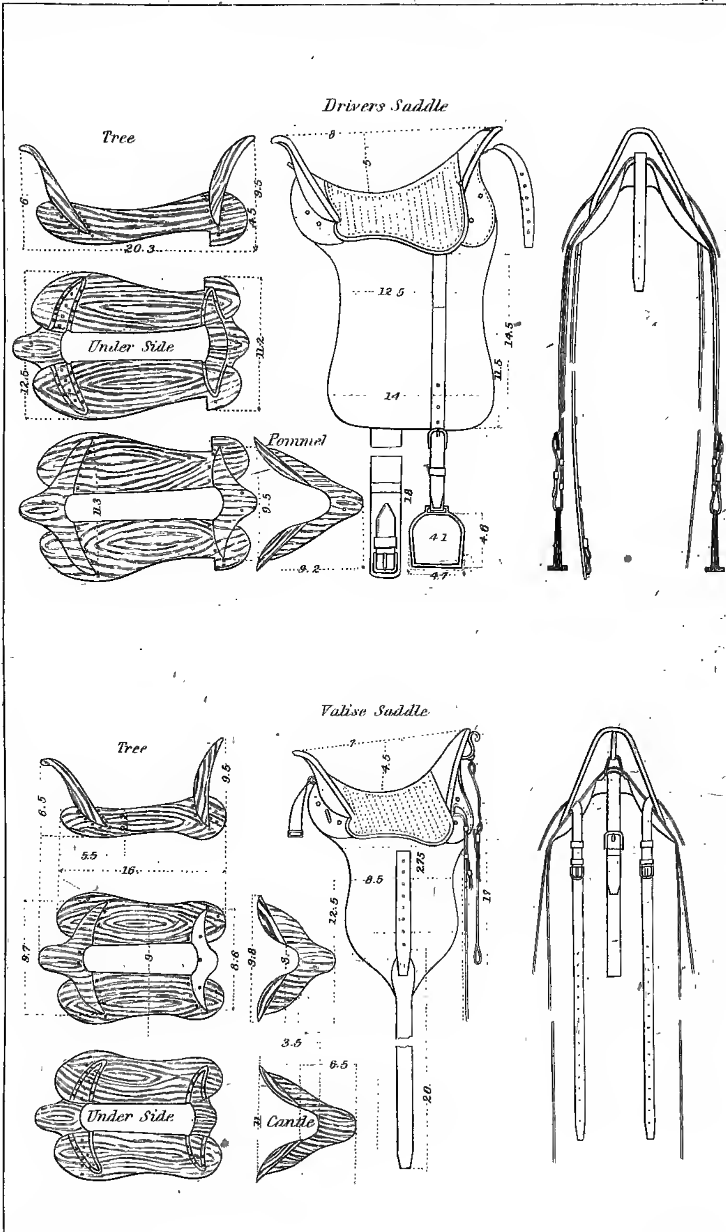
J. W. Butler Sc.

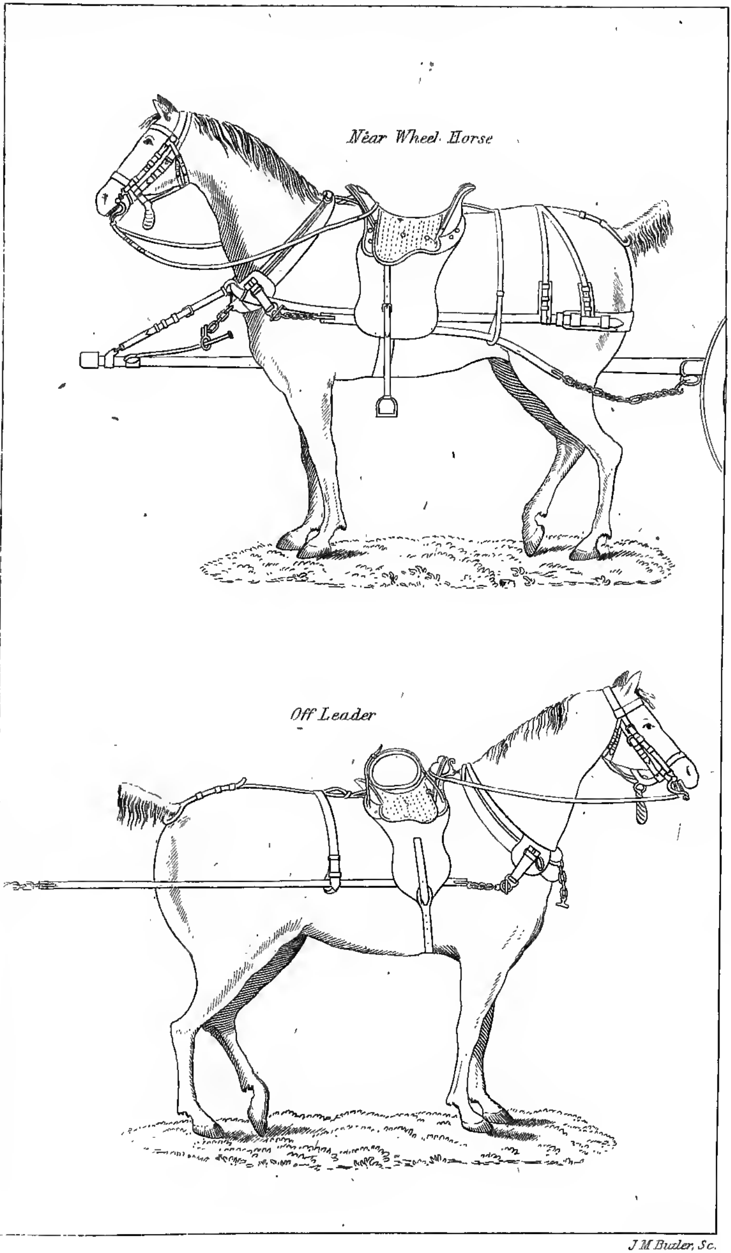


J.M. Butler, Sc

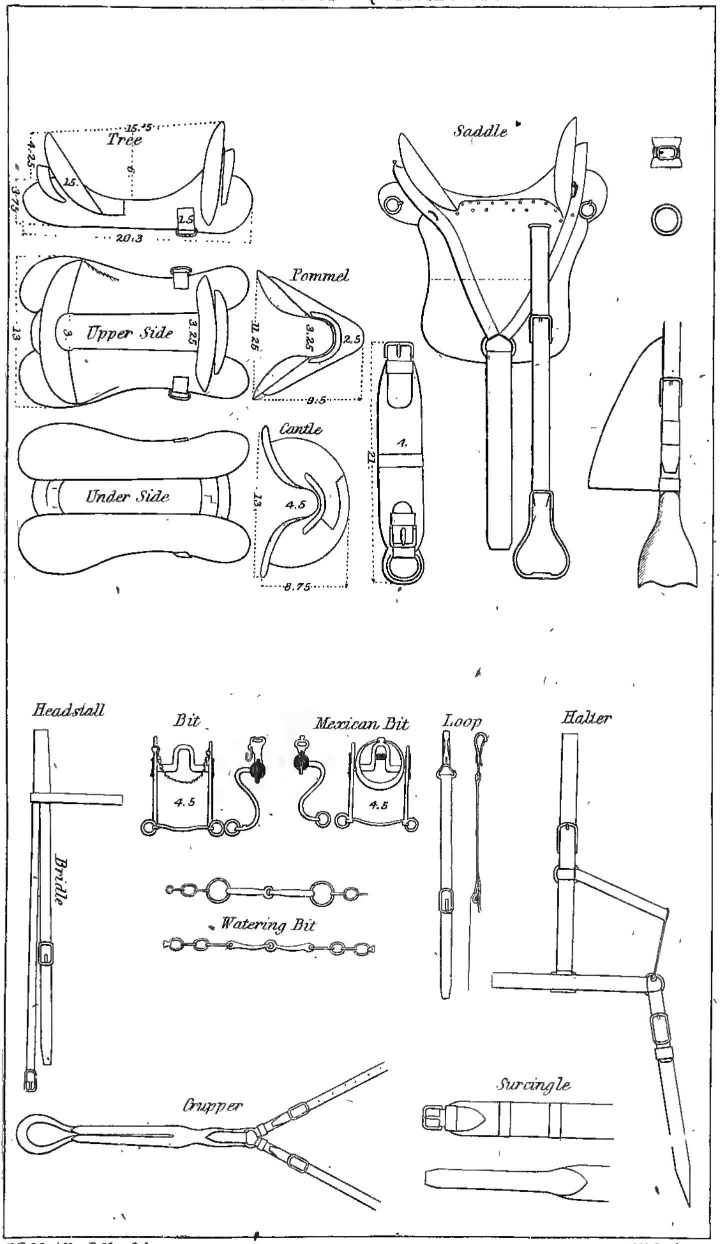


T F S Lindley B Maj Del. J M Butler Sc.

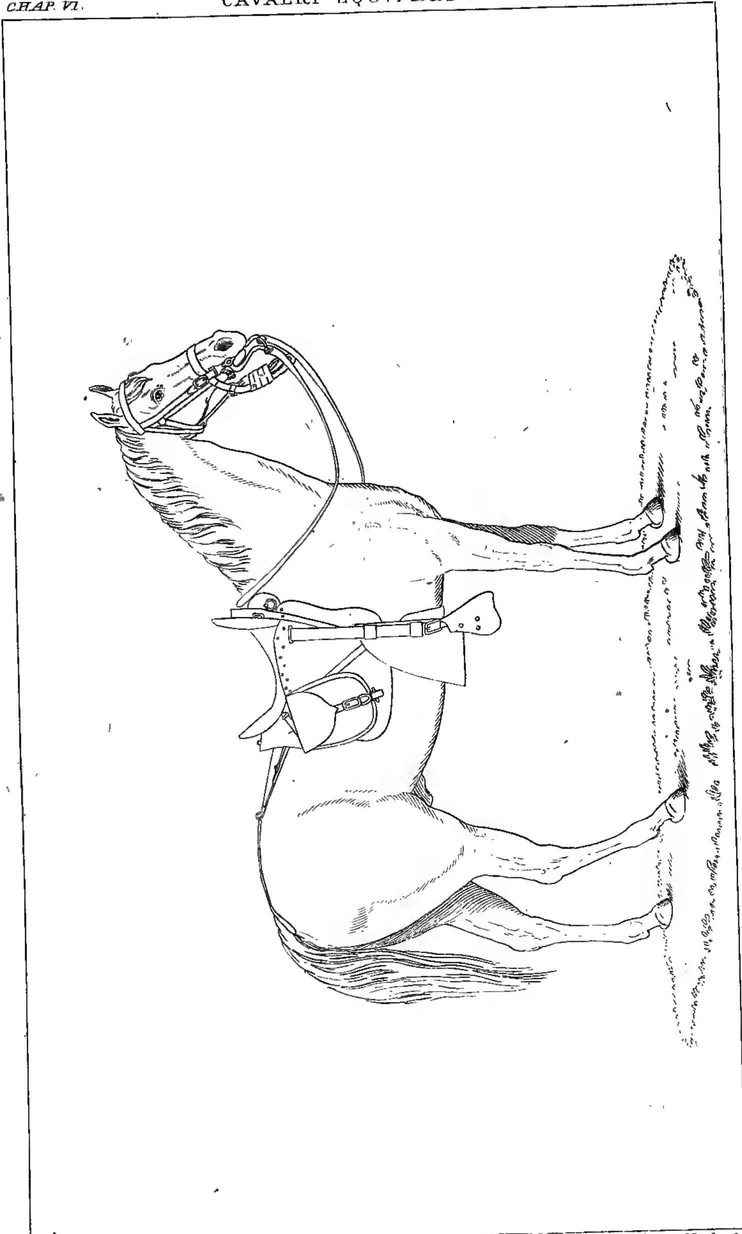

Drivers Saddle
Tree
Under Side
Pommel
Valise Saddle
Tree
Under Side
Cantle



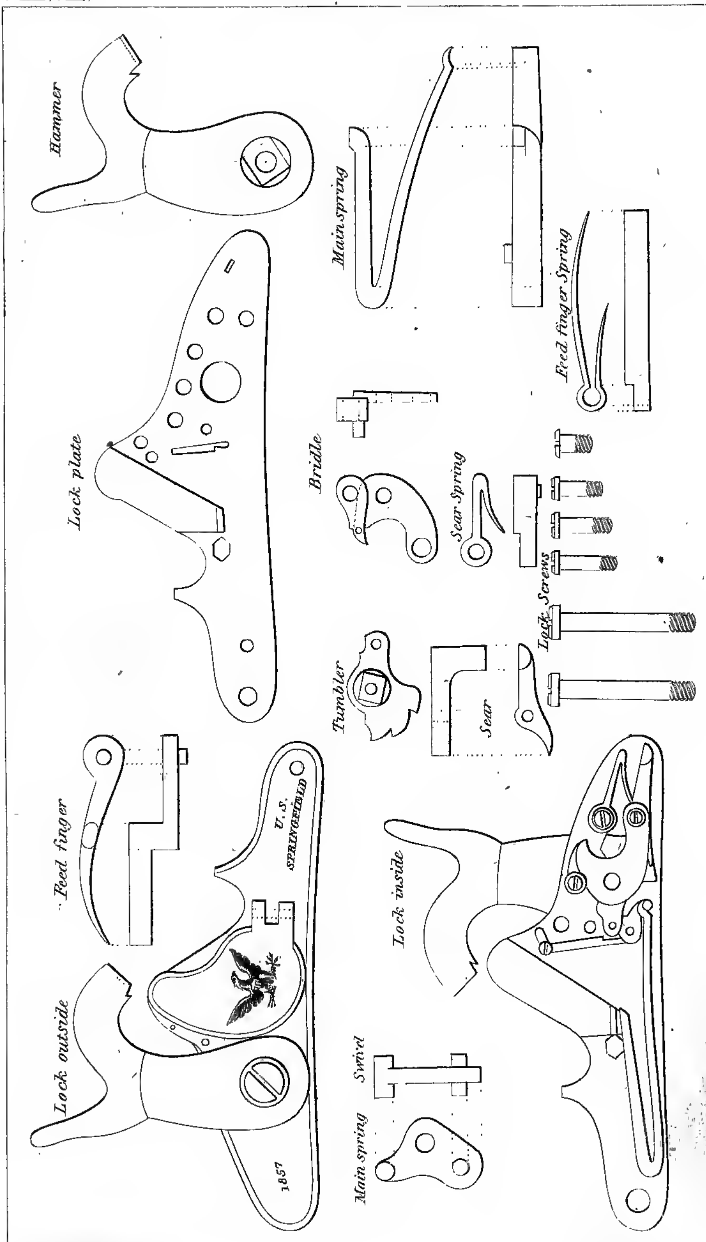
J M Butler, Sc.



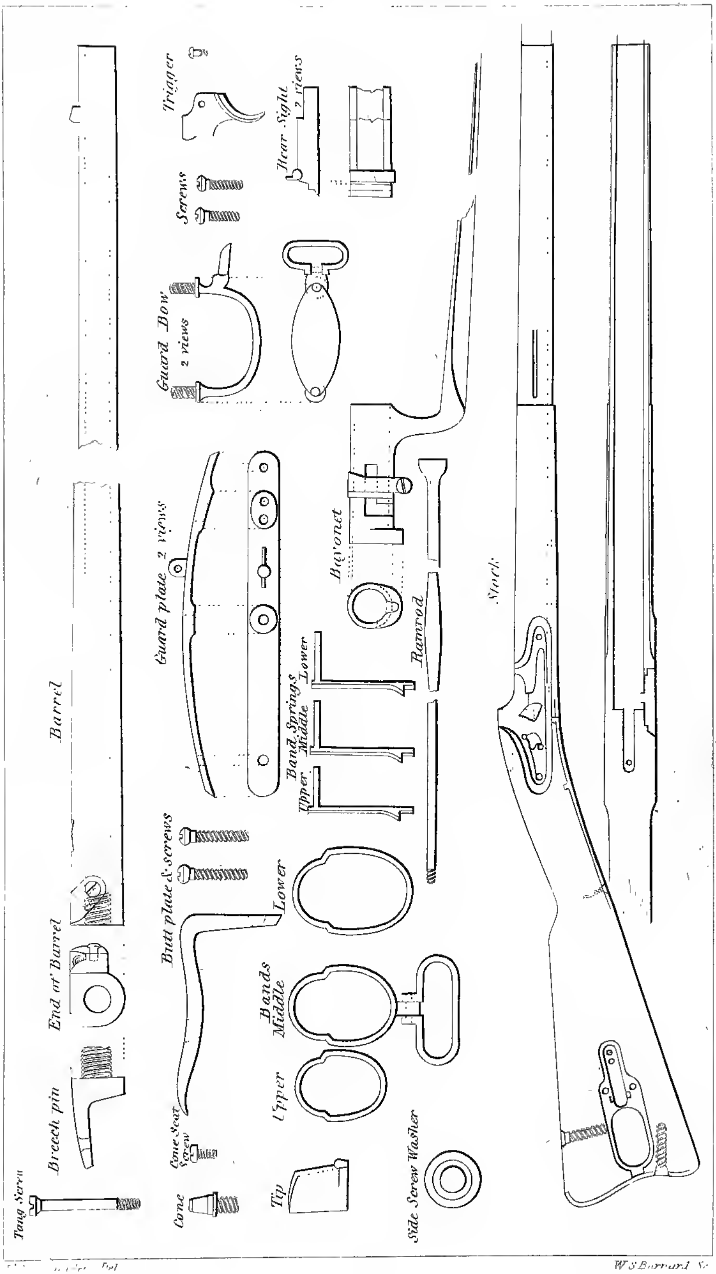
T.T.S. Laidley, B. Maj. Del. J.M. Butler Sc.

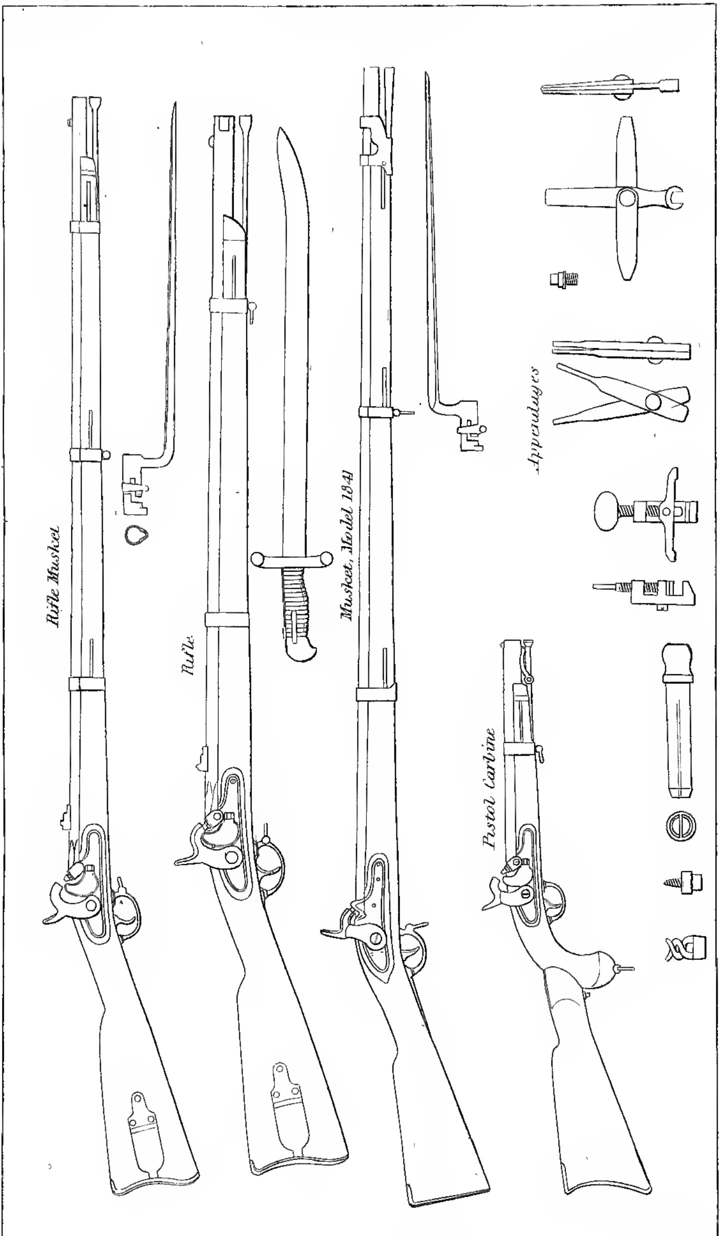


T T S Laidley, E May Del. J M Butler Sc.

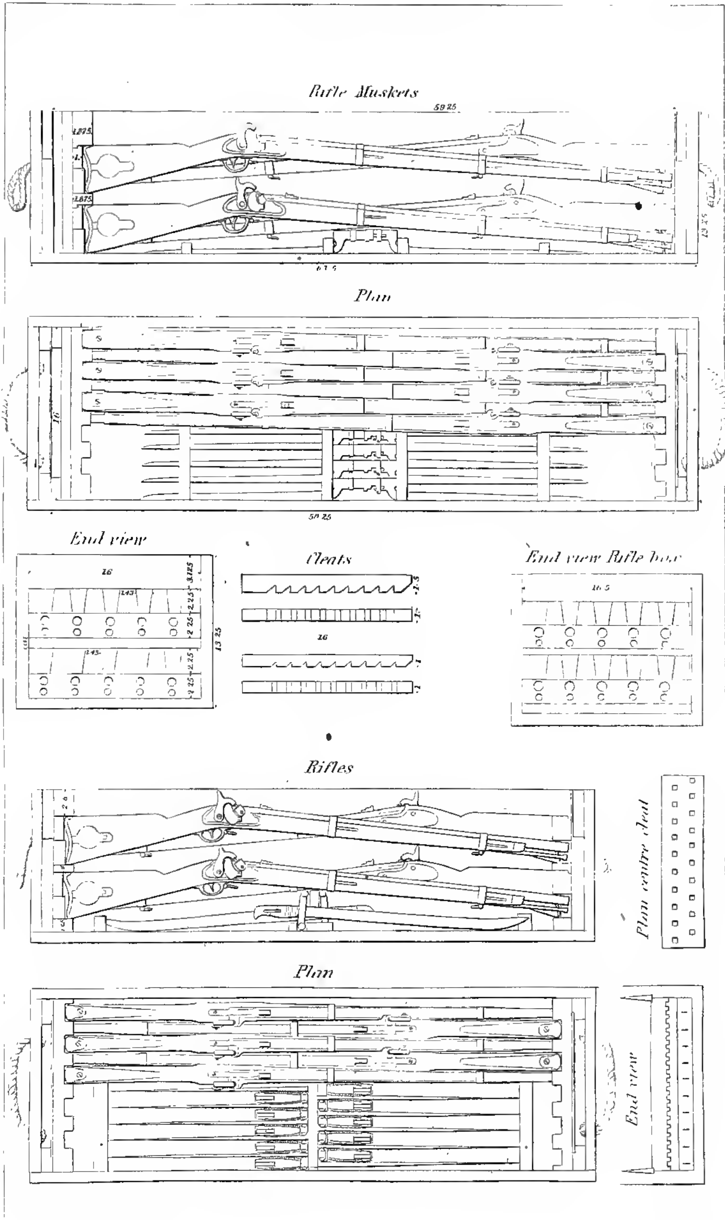


Lt J.S. Saunders, Del.

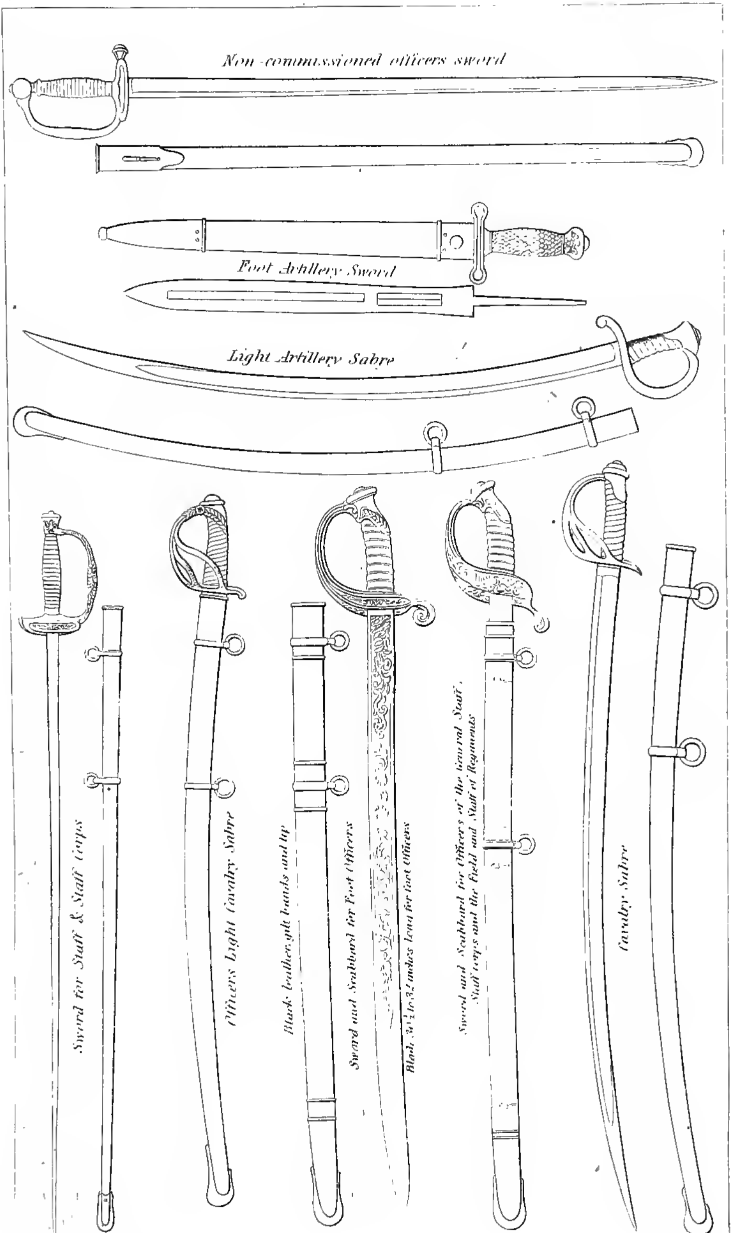

Barrel
End of Barrel
Breech pin
Tang Screw
Trigger
Screws
Guard Bow 2 views
Guard plate 2 views
Butt plate & screws
Cone Seat Screw
Cone
Rear Sight 2 views
Bayonet
Ramrod
Band Springs Upper Middle Lower
Bands Upper Middle Lower
Tip
Side Screw Washer
Stock


Rifle Musket
Rifle
Musket, Model 1841
Pistol Carbine
Appendages

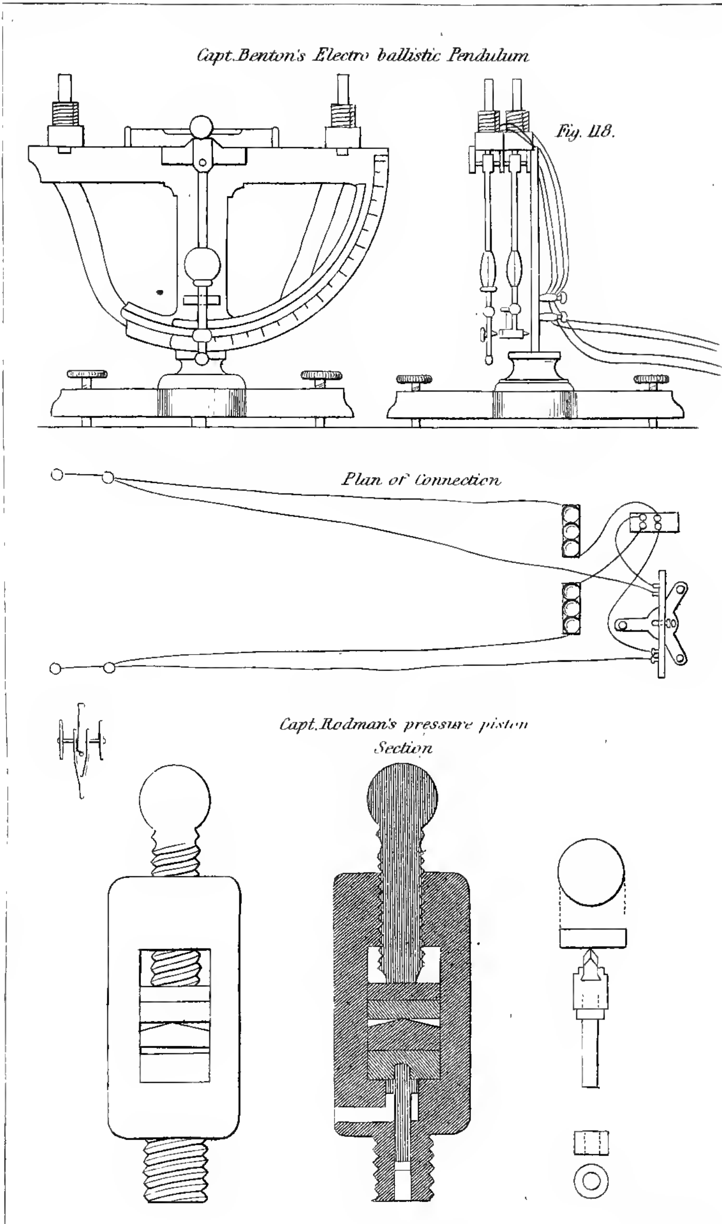
J.M Butler, Sc


Rifle Muskets
Plan
End view
Cleats
End view Rifle box
Rifles
Plan
Plan centre cleat
End view

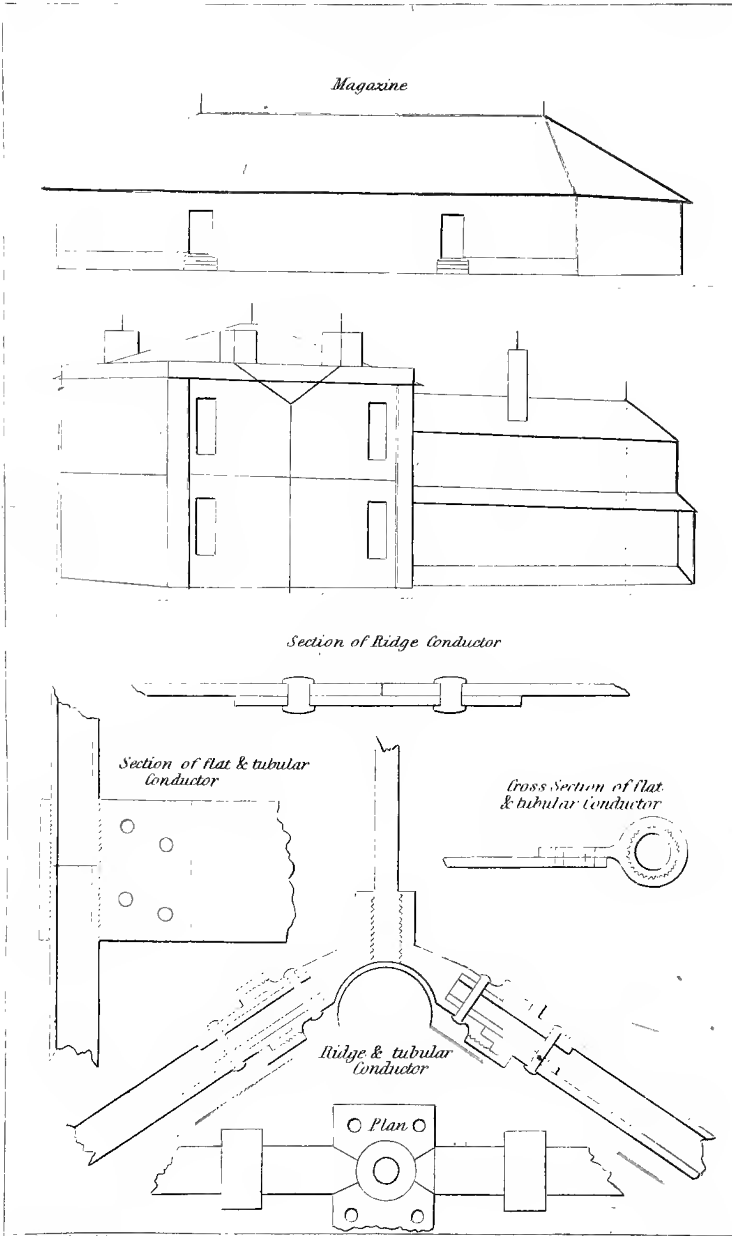
J.M Butler, Sc


Non-commissioned officers sword
Foot Artillery Sword
Light Artillery Sabre
Sword for Staff & Staff Corps
Officers Light Cavalry Sabre
Black leather, gilt bands and tip
Sword and Scabbard for Foot Officers
Blade 30½ to 32 inches long for foot officers
Sword and Scabbard for Officers of the General Staff, Staff corps and the Field and Staff of Regiments
Cavalry Sabre

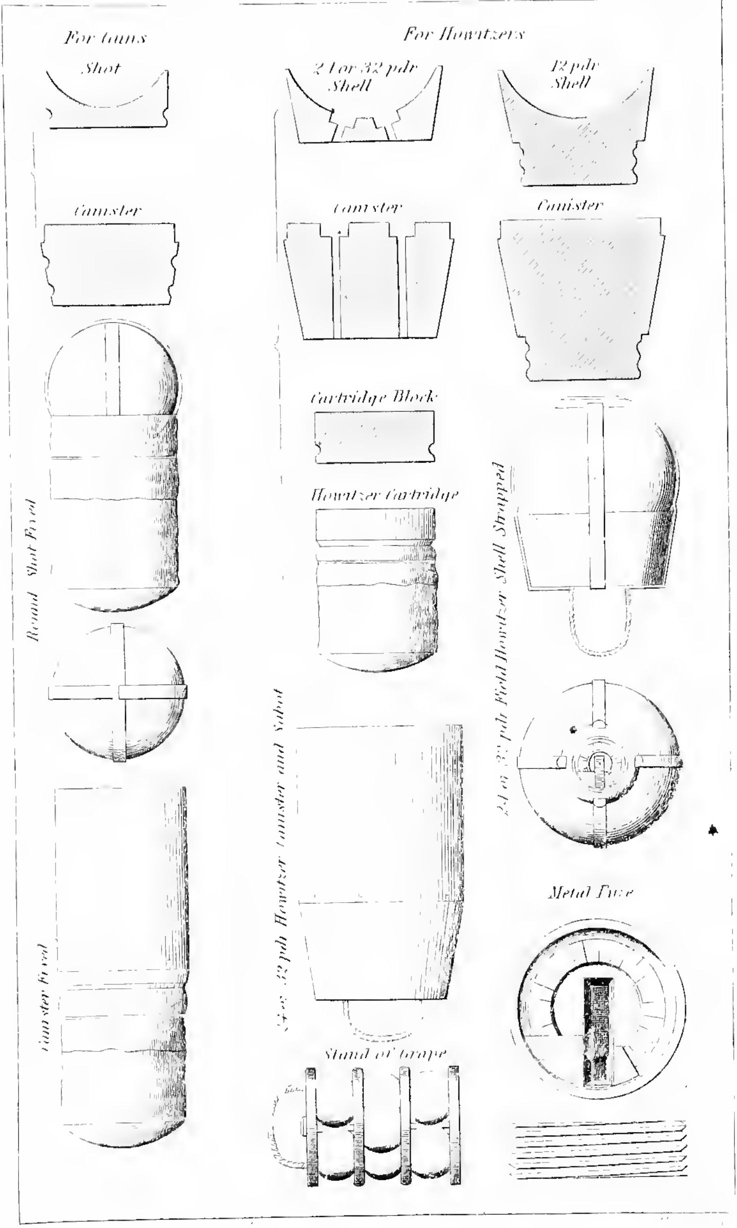
J.M.Butler Sc


Capt. Benton's Electro ballistic Pendulum
Fig. 118.
Plan of Connection
Capt. Rodman's pressure piston
Section

J.M.Butler Sc.

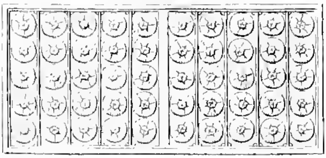

Magazine
Section of Ridge Conductor
Section of flat & tubular Conductor
Cross Section of flat & tubular Conductor
Ridge & tubular Conductor
Plan

J.M.Butler.Sc

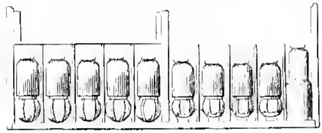

For Guns
Shot
Canister
Round Shot Fixed
Canister Fixed
For Howitzers
24 or 32 pdr Shell
12 pdr Shell
Canister
Canister
Cartridge Block
Howitzer Cartridge
24 or 32 pdr Howitzer Canister and Sabot
24 or 32 pdr Field Howitzer Shell Strapped
Metal Fuze
Stand of Grape

6 Pdr. Gun.

Plan

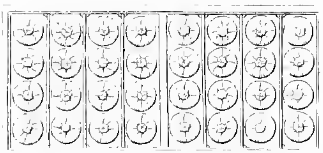


Elevation

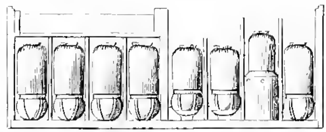


12 Pdr. Gun.

Plan

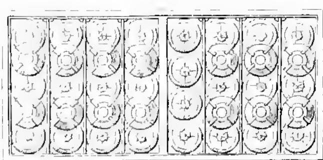


Elevation.

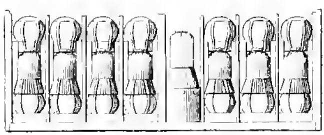


12 Pdr Howitzer

Plan

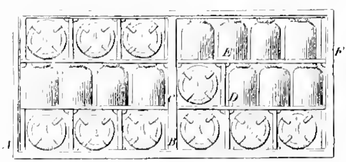


Elevation

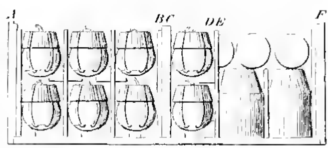


24 Pdr. Howitzer

Plan.

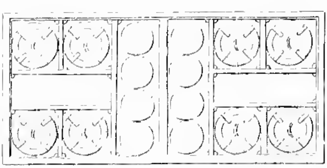


Elevation.

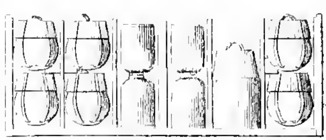


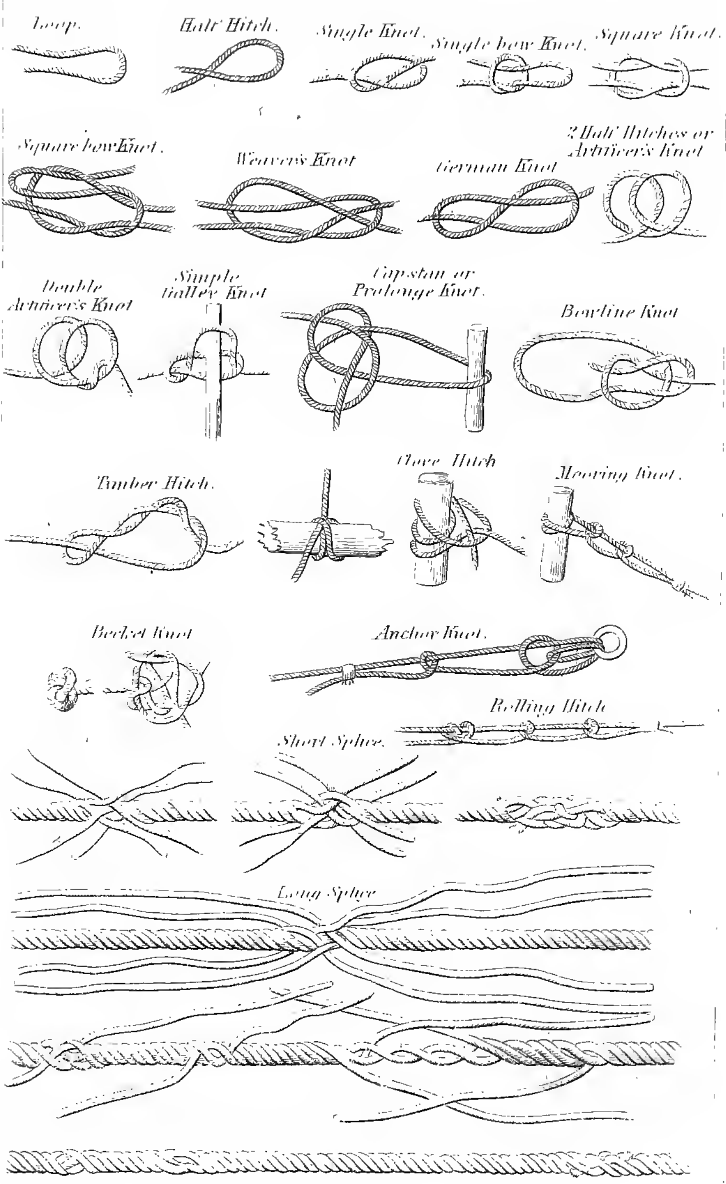
32 Pdr. Howitzer

Plan



Elevation




Loop.
Half Hitch.
Single Knot.
Single bow Knot.
Square Knot.
Square bow Knot.
Weaver's Knot
German Knot
2 Half Hitches or Artificer's Knot
Double Artificer's Knot
Simple Galley Knot
Capstan or Prolonge Knot.
Bowline Knot
Timber Hitch.
Clove Hitch
Mooring Knot.
Becket Knot
Anchor Knot.
Rolling Hitch
Short Splice.
Long Splice